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History Sheet

Rev	Reason for revision	Revised by
0	Issued for permitting use.	J. Rewari
1	Revised to include +3 ft elevation and Appendix A	J. Rewari
2	Revised Appendix A	J. Rewari
3	Revised Section 3, Appendix A & Issued for permitting use.	J. Rewari
4	Revised to include +28 ft elevation and remove Melter 3 tankage. Issued for permitting use.	J. Rewari
5	Revised to include changes to -21 and +28 ft elevations	D.F. Miller
6	Revised to correct inconsistencies between text and appendix A	R. Hanson
7	Major Revision of Section 3 and Appendix A to incorporate flooding volumes and associated liner heights to match issued calculations	K. Bhamidipaty

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1 Introduction

The Washington Administrative Code, WAC 173-303-640[4][e][i][A], requires that secondary containment systems be designed or operated to contain one hundred percent of the capacity of the largest tank within its boundary containing dangerous waste. Per Washington State Department of Ecology Publication 95-420, *Guidance for Assessing Dangerous Waste Secondary Containment Systems*, page 3, where automatic fire extinguishing systems are used, the Uniform Fire Code requires secondary containment for hazardous materials to be sized with additional volume to contain the design flow rate for 20 minutes. This report discusses the assessment of flooding volume that is required to be contained for the low-activity waste vitrification (LAW) facility.

2 Applicable Documents

- WAC 173-303. *Dangerous Waste Regulations*. Washington Administrative Code.
- Washington State Department of Ecology Publication 95-420, *Guidance for Assessing Dangerous Waste Secondary Containment Systems*
- NFPA 13, Standard for the Installation of Sprinkler Systems, 1999

3 Description

3.1 Flooding Volume Description for LAW Facility at -21 Ft Elevation

LAW facility has the following vessel containing dangerous waste, in the process cells, and effluent cell rooms, at -21 ft elevation:

C3/C5 Drain Collection Cell	Room L-B001B
RLD-VSL-00004	C3/C5 Drains/Sump Collection Vessel

The only vessel in the LAW facility containing dangerous waste at (-) 21 ft elevation is the C3/C5 drains/sump collection vessel (RLD-VSL-00004). In the event of a line break, vessel failure, or tank overflow, flooding could occur in the cell. The C3/C5 drains/sump collection vessel (RLD-VSL-00004) is in an enclosed C3/C5 cell area, in room L-B001B (C3/C5 drain collection cell). The vessel could also receive firewater from the floor above.

To calculate the minimum height of C3/C5 drain collection cell (Room L-B001B) stainless steel liner, the following 2 scenarios are considered:

Scenario a:

This scenario is based on the design of the LAW facility and assumes leakage and spillage of the C3/C5 drains/sump collection vessel (RLD-VSL-00004) when the total volume of fluid contained in the vessel is discharged into the cell. The flooding volume is the larger of 110 % (used as a conservative criteria) of the maximum operating volume of the largest vessel, or 100 % of the total volume of the largest vessel. The vessel total volume is defined as internal volume of the vessel including the shell and both heads.

The total vessel volume of 1034 ft^3 is greater than 110 % of the maximum operating volume. Fire sprinklers are provided in this cell; therefore, 193.5 ft^3 of fire water from 20 minutes of sprinkler discharge (includes 10 % margin for overage i.e. safety factor = 1.1) in the cell is added to the flooding volume. The total volume of fluid that must be contained by the liner in the room = 1034 + 193.5 = 1227.5 ft^3.

The room has a sump and sloping segments of floor. The volume of fluid accommodated on the sloping floor between top of sump and the high point on the floor is calculated to be 7.9 ft^3. Therefore, the volume of fluid that occupies the room space above the high point slope is equal to 1227.5 - 7.9 = 1219.6 ft^3.

The liner height is measured from the top of sump. Therefore, the minimum required liner height is calculated as the sum of two parts: (1) height of high point slope above sump, and (2) height of liner top above the high point slope. The high point of floor is 2 in above the top of sump. The available cross-sectional area of the room is calculated to be 387 ft^2. The required liner height above the high point slope is equal to the volume 1219.6 ft^3 divided by the available cross-sectional area of the room (= 387 ft^2), which is equal to 3.16 ft = 3 ft 2 in (rounded to nearest inch).

The liner height from top of sump for scenario a. is equal to 3 ft 2 in + 2 in = 3 ft 4 in.

