PDHonline Course C466 (3 PDH)

Secondary Containment Structures Regulatory Requirements for Hazardous Materials

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2020

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SECONDARY CONTAINMENT STRUCTURES REGULATORY REQUIREMENTS FOR HAZARDOUS MATERIALS

Timothy Laughlin, PE

DRAWINGS AND INFORMATION PRESENTED FOR INFORMATION ONLY AND NOT INTENDED FOR USE IN CONSTRUCTION OF SPECIFIC PROJECTS.

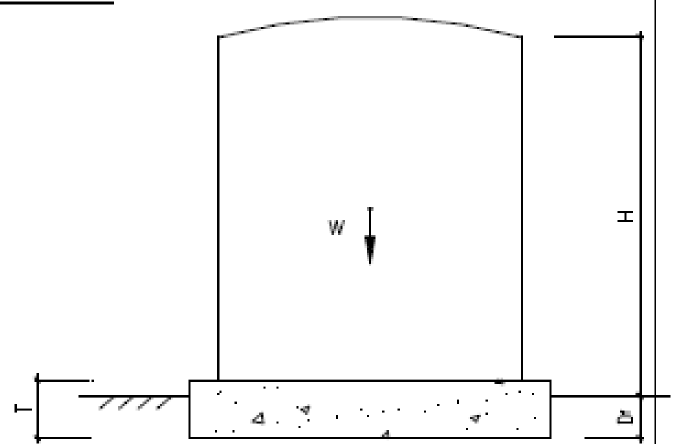
The intent of this document is to provide information for environmental control of Hazardous Materials. It will not serve as construction documents, equipment approvals, building code permits or any other intent.

WARNING: Plans and specifications are each part of an integrated design system. Any modification, alteration, change, deletion, addition, or substitution, of or to any specification(s) could result in property damage, injury, or even death, and requires a full review of the entire system by a *PROFESSIONAL ENGINEER (P.E.).*

THIS CLASS DOES NOT CONTAIN STRUCTURAL ENGINEERING DESIGN OR SOILS ENGINEERING INFORMATION OR CALCULATIONS. MANY OTHER CLASSES OFFER MORE DESIGN DETAILS ON SLAB ON GRADE AND/OR PIER FOOTING DESIGN REGARDING SECONDARY CONTAINMENT POINT & LATERAL LOADS AND SOIL BEARING PRESSURES.

TYPICAL DATA REQUIREMENTS FOR TANK SLAB/FOOTING DESIGN

TANK HEIGHT = H
TANK DIAMETER = d
TANK THICKNESS = t
WT OF TANK & MAX CONTENTS = W (Chemical Type)
SOIL WEIGHT = ws
FOOTING EMBEDMENT DEPTH = Df
FOOTING THICKNESS = T
ALLOW SOIL PRESSURE = Qa
FOOTING DIAMETER = D
TOTAL ANCHORAGE POINTS = n
ANCHOR BOLT DIAMETER = f
CONCRETE STRENGTH = fc'
REBAR YIELD STRESS = fy
FOOTING REBAR ≈ 2 #6 @ 18 in o.c. each



Other Design Considerations/Specifications: TYPICAL

- **Steel reinforcement can also be #4 deformed reinforcing bars, grade 40, (Fy = 40 Kips) 12 inches on center in both directions. Typical 2 to 3-inch of separation from the rebar to all faces of structure.**
- **Sub-Grade soil bearing capacity of the foundation bed is typical (qs) 2000 psf minimum. Pad shall be over 4 inches finished course of pea gravel and a base course of crushed stone 8 inches thick. Finished and Base courses should extend 12 inches beyond the edge of the pad. Compaction of fill/existing soils may be required in 10 inch lifts. Will need soils engineering analysis by qualified geotechnical engineer.**
- **Moisture Control and Vapor Barriers. Prevents debonding of coatings/paints.**
- **Liquid tight expansion joints as needed per site conditions and steel placement. Expansion joints shall not exceed intervals perpendicular to the pads long axis as specified by the professional engineer. Expansion joint shall be sealed by polymeric joint sealant and expansion joint material shall be full depth of slab thickness. In no case shall expansion joint be less than ¼ inch in thickness. Control joints, or contraction joints may be used instead of expansion joints on slabs 4 inches or less.**
- **Pad shall be installed to provide for stormwater runoff. (slope 1/8 to 1/4 inch per foot to drainage system)**

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Engineers may choose to use computer programs for design calculations such as this one listed below.

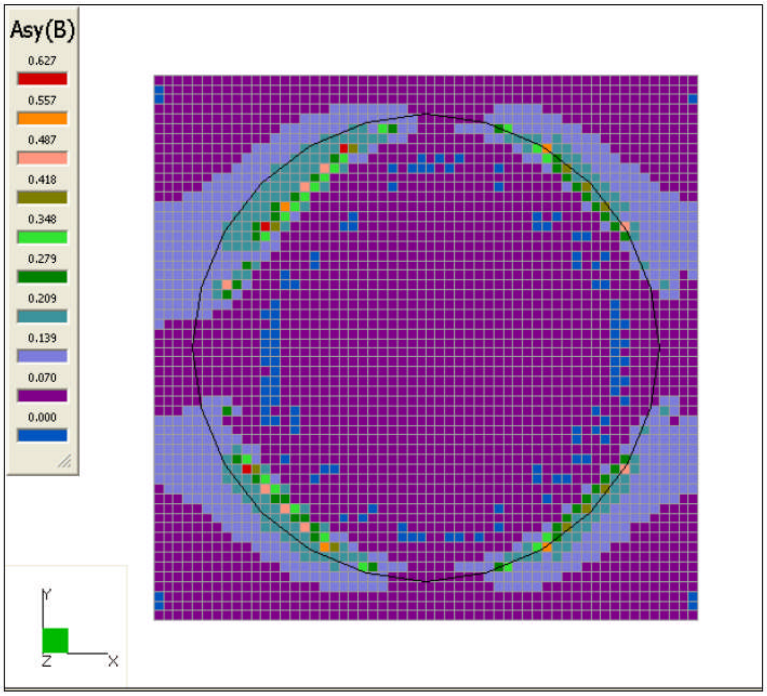
Introduction to spMats-spMats utilizes the Finite Element Method to determine the forces acting throughout a foundation as well as the required reinforcing, foundation settlement, and supporting soil pressure. spMats can design slabs on grade with uniform or variable slab depth and soil properties. The model can incorporate piles in conjunction with the soil system if the soil is considered inadequate to support the applied loads. spMats can take into account multiple load combinations and a variety of unique boundary conditions.

FOR QUESTIONS REGARDING THIS PROGRAM-CONTACT:
STRUCTUREPOINT
5420 Old Orchard Rd
Skokie, IL 60077
Phone: (847) 966-4357 (HELP)
Fax: (847) 966-1542
Sales: info@StructurePoint.org

Web site: http://www.structurepoint.org/

Example program as follows:
12ft. diameter tank 30 ft. in height-30,000 gallons of diesel fuel.
Empty Tank weight is 20,000 pounds.

SLIDE I



Here we can see a concrete slab that supports a 12 ft diameter tank. The program produces a contour map of required reinforcing. Since foundations require variable amount of steel bars based on the direction and vertical position of reinforcing, these contour maps are broken into x and y directions and bottom and top layers. Here we can see the area of reinforcing (As) required for each element in the y-direction (y) of the bottom (B) of the slab.

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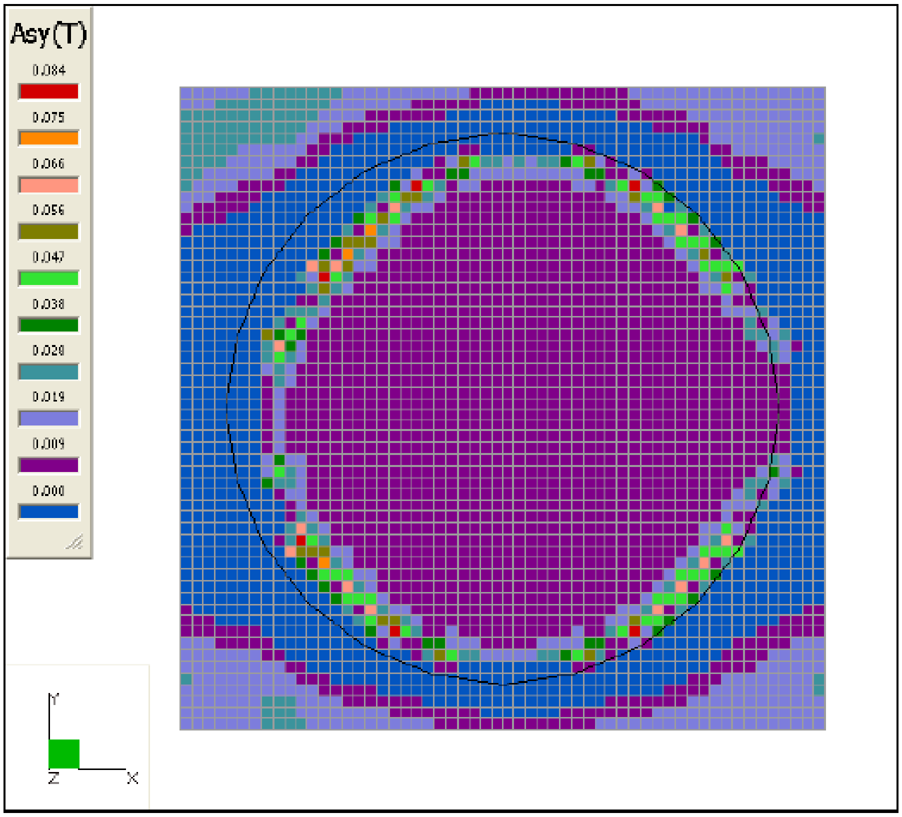
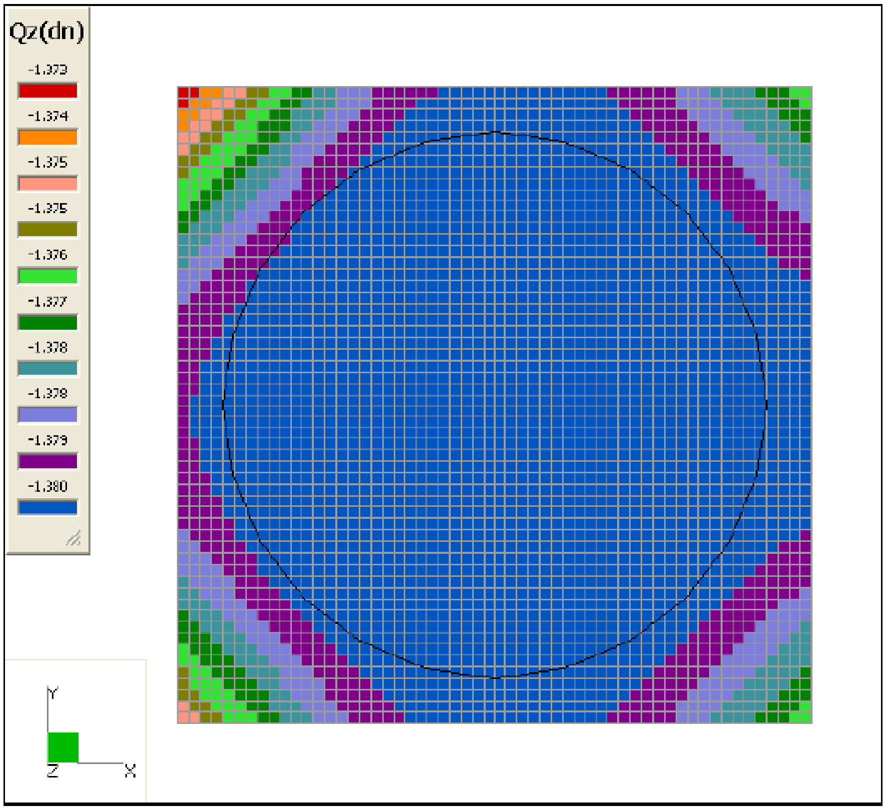
SLIDE II



Similarly, Slide II shows the area of reinforcing (As) required in the y-direction (y) of the top (T) of the slab. Notice that these diagrams follow intuition: since the slab is loaded downward by the tank and its contents, the bottom reinforcing layer contains more steel than the top since concretes contribution to tension resistance is minimal. The program also produces a displacement contour map for quick checks of maximum deflection and settlement versus allowable values. Slide III shows the variation of resulting downward soil pressure.

SLIDE III



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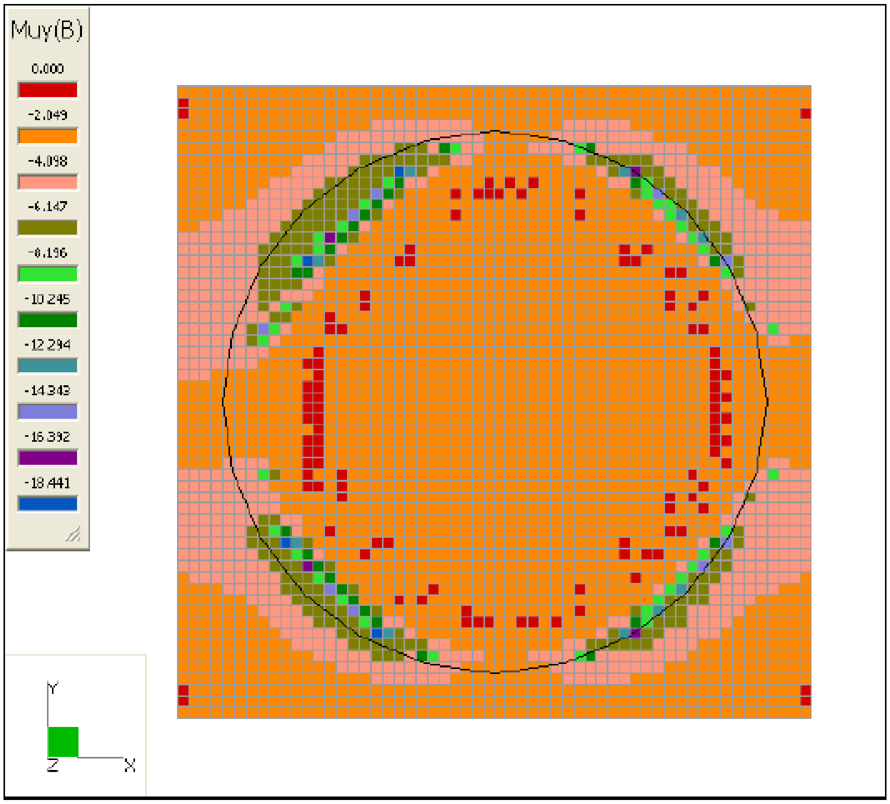
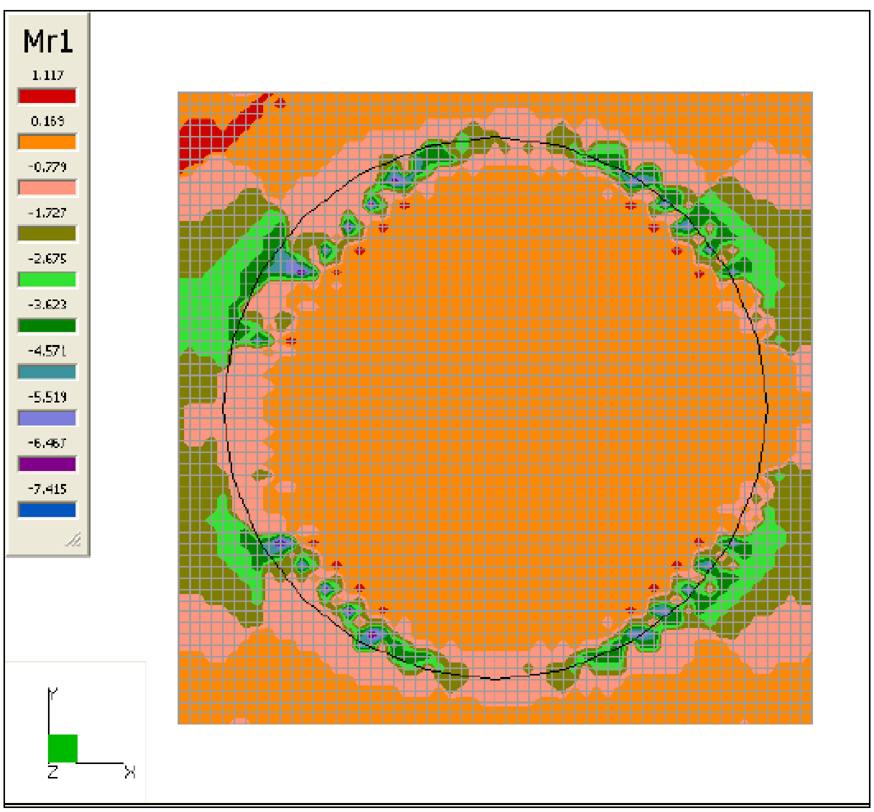
SLIDE IV



Slide IV shows the basis for the reinforcing steel design. It is a contour map of the ultimate internal moment in the y-direction at the bottom of the slab. These moment results are the values that are used to determine how much reinforcing is required. The equivalent principle moment along the principle angle is shown in slide V. These principle moments determine which load case governs the design and like the other moments are used by spMats in the slab design process.

SLIDE V



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C4a - ELEMENT TOP MOMENT ENVELOPES:

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Units --> Moment (kip-ft/ft), Angle (Deg)

Elem	Node	Ld Comb.	M(xx)	M(yy)	M(xy)	M(r1)	Angle
----	----	--------	----------	----------	----------	----------	------
1467	1551	L.C. 1	-0.03	0.02	0.01	0.02	-104.8
	1494	L.C. 1	0.05	0.02	0.02	0.06	25.7
	1550	L.C. 1	0.23	-0.04	-0.06	0.24	-13.1
	1493	L.C. 1	-0.01	0.13	-0.06	0.15	110.0
1468	1552	L.C. 1	0.05	0.03	-0.01	0.05	-20.4
	1495	L.C. 1	0.09	0.05	-0.01	0.10	-15.7
	1551	L.C. 1	0.02	0.03	0.00	0.03	-94.8
	1494	L.C. 1	-0.00	0.01	-0.00	0.01	101.1
1469	1553	L.C. 1	-0.02	0.02	0.00	0.02	-94.2
	1496	L.C. 1	-0.02	0.02	0.01	0.02	-100.8
	1552	L.C. 1	0.06	0.03	-0.01	0.06	-16.2
	1495	L.C. 1	0.03	0.04	-0.01	0.04	116.6
1470	1554	L.C. 1	-0.00	-0.03	-0.02	0.01	-27.8
	1497	L.C. 1	0.15	0.11	-0.03	0.16	-28.3
	1553	L.C. 1	0.04	0.03	-0.00	0.04	-17.1
	1496	L.C. 1	-0.04	0.01	-0.01	0.01	97.5

spMats also provides tabulated information with significant detail for the model and each element. Using this information the user can determine exact values for certain parameters or locations of interest throughout the slab, as well as follow the logic and computations of the program.

The one thing to note with this model is the design assumes a minimum reinforcing ratio of 0.00 in^2 instead of following ACI 318 minimum reinforcing requirements.

COURSE CONTENT

SECONDARY CONTAINMENT STRUCTURES FOR HAZARDOUS MATERIALS/PETROLEUM-ANIMAL-VEGETABLE OILS

Spill containment structures and equipment should prevent spilled material from leaving an area by physically confining the material at the source, diverting it to containment, or returning it to the original area. Areas storing or handling oil that lack secondary containment are in violation of 40 CFR 112.7(c); areas storing or handling Hazardous Waste (HW) that lack secondary containment are in violation of 40 CFR 264 and 265; areas storing PCBs prior to disposal without secondary containment are in violation of 40 CFR 761.65; and Hazardous Substances (HS) areas without secondary containment are at risk of creating a spill that can contaminate the surrounding soil and waterways.

Design parameters for spill containment structures must be evaluated for compatibility with the type and volume of the material stored. These parameters include:

1. **Containment Capacity**
2. **Structural Strength**
3. **Impermeability or Hydraulic Conductivity**
4. **Structural Integrity**

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Secondary containment should be provided for all areas and equipment, regardless of the type(s) of structure(s) involved, having the potential for significant releases of oil to the environment (40 CFR 112.7(c)) and for HW tank systems and container storage areas (40 CFR 264.175, 264.193, and 265.193) and should be provided for areas storing HS. US EPA 40 CFR 280 requires secondary containment for USTs storing HS.

Oil areas with a reasonable potential creating of a spill that may impact navigable waters require secondary containment. Spills can impact navigable waters through spills direct discharge into a body of water, from discharge into storm sewers or ditches, or from spills that seep into the ground. All areas with a reasonable spill potential should be checked to determine if secondary containment is needed.

Spill containment structures and equipment must be designed, maintained, and operated properly to prevent discharged oil or HS from reaching a navigable waterway. Preferably, spills should be controlled by spill containment structures immediately adjacent to the potential spill source. However, if this is not possible due to site constraints, then diversionary structures (culverts, gutters, etc.) can direct spills to a remote impounding containment or treatment area. Holding or storage basins and ponds are typically used for remote secondary containment of large spills.

Spill containment structures include dikes, retaining walls, berms, curbs, catchment basins, quick drainage systems, trenches, retention ponds, double walled tanks, or a combination of these structures. Dikes and retaining walls are typically used with aboveground storage tanks; double-walled tanks are typically used for both aboveground and underground storage tanks. Curbs, berms, catchment basins and quick drainage systems are commonly used for loading/unloading areas. Gravity drainage to an oil-water separator can contain and collect relatively frequent but small oil spills in loading and dispensing areas.

40 CFR 112 also allows sorbents, drip pans, and booms to be used as containment systems. Sorbents and drip pans are commonly used to contain small spills around pumps, filters, valves, and other pieces of equipment. Booms can be placed at a storm water outlet as a precautionary measure to catch any oil before it enters a navigable waterway.

Releases from aboveground storage tanks (ASTs) may be classified into four broad categories:

- Shell Releases;
- Bottom Releases;
- Overfill; and
- Equipment/Appurtenances Leaks.

SECONDARY CONTAINMENT DIKE/BERMS DESIGN CONSIDERATIONS

Dikes, berms, and retaining walls are normally used in areas with the potential for large spills, such as single or multiple aboveground storage and processing tanks. Due to the limitations of concrete block walls, poured reinforced concrete walls are the preferred alternative. A reinforced poured concrete retaining wall can be used when the height needed for a containment wall exceeds the 3 to 4 foot height limitation of concrete block walls.

HW areas regulated by 40 CFR 264 or 265 and located in a 100-year flood plain must be designed to prevent washout of any HW. An exception can be made if the waste can be removed before floodwaters can reach the area. Furthermore, the HW regulations require sufficient freeboard to contain precipitation from a 25-year, 24-hour rainfall event.

A reinforced concrete retaining wall is used when space is not available for a dike. Retaining walls are usually constructed of either reinforced concrete blocks or reinforced poured concrete. Concrete block retaining walls have a few drawbacks:

- They have a height limitation of 3 or 4 feet, in order to withstand potential fluid loads.
- Settling separates the blocks and may even crack them, destroying the integrity of the containment wall.
- They require an epoxy coating due to the porosity of the blocks.
- Spalling of the mortar between the walls can destroy the liquid-tightness of the wall.

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The area within the dike should be sloped to carry drainage away from the tanks to a drain or sump located at the low point of the enclosure. Drainage from the sump to the outside of the enclosure should be controlled by a lock-type gate valve located outside of the enclosure and in a location that will be safely accessible during a fire. The drain valve should be normally closed and only be opened for draining water from the diked basin.

TRENCHES, RETENTION PONDS, AND SURFACE IMPOUNDMENTS

Secondary containment, such as dikes, is not always feasible; drainage trenches, culverts, sewers, swales, or gutters that direct a spill to a retention pond or catchment basin are acceptable alternatives. Closed systems, such as pipelines, should be used for volatile compounds rather than open drainage ditches. Drainage from undiked areas should, if possible, flow into retention areas designed to retain spills or return the material to activity property. Retention ponds and basins should not be located in flood plains or areas subject to flooding. Information regarding flood plains is available from the U.S. Geological Survey, the Corps of Engineers, or local government agencies.

Surface impoundments present significant potential for water and groundwater contamination due to seepage or overflow and must be properly designed. Also, leaks are difficult to detect and expensive to correct; therefore, RCRA requirements impose very strict design and operation standards. Surface impoundments can contain spills if the area is designed to treat the spilled material or collect it and return it to the area. If hazardous wastes are collected or treated in the surface impoundment, then the impoundment is strictly regulated under 40 CFR 264.220 (RCRA); surface impoundments also require a Part B Permit to operate.

Containment structures in an environmentally sensitive area may not always be the most practical means of spill containment. For example, the use of a diversion trench or depression to intercept spills from an aboveground pipeline rupture or a diversion trench that directs surface spills to a retention basin.

Trenches, drainage ditches, and sewers segregate stormwater run-off from chemical storage, transfer, process, and other areas to prevent commingling run-off. Diversion and drainage structures also segregate individual operations to contain spills and prevent incompatible mixing. The diversion trench can separate the drainage from the two tanks and minimizes the potential spill area associated with each tank. This is a recommended practice when several tanks are within one containment area, such as a tank farm.

DESIGN CAPACITY

The most widely accepted practice for sizing secondary containment is based on 40 CFR 112.7(e) which states that secondary containment should be sized to contain the volume of the largest single tank or container in the drainage area plus sufficient freeboard for precipitation. A recommended practice is to use 110% of the largest tank or container volume. Another practice is to use 100% of the largest tank or container plus a 24-hour, 10-year design storm. US EPA believes that the proper standard of ''sufficient freeboard'' to contain precipitation is that amount necessary to contain precipitation from a 25-year, 24-hour storm event. Using a 25-year design storm provides an extra margin of safety. However, final sizing for each particular application should be determined based on good engineering judgment.

Note that the volume displaced by all storage tanks and structures within the containment area must be subtracted from its gross holding capacity. In addition, the required height of the berm must include the additional height required to contain the design storm.

US EPA 40 CFR 264.221(g) requires HW surface impoundments to have dikes designed to prevent overflow from overfilling, wind and wave action, rainfall, run-on, malfunctions of level controllers, alarms and other equipment, and human error. A surface impoundment should have at least two (2) feet of freeboard. However, overflow can be prevented by controlling the filling rate of the impoundment and by providing a means of controlled releases during emergencies, such as overfilling due to rainfall. In addition, runoff control should be provided using dikes or diversion channels.

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STRUCTURAL STRENGTH

Spill control structures should withstand the fluid loads placed upon them by a full capacity spill and rainfall. A professional engineer should design these structures according to industry standards and other appropriate design standards. Poorly designed, constructed, or maintained dikes, particularly concrete blocks, may result in a failure.

Fluid density is a major consideration in the selection of secondary containment systems. Since some chemicals have triple the density, or more, of water, secondary containment structures should not be used indiscriminately for substances with greater than design densities.

Surface impoundment dikes must be designed, constructed, and maintained with sufficient structural integrity to prevent massive failure of the dikes (40 CFR 264.221 (h)). Cracks in the structure indicate poor structural strength and integrity. A spill control structure with insufficient structural strength could result in a massive failure (i.e., dike washed away by spill). Such areas should be retrofitted (strengthened or relieved by spill diversion systems or catch basins) or replaced based on a professional engineers recommendations.

Spill control structures should be structurally sound and free of cracks, holes, or other defects that could lead to a structural failure. Breached dike walls, cracked containment floors, unsealed penetrations, and damaged or nonexistent joint sealants are all indications of a breach in the structural integrity of a containment system. If a spill control structure is in poor condition and cannot adequately contain a spill, the structure should be repaired or replaced immediately. Any materials used in repairs should be compatible with and resistant to any potentially spilled material.