Scenario b:

This scenario is based on the design of the LAW facility and uses a conservative volume of firewater flow to calculate the minimum liner height. The Vessel RLD-VSL-00004 is full and intact so only firewater runoff from higher elevation floor drains is considered for the flooding volume. As shown in Figure 1, firewater flow into some floor drains, sumps, and overflow lines drain into the C3/C5 Floor Drain Vessel (RLD-VSL-00004). In the event of a fire, the firewater could collect on the higher elevations and drain to the tank causing the tank to overflow. Since the tank is full and not leaking in this scenario, firewater would flow out of the tank and into the cell via the overflow nozzle. The firewater used in this scenario is the largest design requirement for the LAW facility. Volume of 20 minutes of firewater outside of the cell is calculated to be 11,220 gallons (or 1,500 ft^3).

Therefore, the required liner height for C3/C5 drain collection cell from top of sump for scenario b. is equal to 4 ft 1 in.

3.2 Flooding Volume Description for LAW Facility at +3 Ft Elevation

LAW facility has the following vessels and miscellaneous units, containing dangerous waste, in the process cells, and effluent cell rooms, at +3 ft elevation:

Process Cell Room L-0123

LCP-VSL-00001	Melter 1 Concentrate Receipt Vessel
LFP-VSL-00001	Melter 1 Feed Preparation Vessel
LFP-VSL-00002	Melter 1 Feed Vessel
LOP-VSL-00001	Melter 1 SBS Condensate Vessel
LOP-WESP-00001	Melter 1 Wet Electrostatic Precipitator (WESP)
LOP-SCB-00001	Melter 1 Submerged Bed Scrubber (SBS)

Process Cell Room L-0124

LCP-VSL-00002	Melter 2 Concentrate Receipt Vessel
LFP-VSL-00003	Melter 2 Feed Preparation Vessel
LFP-VSL-00004	Melter 2 Feed Vessel
LOP-VSL-00002	Melter 2 SBS Condensate Vessel
LOP-WESP-00002	Melter 2 Wet Electrostatic Precipitator (WESP)
LOP-SCB-00002	Melter 2 Submerged Bed Scrubber (SBS)

Effluent Cell Room L-0126

RLD-VSL-00003	Plant Wash Vessel
RLD-VSL-00005	SBS Condensate Collection Vessel

3.2.1 Process Cells

The process cells have 6 vessels in each cell. Both process cells are identical in size and contain a similar set of vessels.

For calculating the minimum height of stainless steel liners for process cell rooms L-0123, and L-0124, the following scenario is considered:

The total volume of fluid contained in the largest vessel is discharged by leakage or spillage into the cell. To calculate the available area of the cell where the flooding volume could leak, the largest cross-sectional area of each of the vessels (except the leaking vessel) are subtracted from the cross-sectional area of the rectangular cell.

Conservative values for the vessel volume are used in the calculation of the liner height by using the volume of the vessel without subtracting the volume of the internal equipment. The largest cross-sectional area of the vessel is used to conservatively calculate the cross-sectional area of the rectangular cell, even though the cross-sectional area of the vessel at the bottom is much smaller.

The liners are sized to hold 100 % of the total volume of the largest vessel or 110 % of its maximum operating volume, whichever is greater. In all cases, the total volume is used because this is larger than 110 % of the volume up to the overflow nozzle.

The largest vessel in each cell is the concentrate receipt vessel, (LCP-VSL-00001, -00002), and the total volume of each is 2427.6 ft^3. These rooms have sumps and sloping segments of floor that accommodate 62.1 ft^3 of liquid in each room from the top of sump to the high point slope. Therefore, the volume of fluid that occupies the room space above the high point slope is equal to 2427.6 - 62.1 = 2365.5 ft^3.

The liner height is measured from the top of sump. Therefore, the minimum required liner height is calculated as the sum of two parts: (1) height of high point slope above sump, and (2) height of liner top above the high point slope. The high point of floor is 2 ⅞ in (= 0.24 ft) above the top of sump. The available cross-sectional area of the room is calculated to be 1411.5 ft^2. The required liner height above the high point slope is equal to the volume 2365.5 ft^3 divided by the available cross-sectional area of the room (= 1411.5 ft^2), which is equal to 1.676 ft.

Therefore, the required liner height above the top of sump is equal to 1.676 ft + 0.24 ft = 1.916 ft = 1 ft 11 in (rounded to nearest inch).

3.2.2 Effluent Cell

Effluent cell room L-0126 has 2 vessels in it. Both vessels are identical in size. Using the same method as for the process cells, the total volume of each of these vessels is 3445 ft^3. This room has sumps and sloping segments of floor that accommodate 11.4 ft^3 of liquid in each room from the top of sump to the high point slope. Therefore, the volume of fluid that occupies the room space above the high point slope is equal to 3445 ft^3 - 11.4 ft^3 = 3433.6 ft^3.