IMPERMEABILITY or is it PERMEABILITY?

Impermeable - A characteristic of some geologic material that limits its ability to transmit significant quantities of water under the head differences ordinarily found in the subsurface (ASCE-1985)

Intrinsic permeability of a medium is largely a function of the size of pores and the degree of interconnectivity. Its relative ease with which porous medium can transmit a fluid under a potential gradient, as a property of the medium itself. The soil intrinsic permeability is independent of the properties of the fluid flowing through the soil and has the dimensional units of $Lenght^2$. Clays have extremely low intrinsic permeability and are often used for a number of engineering purposes such as lining solid-waste disposal sites. The smaller the size of the individual grains, the larger the surface area of the medium providing resistance to flow. As the frictional resistance to flow increases, the intrinsic permeability of the medium reduces.

A Comparison of Saturated Hydraulic Conductivity and Intrinsic Permeability.

Saturated Hydraulic Conductivity (*Ks*)	Intrinsic Permeability (*k*)
Temperature Dependent	Temperature independent
Fluid viscosity dependent	Constant regardless of fluid viscosity, unless the liquid itself changes soil structure
Changes with change in structure	Changes with change in structure
Dimensions depend on flux and gradient; time is a component.	Dimensions are $length^2$ (cm^2), which is a unit of area; time is not a component

From USDA-NRCS: Skopp, J. 1994. Class notes: Physical concepts of soils. University of Nebraska, Lincoln, Nebraska.

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Both the dike and the bottom of secondary containment structures, retention ponds, and lagoons should be sufficiently impervious to contain and prevent seepage of the spillage until it can be removed or treated. Suitable liner materials include concrete, asphalt, synthetic membranes, reinforced air-blown cement mortar, clay soils, and specially treated bentonite/soil mixtures. The construction material must be suitable for the stored material (i.e. asphalt, will provide impermeable containment for heavier fuels, but not for lighter fuels such as jet fuels).

Earthen dikes shall be constructed of impervious clay or covered with a layer of such clay, concrete, or asphalt with rubberized coal tar sealer. The sides and top of the dike and the basin floor around the tank shall be covered with one of the following materials:

- **3 inches of impervious clay such as bentonite covered by 6 inches of sand and 8 inches of crushed stone.**
- **3 inches of concrete paving or air-blown cement mortar reinforced with woven wire fabric. Expansion and contraction joints shall be provided as necessary. Joint material shall be impervious to the fuel.**
- **2 inches of impervious asphalt with rubberized coal tar sealer over 4 inches of compacted base course.**

Drainage system can serve more than one storage tank. The drains shall be constructed of petroleum resistant impervious material. Legally the term impermeable refers to the containment of spills such that they do not reach navigable waters. The material that could potentially spill, needs to be evaluated in conjunction with the spill containment measures to see that a spill not reach navigable waters.

Poured reinforced concrete and asphalt are the most common materials used. Clays are commonly used to construct earthen dikes, due to their relatively impervious characteristics. The containment side of concrete blocks must be treated with sealers if not solid fill by concrete. Special epoxy coatings are sometimes used on floors, swales, and channels to provide chemical-resistant and impervious surfaces.

From the Steel Tank Institute (STI) <u>Standard for the Inspection of Aboveground Storage Tanks SP001</u>

STI Definition of Release prevention barrier (RPB) –"a liquid containment barrier that is sufficiently impervious to the liquid being stored and is installed under the AST. Its purpose is to divert leaks toward the perimeter of the AST where they can be easily detected as well as to prevent liquid from contaminating the environment. RPBs are composed of materials compatible with the liquid stored in the AST and meet proper engineering standards. Examples are steel (such as in steel double-bottom tanks), concrete, elastomeric liners, or other suitable materials provided the above criteria are met."

From American Concrete Institute (ACI) Manual, <u>Concrete Structures for Containment of Hazardous Materials</u>

"2.1—General

Concrete is particularly suitable for above-and below grade environmental primary and secondary containment systems. When properly designed and constructed, concrete containment systems are impermeable and highly resistant to failure during fires.

5.2—Coatings

When the material contained in the primary system is aggressive to concrete, a coating is appropriate.

From the Portland Cement Association manuals <u>Effects of Substances on Concrete and Guide to Protective Treatments" & "Fundamentals of Concrete</u>

Uncoated Concrete Technical Data: Permeability and Watertightness

"Concrete used in water-retaining structures or exposed to weather or other severe exposure conditions must be virtually impermeable or watertight. Watertightness is often referred to as the ability of concrete to hold back or retain water without visible leakage. Permeability refers to the amount of water migration through concrete when the water is under pressure or to the ability of concrete to resist penetration of water or other substances (liquid, gas, or ions). Generally, the same properties of concrete that make it less permeable also make it more watertight.

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The "permeability" hydraulic conductivity of mature hardened paste kept continuously moist ranges from 0.1 x 10^{-12} to 120 x 10^{-12} cm per sec. for water-cement ratios ranging from 0.3 to 0.7 (Powers and others 1954). The permeability of rock commonly used as concrete aggregate varies from approximately 1.7 x 10^{-9} to 3.5 x 10^{-13} cm per sec. The permeability of mature, good-quality concrete is approximately 1 x 10^{-10} cm per sec.

Test results obtained by subjecting 25-mm (1-in.) thick non-air entrained mortar disks to 140 kPa (20 psi) water pressure are given. In these tests, there was no water leakage through mortar disks that had a water-cement ratio of 0.50 by mass or less and were moist-cured for seven days. Where leakage occurred, it was greater in mortar disks made with high water-cement ratios. Also, for each water-cement ratio, leakage was less as the length of the moist-curing period increased. In disks with a water-cement ratio of 0.80, the mortar still permitted leakage after being moist-cured for one month. These results clearly show that a low water-cement ratio and a period of moist curing significantly reduce permeability."

From Effects of Substances on Concrete and Guide to Protective Treatments

All Petroleum Oils such as Gasoline, Kerosene, Diesel, Fuel Oils have no adverse effects on concrete. However, it is recommended that if the concrete is used for the primary tank, (not secondary containment or RPB) that surface treatments be generally used.
"Proper maintenance—including regularly scheduled cleaning or sweeping, and immediate removal of spilled materials—is a simple way to maximize the useful service life of both coated and uncoated concrete surfaces."

From Marks Standard Handbook for Mechanical Engineers (ninth edition)

Page 6-185, "Watertightness: "Concrete can be made practically impervious to water by proper proportioning, mixing and placing."

US EPA regulation 40 CFR part-112.7 (l) & (h) generally requires the following secondary containment systems or their equivalents for Bulk Tanks, Loading & Unloading Racks and Piping Systems: Dikes, berms, retaining walls, curbing, culverting, gutters, weirs, booms, spill diversion ponds, impounding basins, or sumps, and sorbents to be sufficiently impervious.

From US EPA Ombudsman memorandum of August 14, 2002, regarding Sufficiently Impervious. "Dikes, berms or retaining walls must be sufficiently impervious to contain oil. The purpose of secondary containment is to contain oil from escaping the facility and reaching the environment. An owner or operator of a facility should have flexibility in how he prevents a discharge as described in §112.1(b) and any method of containment which achieves that end is sufficient. Similarly, because the purpose of the "sufficiently impervious" standard is to prevent discharges as described in §112.1(b), dikes, berms, remote impounding or retaining walls must be capable of containing oil and preventing such discharges. Discharges as described in §112.1(b) may result from direct discharges from containers, or from discharges from containers to groundwater that travel through the groundwater to navigable waters. Effective containment means that the dike, berm, or retaining wall must be capable of containing oil and sufficiently impervious to prevent discharges from the containment system until it is cleaned up. The same holds true for containment floors or bottoms; they must be able to contain oil to prevent a discharge as described in §112.1(b). However, "effective containment" does not mean that liners are required for secondary containment areas. Liners are an option for meeting the secondary containment requirements, but are not required by the rule." (End)

Use Hydraulic Conductivity readings that are site specific: i.e. 0.01 gallons/day/square foot The reading indicates that for a 1000 sq. ft. dike it would leak 10 gallons per day or total of 30 gallons in 72 hours. Engineered Compacted Clays, Concrete, Liners/Membranes may meet this requirement.

Consider that uncoated concrete is impermeable. *Has an average permeability of 1 x 10^{-10} cm per sec, or put another way, approximately 2.1 x 10^{-6} gallons per day per square foot (water). *For a 1,000 square foot dike this equates to a permeability rate of 0.0021 gallons per day. Using engineering calculations (Darcy's Law), we could calculate the amount of gasoline that could penetrate into the

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concrete and at what depth this would be over time, from a full tank that is 30 feet high. This would not change the outcome substantially from water.

HYDRAULIC CONDUCTIVITY CALCULATIONS/FORMULAS

In the mid-1800s the French engineer Henry Darcy successfully quantified several factors controlling ground water movement. One of these-Hydraulic conductivity is the systematic movement of water from pore to pore. This is different from a medium's permeability. The hydraulic conductivity of a soil is a measure of the soil's ability to transmit water when submitted to a hydraulic gradient. Hydraulic conductivity is defined by Darcy's law.

The US DOE 10 CFR. §960.2 Title 10 – Energy PART 960—GENERAL GUIDELINES FOR THE PRELIMINARY SCREENING OF POTENTIAL SITES FOR A NUCLEAR WASTE REPOSITORY Defines Hydraulic Conductivity as: "*means the volume of water that will move through a medium in a unit of time under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow.*"

The hydraulic conductivity depends on the soil grain size, the structure of the soil matrix, the type of soil fluid, and the relative amount of soil fluid (saturation) present in the soil matrix. The important properties relevant to the solid matrix of the soil include pore size distribution, pore shape, tortuosity, specific surface, and porosity. In relation to the soil fluid, the important properties include fluid density, and fluid viscosity. For a subsurface system saturated with the soil fluid, the hydraulic conductivity, *K*, can be expressed as follows:

$$K = ((k) \times (\rho) \times (g)) / (\mu)$$

The hydraulic conductivity, *K*, is expressed in terms of length per unit of time usually in meters/second (English units in gals/day/ft^2). Where *k*, (meters^2) the intrinsic permeability of the soil, depends only on properties of the solid matrix, and *g*, (meters/second^2) is the acceleration due to gravity. With μ is dynamic viscosity in kilograms/(meter-second). Density of the fluid (ρ) is measure in kilograms/meter^3.

Lab testing must be in accordance with ASTM D5856 – 95 (2007) Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mold Permeameter may be used with laboratory-compacted specimens that have a hydraulic conductivity less than or equal to 1 x 10^{-5} m/s. The hydraulic conductivity of compacted materials that have hydraulic conductivities greater than 1 x 10^{-5} m/s may be determined by Test Method D 2434.

Typical values for the hydraulic conductivity of various unconsolidated deposits and rocks

Type of material	**K (m/day)*	**K (gal./day/ft^2)*
Unconsolidated deposits		
Gravel	*1000*	*24,500*
Clean sand	*100*	*2,450*
Silty sand	*10*	*245*
Silt Loess	*1*	*24.5*
Glacial till	*0.1*	*2.45*
Unweathered marine clay	*0.001*	*0.0245*
Shale-Compacted clay	*0.0001*	*0.00245*
Rocks		
Karst limestone	*1000*	*24,500*

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Permeable basalt	*100*	*2,450*
Fractured igneous and metamorphic rocks	*100*	*2,450*
Limestone and dolomite without karst	*10*	*245*
Sandstone without fractures	*10*	*245*
Unfractured igneous and metamorphic rocks	*0.00001*	*0.000245*
Uncracked/Uncoated Concrete (approximately 0.1 x 10^{-10} cm per sec.)	*8.64 x 10^{-11}*	*2.12 x 10^{-9}*
100% Compacted Bentonites	*1x 10^{-10}*	*2.45 x 10^{-9}*

These are range valves. Exact Soil/Rock/Man Made Liners must be used to determine Hydraulic Conductivity. Most regulatory agencies in the United States require that the hydraulic conductivity of clay liners be less than or equal to 1 x 10^{-9} m/s or 0.00212gal./day/ft^2.

US EPA online conversion calculator for Hydraulic Conductivity units: http://www.epa.gov/athens/learn2model/part-two/onsite/conductivity.html

FROM US EPA SPCC GUIDANCE Chapter 4- SECONDARY CONTAINMENT AND IMPRACTICABILITY DETERMINATIONS

4.2.8 "Sufficiently Impervious"

Section 112.7(c) states that the entire secondary containment system, "including walls and floor, must be capable of containing oil and must be constructed so that any discharge from a primary containment system will not escape containment before cleanup occurs." With respect to bulk storage containers at onshore facilities (except production facilities), §§112.8(c)(2) and 112.12(c)(2) state that diked areas must be "sufficiently impervious to contain oil." The purpose of the secondary containment requirement is to prevent discharges as described in §112.1(b); therefore, effective secondary containment methods must be able to contain oil until the oil is cleaned up. EPA does not specify permeability or retention time performance criteria for these provisions. Instead, EPA gives the owner/operator and the certifying PE flexibility in determining how best to design the containment system to prevent a discharge as described in §112.1(b). This determination is based on a good engineering practice evaluation of the facility configuration, product properties, and other site-specific conditions.

For example, EPA believes that a sufficiently impervious retaining wall, or dike/berm, including the walls and floors, must be constructed so that any discharge from a primary containment system will not escape the secondary containment system before cleanup occurs and before the discharge reaches navigable waters and adjoining shorelines (§§112.7(c), 112.8(c)(2) and 112.12(c)(2)). Ultimately, the determination of imperviousness should be verified by the certifying PE.

The preamble to the 2002 SPCC rule states that "a complete description of how secondary containment is designed, implemented, and maintained to meet the standard of sufficiently impervious is necessary" (67 FR 47102). Therefore, pursuant to §112.7(a)(3)(iii) and (c), the Plan should address how the secondary containment is designed to effectively contain oil until it is cleaned up. Control and/or removal of vegetation may be necessary to maintain the imperviousness of the secondary containment and to allow for the visual detection of discharges. The owner or operator should monitor the conditions of the secondary containment structure to ensure that it remains impervious to oil. Repairs of excavations or other penetrations through secondary containment need to be conducted in accordance with good engineering practice.

The earthen floor of a secondary containment system may be considered "capable of containing oil" until cleanup occurs, or "sufficiently impervious" under §§112.7(c), 112.8(c)(2), and 112.12(c)(2), respectively, if there is no subsurface conduit to navigable waters allowing the oil to reach navigable waters before it is cleaned up. Should oil reach navigable waters or adjoining shorelines, it is a reportable discharge under 40 CFR part 110. The suitability of earthen material for secondary containment systems may depend on the properties of both the product stored and the soil. For example, compacted local soil may be suitable to contain a viscous product, such as liquid asphalt cement, but may not be suitable to contain gasoline. Permeability through the wall (or wall-to-floor interface) of the structure may result in an immediate discharge as described in §112.1(b).

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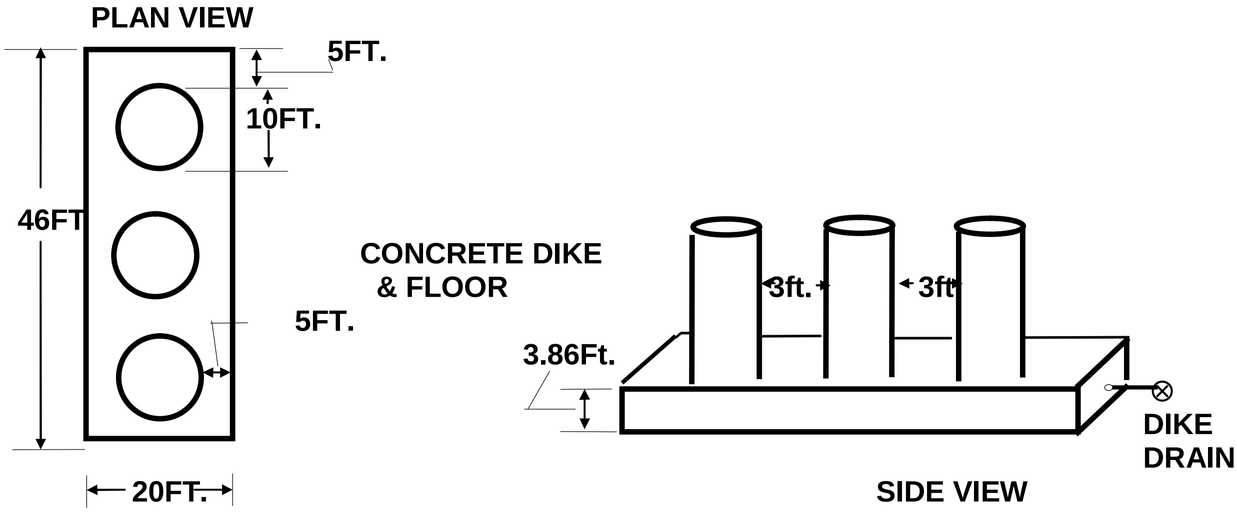
SECONDARY CONTAINMENT VOLUME REQUIREMENTS FOR ASTs

The US EPA has established regulations requiring spill prevention and control for aboveground storage tanks greater than gallons or two tanks with total capacity greater than 1320 gallons. The IFC/NFPA Fire Code requires secondary containment for ASTs greater than 60 gallons. Secondary containment can be dikes, berms, remote impounding or other various means. Dikes and berms must hold the single largest tank plus 10 percent for rainwater allowances. Another design criterion that can be used is the single largest tank plus the freeboard allowance factor. The freeboard allowance is typically the minimum dike wall height to contain the single largest tank volume plus 6 inches. The dikes floors are required to be coated, lined or have impermeable earth to prevent seepage.



Consider the above drawing and example dike volume design procedure. We have three 20,000 gal. vertical tanks. Tanks are 10 Ft. in Diameter with a radius of 5 Ft., 5 Ft. from dike walls and 3 Ft. from each other. For our example we will add ten percent to the single largest tank which would equal 22,000 gals. Convert gallons to cubic feet by dividing gallons by 7.48 gals./cubic Ft. Therefore, 22,000 gals. ÷ 7.48 = 2942 Cubic Feet. The minimum area of the pad is 20 Ft. X 46 Ft. = 920 Square Feet. The other two tanks must be taken into consideration for their displacement area by calculating π X radius squared X 2 tanks. Therefore, 3.14 X 5^2 X 2 = 157 $Ft.^2$ Net dike available area, 920 $Ft.^2$ - 157 $Ft.^2$ = 763 $Ft.^2$ To determine dike wall height, divide 2942 $Ft.^3$ by 763 $Ft.^2$ = 3.86 Ft. or 3 Ft. 11 inches high.

Tanks should be kept at a minimum of 3 feet from the toe of the dike wall. Calculations for horizontal tanks would follow the same procedure. <u>Horizontal tank ends must be kept a minimum of 3 feet inside dike wall</u>. For one tank only, use dike length X dike width X dike height = cubic feet, then convert to gallons to match minimum volume needed.

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CONSTRUCTION MATERIALS USED FOR SECONDARY CONTAINMENT STRUCTURES

Material	Permeability	Resistance to Erosion-Weathering	Resistance to Vegetation	Strength	Chemical Compatibility	Maintenance Requirements	Costs
1.Earthen Dikes							
Natural Soils	**H**	**L**	**L**	**L/M**	**H**	**H**	**L**
Clay Core	**L**	**L**	**L**	**M**	**H**	**M**	**L**
Clay Cap/Cover	**L**	**M**	**L**	**M**	**H**	**H**	**M**
Asphalt Cover	**L**	**H**	**H**	**M**	**L/H**	**M**	**M**
Synthetic Membrane	**L**	**M**	**M**	**M**	**H**	**M**	**M**
Cement Mortar Cover	**L**	**H**	**H**	**M**	**H**	**L**	**H**
2. Reinforced Concrete Dikes	**L**	**H**	**H**	**H**	**H**	**L**	**H**
3. Concrete Block Dikes	**M/H**	**H**	**H**	**M**	**M**	**L**	**M**
H= High, M= Medium, L = Low							

(FROM US NAVY)

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Comparison of Various Synthetic Polymeric Membranes (FROM US NAVY)

Liner Type	Advantages	Disadvantages	Relative Cost
Polyvinyl Chloride (PVC)	Good resistance to ozone and ultraviolet light when properly stabilized	Good resistance to puncture, abrasion, and microbial activity High tensile strength, Poor resistance to hydrocarbons, solvents, and oils; May deteriorate in presence of certain chemicals and in contact with heat	Low
Oil-Resistant PVC	Improved resistance to aromatic hydrocarbons relative to standard grades of PVC	Poor low temperature handling properties	Moderate to high
Polyethylene	Excellent resistance to bacterial Deterioration; Good tensile strength; Few restrictions on chemical exposure Good low-temperature characteristics	Poor puncture resistance Poor tear strength Susceptible to weathering and stress cracking	Low
Chlorinate Polyethylene (CPE)	Excellent weatherability; Good tensile and elongation strength Good resistance to ultraviolet light and ozone; Excellent crack and impact resistance at low temperatures; Moderate to good hydrocarbon resistance Resistant to acids and bases	Limited range of tolerance for chemicals, oils, and solvents Low recovery when subject to tensile stress	Moderate
Butyl Rubber	High tolerance for temperature Extremes; Good tensile and shear strength; Good resistance to puncture; Ages well in general, but some compounds will crack on ozone exposure	Slightly affected by oxygenated solvents and other polar liquids Poor sealability and workability	
Neoprene	Excellent aging and weathering characteristics Overall good resistance to hydrocarbons, but shows some swell when exposed to aromatics and other cyclic hydrocarbons Flexible and elastic over a wide range of temperatures	Not heat- or solvent-sealable	High
Elasticized Polyolefin (DuPont 3110)	Resistant to ultraviolet light; does not require earth cover; Good resistance to weathering and aging; Good resistance to ozone attack and soil microorganisms; Good resistance to hydrocarbons: will accommodate a broad range of solvents	Relatively untested Vulnerable at low temperatures	Moderate

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Comparison of Various Synthetic Polymeric Membranes (FROM US NAVY)

Liner Type	Advantages	Disadvantages	Relative Cost
Chlorosulfonated Polyethylene (CSPC or Hypalon)	Good puncture resistance Good resistance to microbial attack Excellent resistance to low temperature cracking Excellent weather resistance Good resistance to ozone and ultraviolet light Flexible and resilient	Low tensile strength Poor resistance to aromatic hydrocarbons	
Ethylene Propylene Diene Monomer (EPDM)	Good weathering characteristics Good temperature flexibility Good heat and ultraviolet light resistance Resistant to mildew, mold, and fungus Excellent resistance to water vapor transmission	Low peel and shear strength Not recommended for petroleum, aromatic, or halogenated solvents Resistant only to dilute acids and alkalis	
Butyl Rubber	Excellent resistance to water Excellent resistance to ultraviolet light and ozone	Poor resistance to hydrocarbons, particularly petroleum solvents, aromatics, and halogenated solvents	Moderate to high
Epichlorohydrin Rubbers	Resistant to hydrocarbon solvents, fuels, and oils Resistant to ozone and weathering High tolerance for temperature extremes Good tensile and tear strength	Permeable to gas and water vapor	Moderate

REGULATORY REQUIREMENTS:

1) US EPA SPILL PREVENTION CONTROL AND COUNTERMEASURE PLAN (SPCC PLAN) Federal Regulation 40 CFR Part 112, Dated July 17, 2002

Applies to all aboveground tanks (ASTs) containing *oils* that if spilled or leaked could reasonably affect navigable waters of the United States. Any single AST greater than 1,320 gallons or any aggregated capacity greater than 1,320 gals. (see rule for exclusions/details) must have secondary containment.

§112.2 *Oil* means oil of any kind or in any form, including, but not limited to: fats, oils, or greases of animal, fish, or marine mammal origin; vegetable oils, including oils from seeds, nuts, fruits, or kernels; and, other oils and greases, including petroleum, fuel oil, sludge, synthetic oils, mineral oils, oil refuse, or oil mixed with wastes other than dredged spoil.

The U.S. Coast Guard (USCG) compiled a list of substances it considers oil, based on the CWA definition. The list is available on the USCG Web site at http://www.uscg.mil/vrp/faq/oil.shtml Note, however, that the USCG list is not comprehensive and does not define "oil" for purposes of 40 CFR part 112. EPA may determine that a substance, chemical, material, or mixture is an oil even if it is not on the USCG list.

EPA interprets the Clean Water Act definition of oil to include non-petroleum oils as well as petroleum and petroleum-refined products. Non-petroleum oils include synthetic oils, such as silicone fluids, tung oils, milk and wood-derivative oils, such as resin/rosin oils, animal fats and oil, and edible and inedible seed oils from plants. Many non-petroleum oils have similar physical properties as petroleum-based oils; for example, their solubility in water is limited, they both create slicks on the surface of water,

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and they both form emulsions and sludge's. In addition, non-petroleum oils tend to be persistent, remaining in the environment for long periods of time.

§112.7 (c) Provide appropriate containment and/or diversionary structures or equipment to prevent a discharge as described in §112.1(b), except as provided in paragraph (k) of this section for qualified oil-filled operational equipment, and except as provided in §112.9(d)(3) for flowlines and intra-facility gathering lines at an oil production facility. The entire containment system, including walls and floor, must be capable of containing oil and must be constructed so that any discharge from a primary containment system, such as a tank, will not escape the containment system before cleanup occurs. In determining the method, design, and capacity for secondary containment, you need only to address the typical failure mode, and the most likely quantity of oil that would be discharged. Secondary containment may be either active or passive in design. At a minimum, you must use one of the following prevention systems or its equivalent:
(1) For onshore facilities:
(i) Dikes, berms, or retaining walls sufficiently impervious to contain oil;
(ii) Curbing or drip pans;
(iii) Sumps and collection systems;
(iv) Culverting, gutters, or other drainage systems;
(v) Weirs, booms, or other barriers;
(vi) Spill diversion ponds;
(vii) Retention ponds; or
(viii) Sorbent materials.
(2) For offshore facilities:
(i) Curbing or drip pans; or
(ii) Sumps and collection systems.

112.8(a) Meet the general requirements for the Plan listed under § 112.7, and the specific discharge prevention and containment procedures listed in this section.

112.8(b) Facility drainage. (1) Restrain drainage from diked storage areas by valves to prevent a discharge into the drainage system or facility effluent treatment system, except where facility systems are designed to control such discharge. You may empty diked areas by pumps or ejectors; however, you must manually activate these pumps or ejectors and must inspect the condition of the accumulation before starting, to ensure no oil will be discharged.
112.8(c) Bulk storage containers. (1) Not use a container for the storage of oil unless its material and construction are compatible with the material stored and conditions of storage such as pressure and temperature.

2) US EPA Title 40: Protection of Environment 264—STANDARDS FOR OWNERS AND OPERATORS OF HAZARDOUS WASTE TREATMENT, STORAGE, AND DISPOSAL FACILITIES

§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: (Same as §265.193)

3) US EPA Title 40: Protection of Environment PART 265—INTERIM STATUS STANDARDS FOR OWNERS AND OPERATORS OF HAZARDOUS WASTE TREATMENT, STORAGE, AND DISPOSAL FACILITIES

§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):

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(1) For all new and existing tank systems or components, prior to their being put into service.
(2) For tank systems that store or treat materials that become hazardous wastes, within two years of the hazardous waste listing, or when the tank system has reached 15 years of age, whichever comes later.
(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;

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(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 §261.21 of this chapter; or
(B) Meets the definition of reactive waste under §261.23 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 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 hydrogeology 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:

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(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

4) US EPA PART 761—POLYCHLORINATED BIPHENYLS (PCBs) MANUFACTURING, PROCESSING, DISTRIBUTION IN COMMERCE, AND USE PROHIBITIONS

§761.65 Storage for disposal. This section applies to the storage for disposal of PCBs at concentrations of 50 ppm or greater and PCB Items with PCB concentrations of 50 ppm or greater.