Conservative values for the vessel volume are used in the calculation of the liner height by using the volume of the vessel without subtracting the volume of the internal equipment. The largest cross-sectional area of the vessel is used to conservatively calculate the cross-sectional area of the rectangular cell, even though the cross-sectional area of the vessel at the bottom is much smaller.

The liner height is measured from the top of sump. Therefore, the minimum required liner height is calculated as the sum of two parts: (i) height of high point slope above sump, and (ii) height of liner top above the high point slope. The high point slope of floor is 2 ⅛ in (= 0.177 ft) above the top of sump. The available cross-sectional area of the room is calculated to be 996.54 ft^2. The required liner height above the high point slope is equal to the volume 3433.6 ft^3 divided by the available cross-sectional area of the room (= 996.54 ft^2), which is equal to 3.446 ft.

Therefore, the required liner height from top of sump is equal to 3.446 ft + 0.177 ft = 3.623 ft = 3 ft 8 in (rounded to nearest inch).

3.3 Flooding Volume Description for LAW Facility at +28 Ft Elevation

LAW facility has the following tank, containing dangerous waste, at +28 ft elevation:

Caustic Scrubber Blowdown Pump Room, Room L-0218

LVP-TK-00001	Caustic Collection tank

3.3.1 Room L-0218

Caustic Scrubber Blowdown Pump Room, L-0218, at elevation +28 contains the caustic collection tank (LVP-TK-00001). The tank sits on a 6" high octagonal pedestal. The floor in room L-0218 is not sloped, however, the octagonal tank pedestal is provided with grooves that slope from the center of the tank pedestal to divert a potential leak under the tank. Also located in this room are 4 pumps on individual pedestals. The room's concrete vault walls are designed and provided with a special protective coating approved by Ecology in accordance with the *Engineering Specification for Field Applied Special Protective Coatings for Secondary Containment* (24590-WTP-3PS-AFPS-TP006).

For calculating the minimum height of the secondary containment coating on the vault walls, the following scenario is considered:

The total volume of the fluid contained in the tank is discharged by leakage or spillage into the secondary containment. In addition to this, if there is a fire in the area during this event, the automatic fire protection sprinkler system will activate and add fire protection water to the fluid discharged from the tank. Therefore, the secondary containment wall is sized to handle the volume of the fire protection water from the sprinkler system over the design area for a period of 20 minutes, including a 10 % margin for overage (i.e., safety factor =1.1), in addition to the 100 % capacity of the tank.

To calculate the minimum secondary containment wall coating height, the available volume of the room (this includes the vessel cross-sectional area) and the volume of fire water must also be calculated; altogether, the calculation is done in four steps.

Step 1: Calculate the volume of fluid within the caustic collection tank. This takes into account the entire volume of 1950 ft^3.

Step 2: Calculate the volume of available secondary containment coating up to a height of 6". This step excludes the 6" tank pedestal and the 4 pump pedestals to a height of 6", from the available area of the room. This volume = 204.4 ft^3.

Step 3: Calculate the additional height of the secondary containment coating after the first 6". This step excludes the area above the 4 pump pedestals to a height of the ceiling (height of pump pedestals is considered to be the height of the room for conservatism) from the total area of the room. The remaining wall height is found by dividing the remaining fluid volume by the area available. The available area of the room above the pump pedestals = 595.17 ft^2, and the remaining fluid volume = 1745.6 ft^3. The additional height of the secondary containment after the first 6" is equal to 2.933 ft.

Step 4: Calculate the volume of 20 minutes of firewater from the sprinkler system, multiplied by a safety factor of 1.1. Calculate the height of the secondary containment wall for firewater by dividing the volume of firewater by the area of the room minus the area of the 4 pump pedestals. The firewater volume = 319.423 ft^3 and the additional height of secondary containment required = 319.423 ft^3 / 595.14 ft^2 = 0.537 ft.

The secondary containment wall coating height is then: 6" (Step 1) plus additional height of the wall (Step 3) plus height required for firewater (Step 4).

The secondary containment wall coating height required for this room is 0.5 ft + 2.933ft + 0.537 ft = 3.97 ft, rounded to 4 ft.

3.4 Curb Height in the Curbed Section of Room L-0304 F (Caustic Scrubber Area) at +48 Ft Elevation)

This report addresses the following miscellaneous unit containing dangerous waste at + 48 ft elevation.