5) OCCUPATIONAL SAFETY AND HEALTH STANDARDS (OHSA)• SUBPART: H • SUBPART TITLE: HAZARDOUS MATERIALS, FLAMMABLE AND COMBUSTIBLE LIQUIDS OSHA 1910.106-

1910.106(b)(2)(vii)(c)
"Diked areas." Where protection of adjoining property or waterways is accomplished by retaining the liquid around the tank by means of a dike, the volume of the diked area shall comply with the following requirements:
1910.106(b)(2)(vii)(c)(1)
Except as provided in subdivision (2) of this subdivision, the volumetric capacity of the diked area shall not be less than the greatest amount of liquid that can be released from the largest tank within the diked area, assuming a full tank. The capacity of the diked area enclosing more than one tank shall be calculated by deducting the volume of the tanks other than the largest tank below the height of the dike.
1910.106(b)(2)(vii)(c)(2)
For a tank or group of tanks with fixed roofs containing crude petroleum with boilover characteristics, the volumetric capacity of the diked area shall be not less than the capacity of the largest tank served by the enclosure, assuming a full tank. The capacity of the diked enclosure shall be calculated by deducting the volume below the height of the dike of all tanks within the enclosure.
1910.106(b)(2)(vii)(c)(3)
Walls of the diked area shall be of earth, steel, concrete or solid masonry designed to be liquid tight and to withstand a full hydrostatic head. Earthen walls 3 feet or more in height shall have a flat section at the top not less than 2 feet wide. The slope of an earthen wall shall be consistent with the angle of repose of the material of which the wall is constructed.
1910.106(b)(2)(vii)(c)(4)

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The walls of the diked area shall be restricted to an average height of 6 feet above interior grade.
1910.106(b)(2)(vii)(c)(5)
[Reserved]
1910.106(b)(2)(vii)(c)(6)
No loose combustible material, empty or full drum or barrel, shall be permitted within the diked area.

OHSA CONFINED SPACE ENTRY PROGRAM

Many companies may be using contractors at your AST facilities to meet the new EPA SPCC regulations to integrity test tanks. Host Employee must ensure that OHSA Confined Space Entry Program is properly conducted by your subcontractors. Under Federal Regulation 29 CFR 1910.146(a) "Confined space" means a space that: (1) Is large enough and so configured that an employee can bodily enter and perform assigned work; and (2) Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry.); and (3) Is not designed for continuous employee occupancy. All dikes, berms, and remote impounding areas that are used for petroleum/HW/HS secondary containment and that have walls over 4 feet in height are consider OHSA Confined Spaces.
1910.146(c)(1) The employer shall evaluate the workplace to determine if any spaces are permit-required confined spaces.

For a complete review of the regulations go to the below web site:
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9797

6) **National Fire Protection Association (NFPA) Pamphlet #30 Flammable & Combustible Liquids Code. Requires Secondary Containment for Flammable and Combustible Liquids.**

7) **International Building/Fire Codes (2009)**

3404.2.10 Drainage and diking.
The area surrounding a tank or group of tanks shall be provided with drainage control or shall be diked to prevent accidental discharge of liquid from endangering adjacent tanks, adjoining property or reaching waterways.
Exceptions:
1. The code official is authorized to alter or waive these requirements based on a technical report which demonstrates that such tank or group of tanks does not constitute a hazard to other tanks, waterways or adjoining property, after consideration of special features such as topographical conditions, nature of occupancy and proximity to buildings on the same or adjacent property, capacity, and construction of proposed tanks and character of liquids to be stored, and nature and quantity of private and public fire protection provided.
2. Drainage control and diking is not required for listed secondary containment tanks.

3404.2.10.1 Volumetric capacity.
The volumetric capacity of the diked area shall not be less than the greatest amount of liquid that can be released from the largest tank within the diked area. The capacity of the diked area enclosing more than one tank shall be calculated by deducting the volume of the tanks other than the largest tank below the height of the dike.

3404.2.10.2 Diked areas containing two or more tanks.
Diked areas containing two or more tanks shall be subdivided in accordance with NFPA 30.

Protection of piping from exposure fires.
3404.2.10.3 Piping shall not pass through adjacent diked areas or impounding basins, unless provided with a sealed sleeve or otherwise protected from exposure to fire.

3404.2.10.4 Combustible materials in diked areas.
Diked areas shall be kept free from combustible materials, drums and barrels.

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3404.2.10.5 Equipment, controls and piping in diked areas.

Pumps, manifolds and fire protection equipment or controls shall not be located within diked areas or drainage basins or in a location where such equipment and controls would be endangered by fire in the diked area or drainage basin. Piping above ground shall be minimized and located as close as practical to the shell of the tank in diked areas or drainage basins.

Exceptions:

1. Pumps, manifolds and piping integral to the tanks or equipment being served which is protected by intermediate diking, beams, drainage or fire protection such as water spray, monitors or resistive coating.

2. Fire protection equipment or controls which are appurtenances to the tanks or equipment being protected, such as foam chambers or foam piping and water or foam monitors and hydrants, or hand and wheeled extinguishers.

INDUSTRY STANDARDS

8) American Concrete Institute -ACI 350.2R-04 Concrete Structures for Containment of Hazardous Materials

Web site: http://www.concrete.org/general/home.asp

"This report is intended for use in the structural design and construction of hazardous material containment systems. Hazardous material containment structures require secondary containment and, sometimes, leak-detection systems. Because of the economic and environmental impact of even small amounts of leakage of hazardous materials, both primary and secondary containment systems should be virtually leak free. Therefore, when primary or secondary containment systems involve concrete, special design and construction techniques are required."

Concrete pad shall be constructed in accordance with Chapter 19 of the IBC Building Code and the American Concrete Institute. Petroleum Secondary Containment Dike shall be in compliance with the applicable requirements of US EPA 40 CFR Part 112 (2002), National Fire Protection Association Pamphlet (NFPA) #30, and/or OSHA 29 CFR Part 1910.106. The reference regulations require the dike to be "liquid tight" or "sufficiently impervious". The dike floor must be sufficiently impervious to hold the spilled petroleum until clean up begins. Typically, although not mandated, the dike must hold the petroleum for a minimum of 72 hours.

New dike floor shall slope to dike discharge drain. Dike discharge drain should be lockable.

Notes from Concrete Structures for Containment of Hazardous Materials American Concrete Institute (ACI) 350.2R-04.

2.1…The addition of pozzolans, latex, and polymer modifierscan increase concrete's resistance to chemical attack…

2.2…A minimum slope of 2% should be included in the design of floors and trench bottoms to prevent ponding and help drainage. Secondary containment systems for flammable and combustible liquids should have a slope that is in accordance with NFPA 30, "Flammable and Combustible Liquids Code," or an applicable fire code…

2.2.3 Footings—Footings should be cast on top of, or monolithically with, the floor slab to enhance liquid tightness. Upturned footings help reduce restraint of shrinkage and its associated cracking.

3.1—Waterstops 3.1.1 *General*—Waterstops should be provided at expansion/contraction joints and where construction joints cannot be avoided. Waterstops are positioned in concrete joints to prevent the passage of liquid through the joint. Mechanical joints may be considered for repairing an existing joint.

3.2—Joint sealants: 3.2.1 *General*— Provide joints with chemically resistant sealants. See ACI 504R for additional information on sealing joints. Sealants are generally applied in liquid or semiliquid form, and are thus formed into the required shape within the mold provided at the joint opening. The

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manufacturer's recommendations and applications for use should be thoroughly explored for each specific application of a sealant. ACI 504R provides additional information on joint sealants.

4.2.1 Curing—Curing is one of the most important operations in reinforced concrete construction. Without proper curing, even the best-designed reinforced concrete develops surface cracks. Refer to ACI 308R and ACI 308.1 for a complete description of curing procedures.

5.1—Liners; Liners can function as either the primary or secondary containment, depending upon the type of installation and the location of the liner within the installation. A liner should exhibit good chemical resistance to deterioration and compatibility with the hazardous material. Many different types of liner materials can be used.

5.2—Coatings; When the material contained in the primary system is aggressive to concrete, a coating is appropriate. Secondary containment systems can also require a coating in areas where piping connections and disconnections are frequently made or when required by the applicable environmental authority. Coating systems include materials such as paints, mortars, liquefied rubbers, and resins.

6.1—General; A secondary containment system should prevent any primary containment leak from escaping to the environment. The secondary containment system should either retain such a leak until it is removed or should direct the leaked material to a predetermined and controllable drainage channel or sump. Secondary containment systems are normally dry in service. These systems include chemical tank farms, truck unloading stations, sumps, drumming rooms, apron slabs, trenches, and other areas where hazardous materials are handled or transferred.
(END ACI -350 REFERENCES)

9) USDA's Natural Resources Conservation Service (NRCS) Conservation Practice Standards Agricultural Secondary Containment Facility Code 710 & Waste Storage Facility Code 313

Web site: http://www.nrcs.usda.gov/

An agricultural secondary containment facility is a permanently located above ground facility designed to provide secondary containment of on-farm oil products.

10) Northern New England Concrete Promotion Association, 50 Market Street, Suite 1-A #221 South Portland, ME 04106, Phone (888)875-3232, web: www.nnecpa.org

11) Petroleum Equipment Institute (PEI), P. O. Box 2380, Tulsa, OK 74101-2380
Phone 918-494-9696, web site: http://www.pei.org/

Recommended Practices for Installation of Bulk Storage Plants (PEI/RP800-08) provides a basic reference that consolidates published and unpublished information from equipment manufacturers, contractors, installers, bulk-plant facility owners and regulators describing recommended practices for the construction of new petroleum bulk-storage systems.
The document applies to underground, aboveground, atmospheric and shop-fabricated tanks, associated piping, diking, spill containment, equipment intended for the bulk storage and transfer of petroleum, biofuels, and related products to and from wheeled delivery vehicle tanks. The recommended practices apply to single- and double-walled horizontal and vertical tanks, as well as insulated and fire-protected (resistant) tanks.

12) Steel Tank Institutes (STI) Standard for "Inspection of In-Service Shop Fabricated Aboveground Tanks for Storage of Combustible & Flammable Liquids" SP001 for testing

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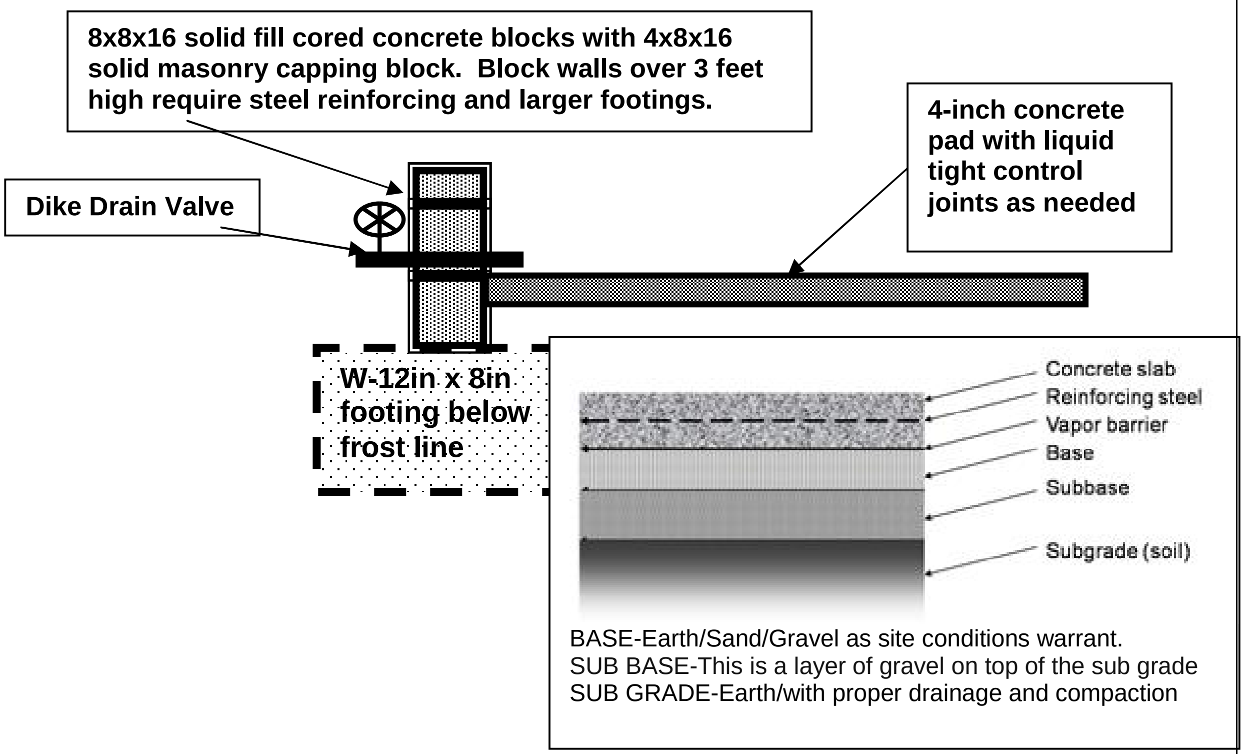
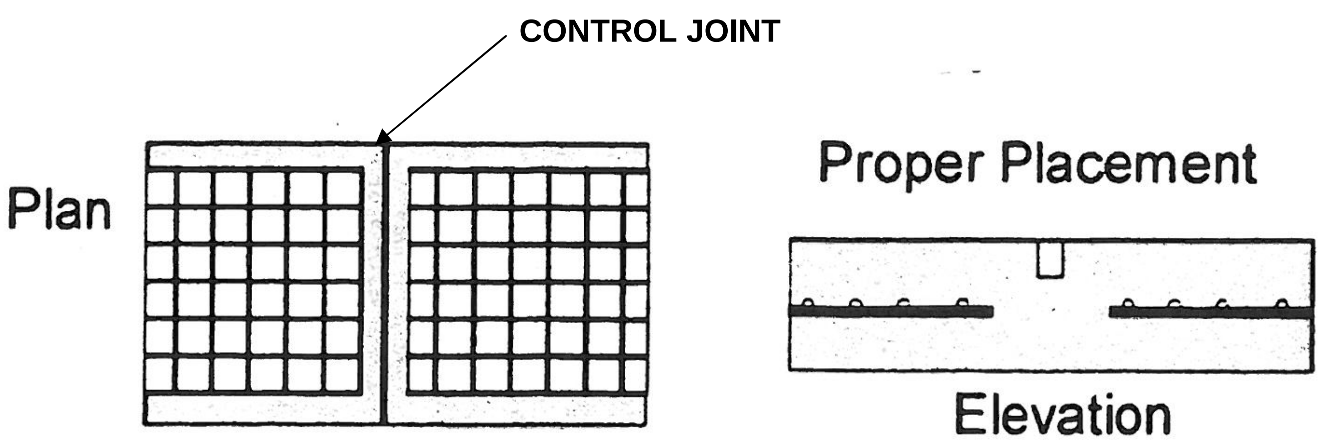
and inspection standards. For a copy contact STI, 570 Oakwood Road, Lake Zurich, IL 60047, phone-847/438-8265, Web site: www.steeltank.com.

Typical Solid Fill Masonry Dike Wall and Concrete Floor/Wall Details:





WELDED WIRE FABRIC DETAIL (WWF)

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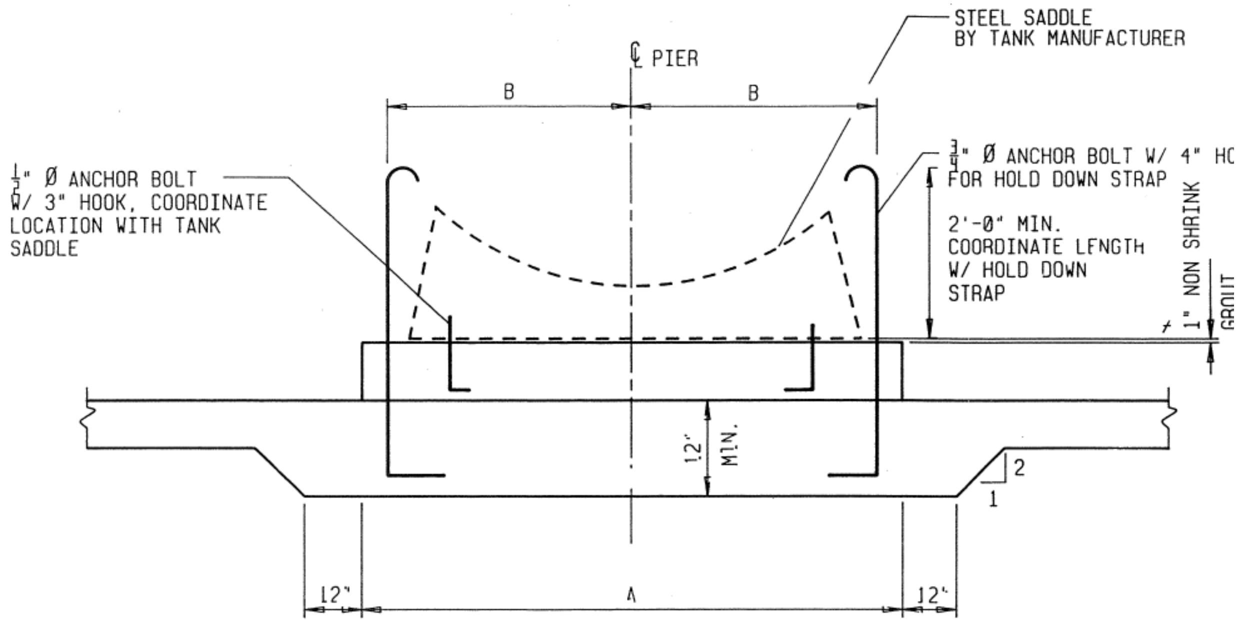
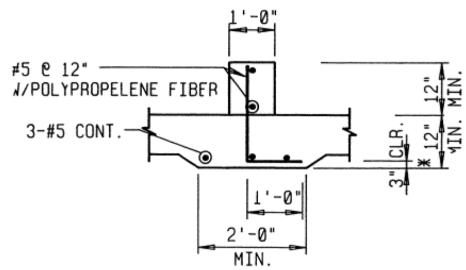
CONCRETE PIER DETAILS (HORIZONTAL TANK)



* NOTE: TOP OF PIER SHALL BE SMOOTH AND LEVEL AND FULLY SUPPORT TANK SADDLE. WHEN TOP OF PIER IS NOT LEVEL OR SMOOTH PROVIDE A MINIMUM OF 1 INCH OF NON-SHRINK GROUT BELOW TANK SADDLE

PIER ELEVATION
SCALE: ½" = 1'-0"



PIER DETAIL
SCALE: ½" = 1'-0"

* - NOTE: THICKENED SLAB REQUIRED BELOW PIER FOR DIKE FLOOR LESS THAN 12 INCHES THICK

PIER DATA TABLE

TANK SIZE (GAL.)	MIN. NO OF PIERS	TYPICAL SADDLE DIMENSIONS		PIER LENGTH A	B	MAXIMUM CENTER TO CENTER SPACING OF PIERS
		LENGTH	WIDTH			
4,000	2	4'-6"	4"	6'-0"	2'-9"	10'-0"
6,000	2	7'-0"	6"	8'-6"	4'-1"	10'-10"
8,000	2	7'-0"	6"	8'-6"	4'-1"	14'-3¾"
10,000	3	7'-0"	6"	8'-6"	4'-1"	11'-3"

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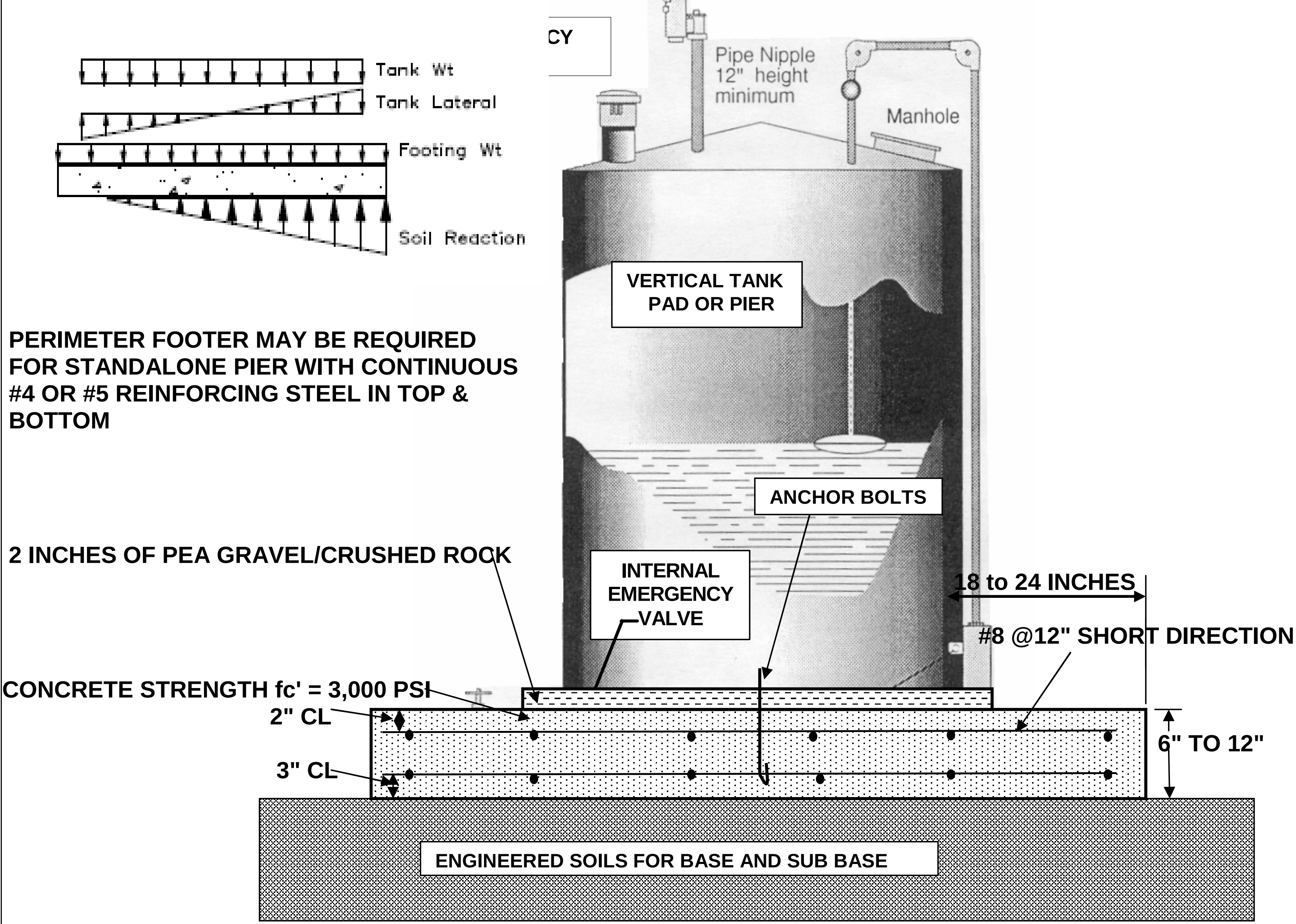
VERTICAL TANK FREE BODY DIAGRAM



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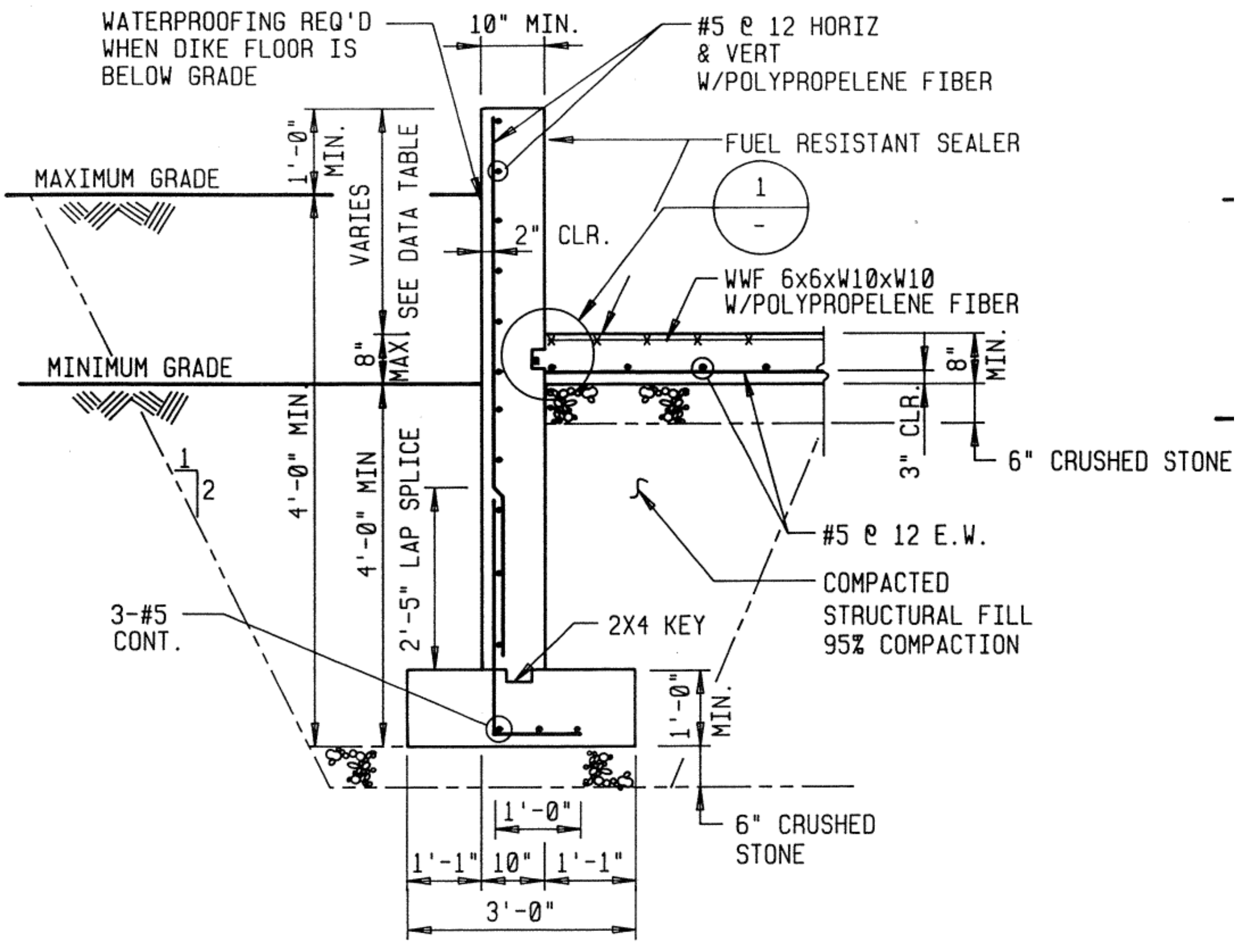
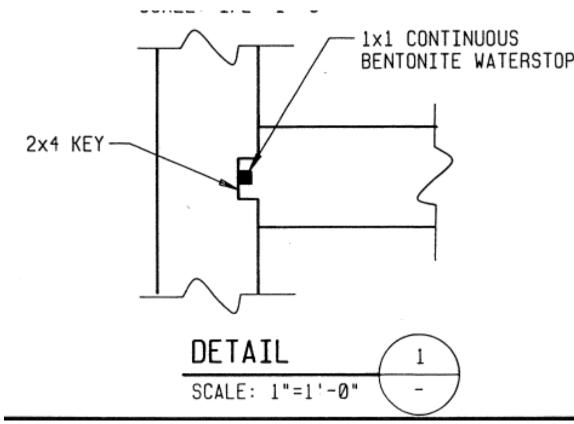
POUR IN PLACE DIKE WALL AND FLOOR