Secondary Offgas Equipment Room L-0304 F (curbed section only)

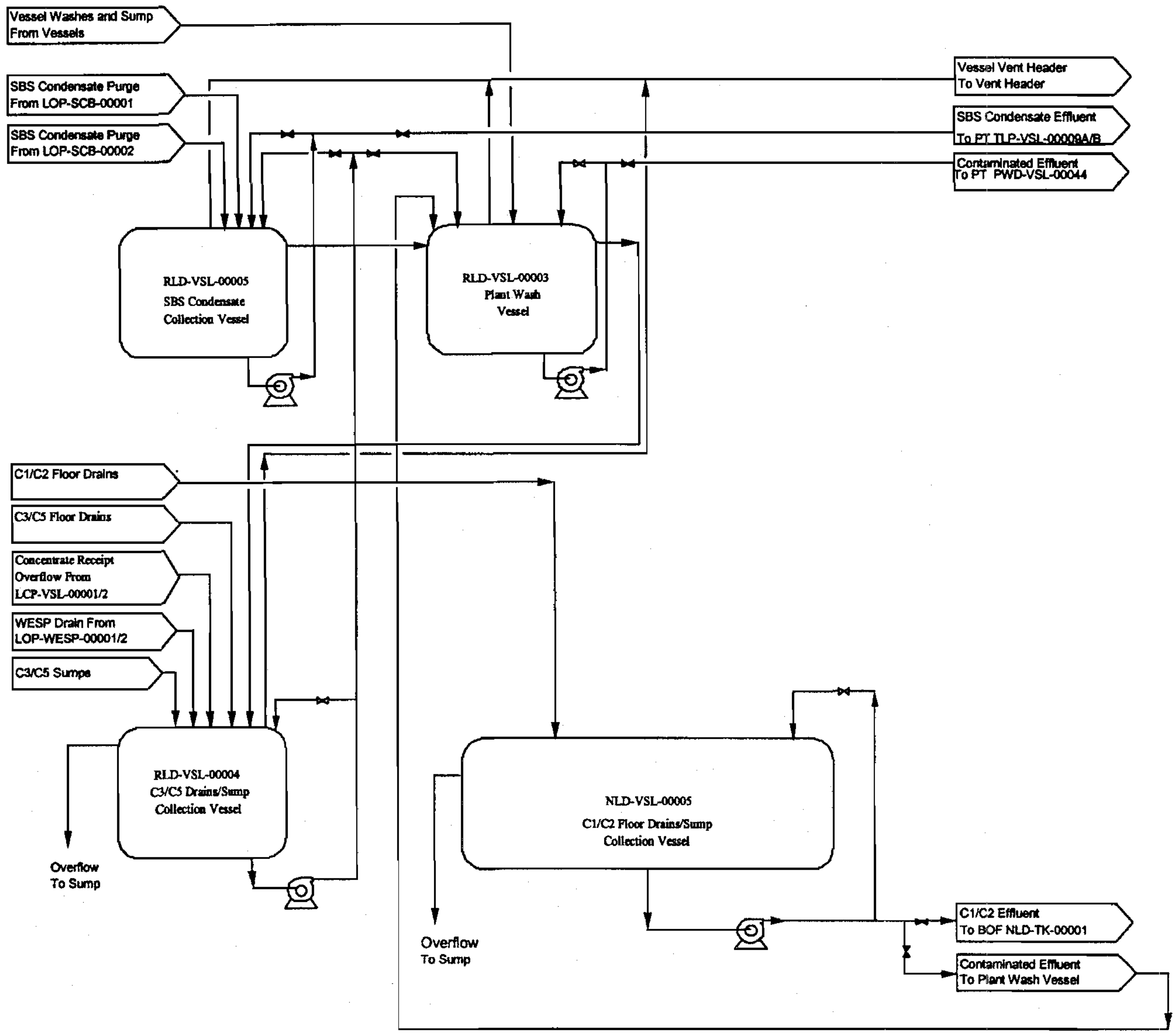
LVP-SCB-00001 Caustic Scrubber (curbed section)

A curbed area with an open floor drain (RLD-FD-00025) has been provided in South-East corner of Room L-0304 F. The LVP Caustic Scrubber is located inside the curbed area that is designed to prevent a potential spill or leak from flowing into the other sections of Secondary Off-gas Equipment Room (L-0304 F). The curbed area is also designed to prevent firewater inflow to the caustic scrubber area due to sprinkler activation in the adjacent part of room L-0304 F. The curbed area is designed and provided with a special protective coating approved by Ecology in accordance with the *Engineering Specification for Field Applied Special Protective Coatings for Secondary Containment* (24590-WTP-3PS-AFPS-TP006). The floor drain will direct a potential spill or leak from the caustic scrubber LVP-SCB-00001 to RLD-VSL-00004 located at -21 ft. elevation.