FROST WALL FOUNDATION SECTION

SCALE: 1/2"=1'-0"



DETAIL

SCALE: 1"=1'-0"

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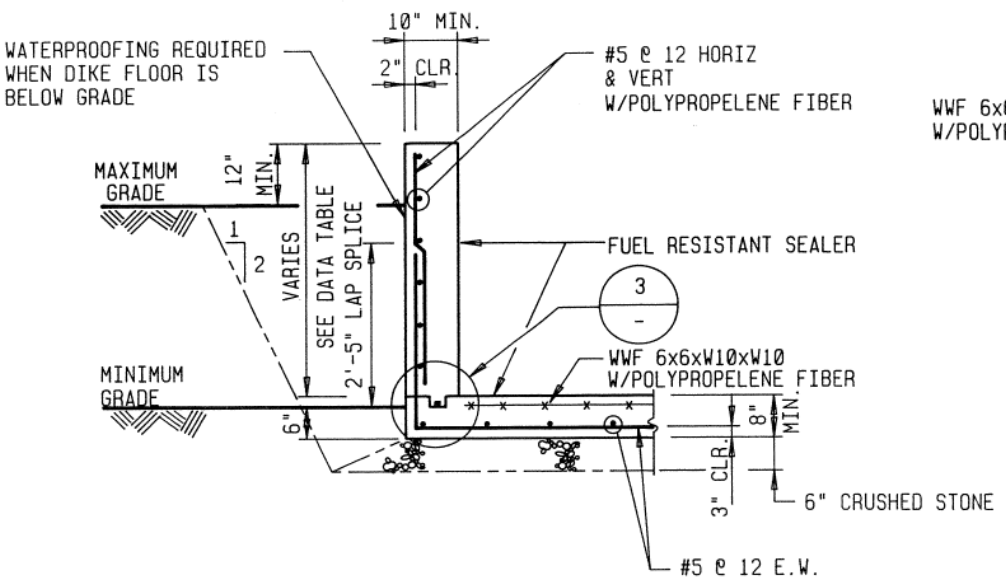
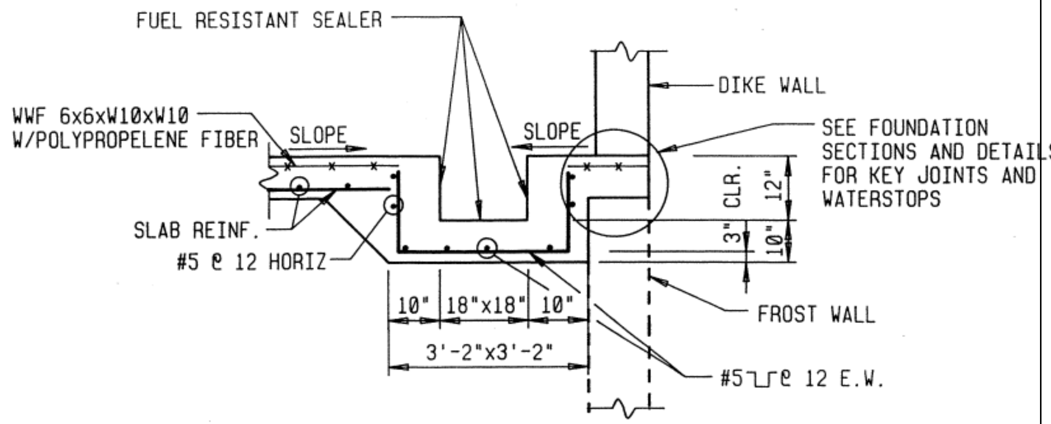
SLAB, PIPING PENETRATION & SUMP DETAILS



FLOATING SLAB FOUNDATION SECTION

SCALE: 1/2"=1'-0"



SUMP DETAIL

SCALE: ½"=1'-0"

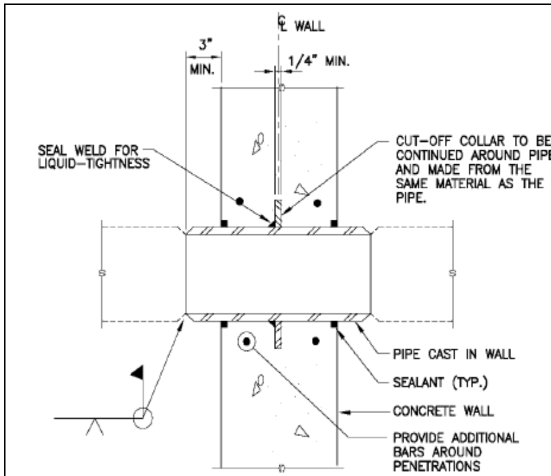


Fig. 4.5—Steel pipe penetration detail.

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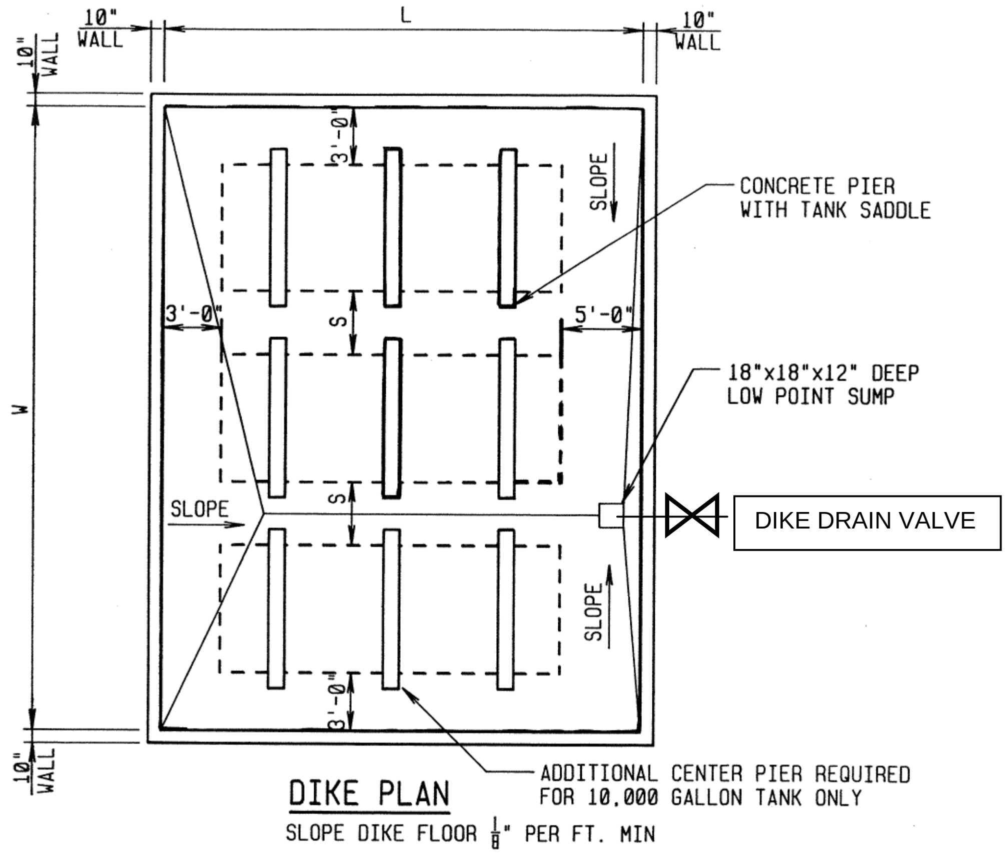
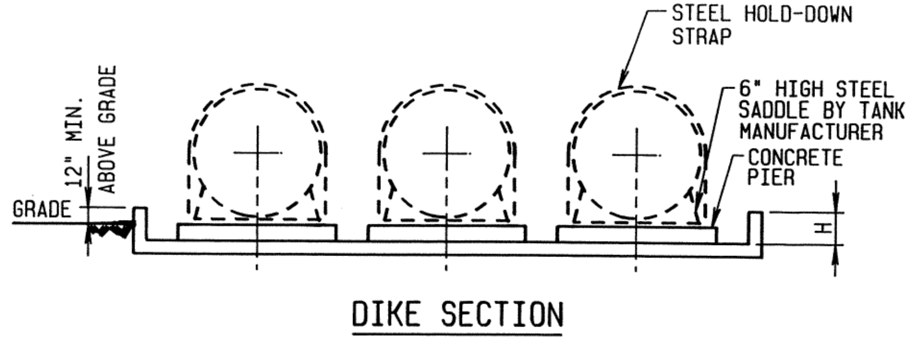
TYPICAL HORIZONTAL DIKE PLAN-(S=3 FEET MINIMUM BY FIRE CODE)





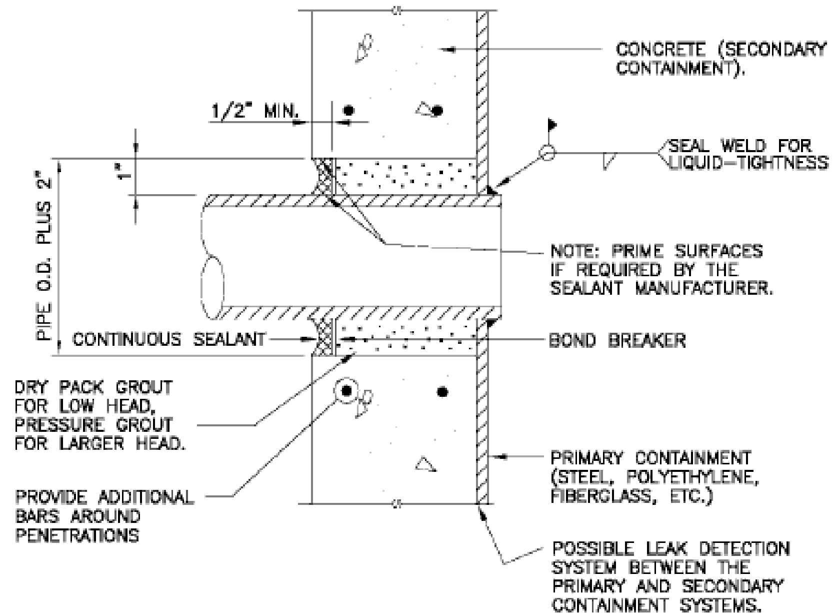


Fig. 4.6—Pipe penetration detail at a lined containment structures.

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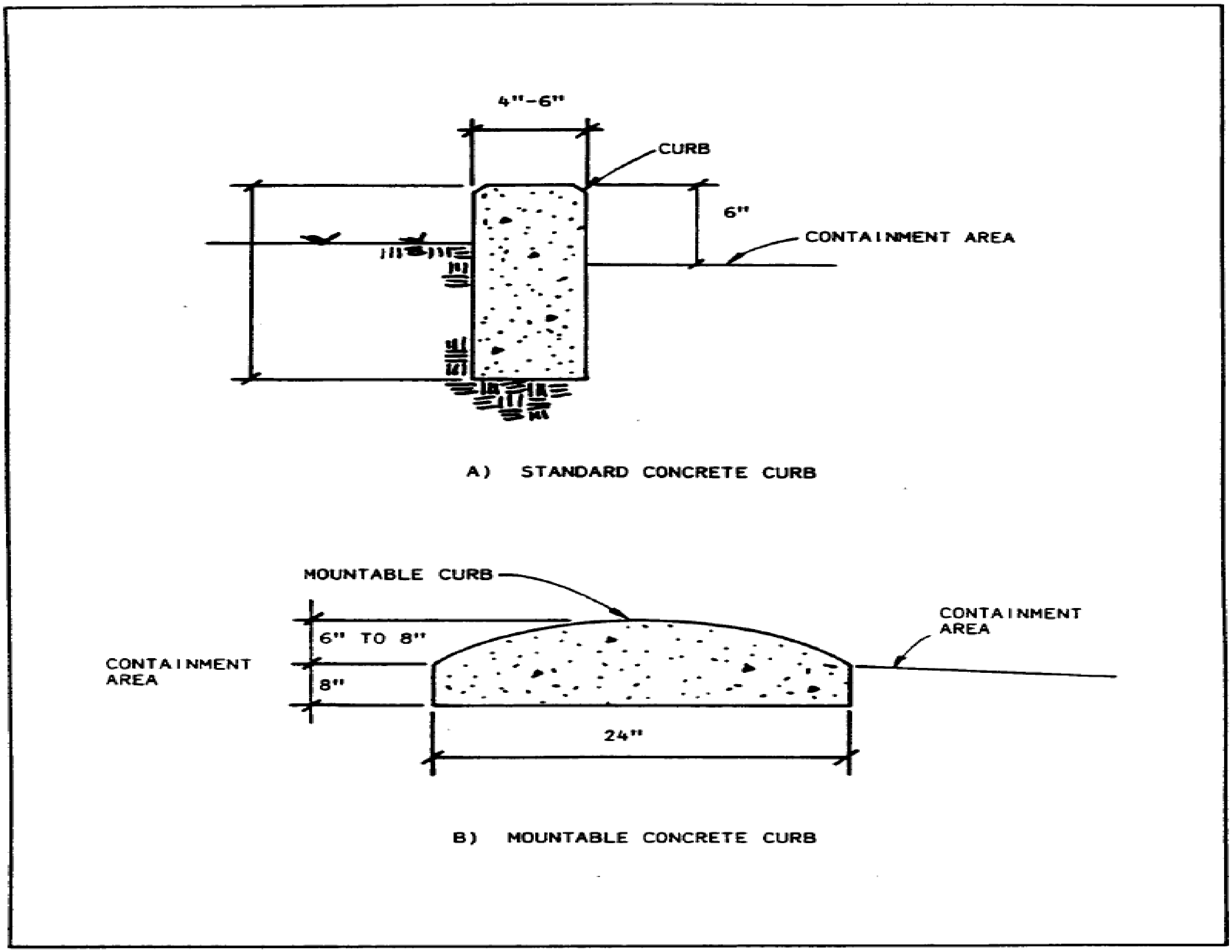
SECONDARY CONTAINMENT BY CURBING (SOURCE US NAVY)



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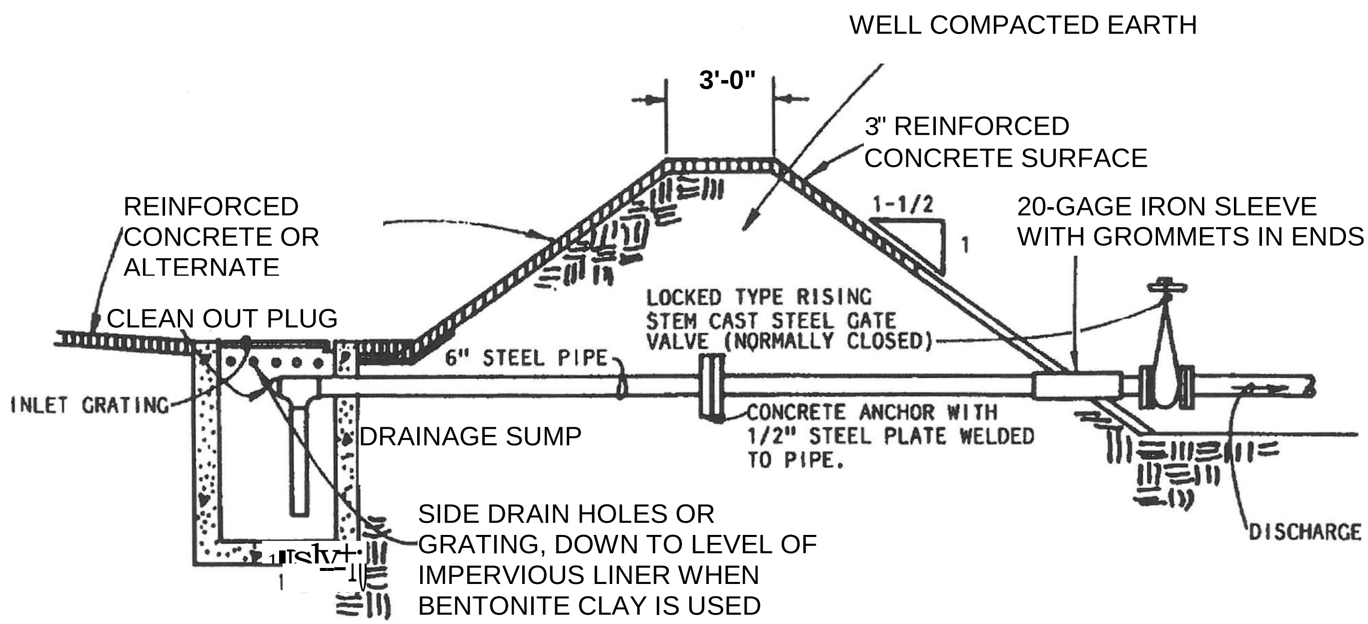
EARTHEN BERM (SOURCE US NAVY)

ALTERNATE METHODS:

1. 3" LAYER OF BENTONITE TYPE CLAY COVERED BY 6" OF SAND AND 8" OF CRUSHED STONE.
2. 2" LAYER OF ASPHALT WITH RUBBERIZED COAL TAR SEALER OVER 4" OF COMPACTED BASE COURSE.



Source: DM-22 (Petroleum Fuel Facilities).

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GENERIC NOTES:

CODES AND PERMITS

1) ALL INSTALLATIONS CONNECTED TO A FUEL BURNING DEVICE SHALL MEET THE REQUIREMENTS OF: NFPA 31, "STANDARD FOR THE INSTALLATION OF OIL BURNING EQUIPMENT", AND BUILDING CODE REGULATIONS.
2) ALL INSTALLATIONS FOR MOTOR FUEL STORAGE/DISPENSING SHALL MEET REQUIREMENTS OF: NFPA 30, "FLAMMABLE AND COMBUSTIBLE LIQUID CODE" WHEN APPLICABLE, NFPA 30A, "AUTOMOTIVE AND MARINE SERVICE STATION CODE", AND BUILDING CODES RELATING TO GASOLINE AND OTHER FLAMMABLE LIQUIDS"
3) ALL INSTALLATIONS SHALL MEET THE REQUIREMENTS OF EPA REGULATION 40 CFR 112 INCLUDING PREPARATION OF A CERTIFIED, "SPILL PREVENTION CONTROL AND COUNTERMEASURE" (SPCC) PLAN.
4) LOCAL BUILDING CODES AND ORDINANCES MUST BE REVIEWED AS THEY MAY BE MORE STRINGENT THAN STATE OR NFPA REQUIREMENTS.
5) TANK SIZE & DIMENSIONS ARE TYPICAL. CONFIRM WITH ACTUAL TANK PURCHASED.
6) NUMBER, DIMENSIONS AND ANCHOR BOLT REQUIREMENTS OF STEEL SADDLES VARY BETWEEN TANK MANUFACTURERS. CONFIRM PRIOR TO ESTABLISHING CONCRETE PIER REQUIREMENTS.
7) MINIMUM DIKE SIZES ARE BASED ON VOLUME OF LARGEST TANK, PLUS SUFFICIENT FREEBOARD ALLOWANCE ADDITIONAL DIKE WALL HEIGHT OF X.X INCHES AS FREEBOARD FOR RAIN & EXCESS FLUID COLLECTION.
8) LOW POINT SUMP IS REQUIRED FOR REMOVAL OF RAIN OR SPILLED LIQUID. DO NOT PIPE TO EXTERIOR DRAIN DUE TO SIGNIFICANT RISK OF FREEZING DAMAGE AND POTENTIAL UNMANAGED DISCHARGE. USE OF PERMANENTLY MOUNTED HAND PUMP IS SUGGESTED FOR MANUAL LIQUID REMOVAL.
9) NO PIPING OR CONDUITS SHALL PENETRATE DIKE FLOOR OR WALL UNLESS APPROVED BY PROFESSIONAL ENGINEER.
10) HOLD DOWN STRAPS MAY BE REQUIRED FOR ALL TANKS IN DIKES CONTAINING MULTIPLE TANKS IN ORDER TO PREVENT TANK UPLIFT IF A SPILL OCCURS.
11) DIKE PLAN SIZE MAY BE INCREASED TO ACCOMMODATE USE OF STANDARD FORMS.
12) PROVIDE HANDRAIL ALONG TOP OF DIKE WALL WHERE DIKE FLOOR IS 3FT. OR GREATER BELOW GRADE.
13) IT IS SUGGESTED THAT CONSTRUCTION PHOTOGRAPHS BE UTILIZED TO FULLY DOCUMENT CONSTRUCTION FEATURES, AND PROVE THE INSTALLATION OF REINFORCING STEEL, KEY JOINTS, WATER STOPS, ETC.

STRUCTURAL NOTES

14) FOUNDATIONS SHALL BEAR ON NATURAL UNDISTURBED SOIL OR WELL GRADED GRAVEL. LOOSE SOIL SHALL BE OVER EXCAVATED TO UNDISTURBED SOIL AND REPLACED WITH WELL GRADED GRAVEL FILL COMPACTED TO 95 PERCENT MAXIMUM DENSITY. CONCRETE SHALL NOT BE PLACED IN WATER OR ON FROZEN GROUND.

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15) WHERE LEDGE IS ENCOUNTERED. FOUNDATIONS SHALL BEAR DIRECTLY ON LEDGE. IN CASES OF PARTIAL LEDGE CONDITIONS PROVIDE A MINIMUM OF 12 INCHES CRUSHED STONE BELOW FOUNDATION. IN NO CASE SHALL FOUNDATIONS BEAR PARTIALLY ON LEDGE AND PARTIALLY ON SOIL.
16) BACKFILL AGAINST DIKE WALLS SHALL BE WELL GRADED FREE DRAINING GRAVEL WITH 0-7% PASSING 200 SEIVE COMPACTED TO 90% MAXIMUM DENSITY. DO NOT USE CLAY OR GRAVEL WITH FINES.
17) FROST DEPTH IS X.X FEET BELOW GRADE. CONSULT LOCAL CODES FOR FROST DEPTH REQUIREMENTS AT PROJECT SITE.
18) FOUNDATION DESIGN IS BASED ON ASSUMING A WELL DRAINED SITE. IN CASES OF HIGH WATER TABLE OR POOR SITE DRAINAGE, A FOUNDATION DRAINAGE SYSTEM AND MODIFIED CONSTRUCTION DETAILS DESIGNED BY A PROFESSIONAL ENGINEER IS NECESSARY FOR SUCCESSFUL APPLICATION.
19) MAXIMUM PARTICLE SIZE OF CRUSHED STONE FOR BACKFILL SHALL BE 1-1/2 INCHES.
20) ALL CONCRETE WORK AND REINFORCING DETAILS SHALL CONFORM TO THE FOLLOWING LATEST ACI STANDARDS:

ACI 301 SPECIFICATIONS FOR STRUCTURAL CONCRETE FOR BUILDINGS

ACI 304 RECOMMENDED PRACTICE FOR MEASURING MIXING, TRANSPORTING, AND PLACING CONCRETE

ACI 315 DETAILING REINFORCED CONCRETE STRUCTURES

ACI 305 HOT WEATHER CONCRETING

ACI 306 COLD WEATHER CONCRETING

ACI 318 BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE

21) ALL CONCRETE SHALL HAVE A MINIMUM 28 DAY COMPRESSIVE STRENGTH OF 4,000 PSI.
22) MAXIMUM COARSE AGGREGATE SIZE FOR CONCRETE MIX SHALL BE 3/4".
23) AIR ENTRAINMENT SHALL BE 6% ± 1%.
24) SLUMP SHALL BE 3" ± 1". FOR SLUMPS IN EXCESS OF 4”, A SUPERPLASTICIZER SHALL BE USED. MAXIMUM ALLOWABLE SLUMP WITH A SUPERPLASTICIZER SHALL BE 7".
25) DIKE FLOOR SHALL HAVE A BROOM FINISH
26) CONCRETE SHALL BE CONSOLIDATED WITH A VIBRATOR SO AS TO ELIMINATE HONEYCOMB AND BUG HOLES IN EXCESS OF ½ INCH.
27) CONCRETE SLAB SHALL BE MOIST CURED FOR SEVEN DAYS. IN LIEU OF MOIST CURING, A LIQUID MEMBRANE CURING COMPOUND CONFORMING TO ASTM C 309 MAY BE USED. LIQUID MEMBRANE CURING COMPOUNDS SHALL BE CHECKED FOR COMPATIBILITY WITH STORED PETROLEUM/CHEMICAL TYPE RESISTANT SEALER-HARDENERS.
28) CONCRETE WALLS AND FOOTINGS SHALL BE CURED BY LEAVING FORMS IN PLACE FOR THREE DAYS COVERING TOPS OF WALLS WITH HAY OR POLYETHYLENE SHEETING. IN LIEU OF LEAVING FORMS IN PLACE, WALLS AND FOOTINGS MAY BE SPRAYED WITH A LIQUID MEMBRANE CURING COMPOUND, CONFORMING TO ASTM C 309, IMMEDIATELY UPON STRIPPING OF THE FORMS. LIQUID MEMBRANE CURING COMPOUNDS SHALL BE CHECKED FOR COMPATIBILITY WITH STORED PETROLEUM/CHEMICAL TYPE RESISTANT SEALER-HARDENERS.

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29) 100% VIRGIN POLYPROPYLENE FIBRILLATED FIBERS SPECIFICALLY MANUFACTURED FOR USE IN CONCRETE REINFORCEMENT, CONTAINING NO REPROCESSED OLEFIN MATERIALS AND CONFORMING TO ASTM C-1116 ARE RECOMMENDED FOR CONTROL OF PLASTIC SHRINKAGE CRACKING IN THE SLAB AS WELL AS FOR THE REDUCING THE HYDROSTATIC PERMEABILITY IN THE WALLS AND THE SLAB. DOSAGE RATE SHALL BE A MINIMUM 11/2 LBS./CUBIC YARD OF CONCRETE
30) WELDED WIRE FABRIC (WWF) SHALL CONFORM TO ASTM A185, SMOOTH WIRE. FY = 65,000 PSI
31) REINFORCING STEEL SHALL CONFORM TO ASTM A615 GRADE 60, DEFORMED BARS. FY = 60,000 PSI
32) ANCHORS BOLTS SHALL BE ASTM A36.
33) APPLY PETROLEUM/CHEMICAL TYPE RESISTANT SEALER-HARDENERS TO FLOOR AND WALLS OF DIKE. PROFESSIONAL ENGINEER SHALL APPROVE SEALER HARDENER.
34) PROFESSIONAL ENGINEER SHALL APPROVE BENTONITE WATERSTOP.
35) WATERPROOFING IS REQUIRED ALONG EXTERIOR FACE OF DIKE WHEN DIKE FLOOR IS BELOW GRADE. PROFESSIONAL ENGINEER SHALL APPROVE WATERPROOFING.
36) FORM TIE SHALL BE BROKEN BACK AND PATCHED ON THE INSIDE AND OUTSIDE OF THE DIKE WALL. PATCHING SHALL BE COMPLETED PRIOR TO THE APPLICATION OF THE PETROLEUM/CHEMICAL TYPE RESISTANT SEALER-HARDENERS.

SUMMARY

This course only offers a brief outline of the Federal and State regulatory requirements on the regulatory requirements and installation of secondary containment systems. We strongly suggest that you contact a qualified professional engineer and/or a professional geotechnical soils engineer/geologist for details on the federal, state and local laws, industry standards and good engineering practice in the event you plan to install a secondary containment installation for control of hazardous materials, petroleum/vegetable oils, and animal fats.

Once you finish studying the above course content, you need to take a quiz to obtain the PDH credits.

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