The caustic scrubber system continuously recycles scrubber solution between the caustic scrubber and the caustic collection tank (LVP-TK-00001) located directly below the scrubber at the +28 ft. elevation. The caustic scrubber is normally operated under vacuum (-124 in. WC nominal). In the event of any small to moderate leak in the caustic scrubber, room air will be pulled in, which mitigates the out-leakage of scrubber solution. Any large leak in the recirculation piping would trigger a loss of flow interlock that shuts down the recirculation pumps isolating the caustic scrubber from the recirculation piping.

A calculation for the curb height (flood volume) for this area was not completed because the curb height is based principally on the discharge of the fire protection sprinkler system with only minimal contribution from leakage of caustic scrubber and associated ancillary equipment. The floor drains and curbs are sized for 20 minutes of fire sprinkler water flow. The floor and curb area is coated with a special protective coating to the top of the 4 inch curb. This room is shown on drawing 24590-LAW-P1-P01T-00005 (*LAW Vitrification Building General Arrangement Plan at El 48'- 0"*).

Figure 1 LAW Effluent General Flow Diagram



Appendix A

Calculation of Volume and Liner Height

Appendix A: Calculation of Volume and Liner Height

1 Purpose

The purpose of this calculation is to size the height of the liners in the process cells for LAW vitrification facility at elevation -21 ft and elevation +3 ft. C3/C5 drains/sump collection vessel (RLD-VSL-00004) room L-B001B is shown at elevation -21 ft on drawing 24590-LAW-P1-P01T-P0001 (*LAW Vitrification Building General Arrangement Plan at El. -21'- 0'*). Process cell rooms L-0123 and L-0124 and effluent cell room L-0126 at elevation +3 ft are shown on drawing 24590-LAW-P1-P01T-P0002 (*LAW Vitrification Building General Arrangement Plan at El 3'-0"*).

Additionally, this calculation will size the height of the secondary containment with protective coating required for the caustic scrubber blowdown pump room, Room L-0218 at elevation +28. This room is shown on drawing 24590-LAW-P1-P01T-P0004 (*LAW Vitrification Building General Arrangement Plan at El 28'-0"*).

2 Criteria and Design Input

2.1 Process and Effluent Cell Liner Height

Per Assumption 3.1.1, the vessels are conservatively assumed to be completely filled (including the top head) and sitting on the floor. The largest vessel total volume is used as the volume in determining the liner height. To allow for the worst case scenario, the volume of the vessel is assumed to leak completely onto the floor.

The liners are sized to hold 100 % of the total volume of the largest tank or 110 % of its maximum operating volume, whichever is larger. In all cases, the total volume is used because this is larger than 110 % of the volume up to the overflow nozzle.

For the process cells and the effluent cells, the largest vessel total volume is used as the volume in determining the liner height. The fire water spray in these cells is at a density of 0.17 gal/min/ft^2, for 20 minutes and is multiplied by a safety factor of 1.1.

The following vessels are contained within the process and effluent cells.

LCP-VSL-00001	Melter 1 Concentrate Receipt Vessel	Room L-0123	El. +3'
LCP-VSL-00002	Melter 2 Concentrate Receipt Vessel	Room L-0124	El. +3'
LFP-VSL-00001	Melter 1 Feed Preparation Vessel	Room L-0123	El. +3'
LFP-VSL-00002	Melter 1 Feed Vessel	Room L-0123	El. 3.3'
LFP-VSL-00003	Melter 2 Feed Preparation Vessel	Room L-0124	El. +3'
LFP-VSL-00004	Melter 2 Feed Vessel	Room L-0124	El. +3'
RLD-VSL-00003	Plant Wash Vessel	Room L-0126	El. +3'
RLD-VSL-00005	SBS Condensate Collection Vessel	Room L-0126	El. +3'

LOP-VSL-00001	Melter 1 SBS Condensate Vessel	Room L-0123	El. +3'
LOP-SCB-00001	Melter 1 SBS Vessel	Room L-0123	El. +3'
LOP-VSL-00002	Melter 2 SBS Condensate Vessel	Room L-0124	El. +3'
LOP-SCB-00002	Melter 2 SBS Vessel	Room L-0124	El. +3'
LOP-WESP-00001	Melter 1 WESP	Room L-0123	El. +3'
LOP-WESP-00002	Melter 1 WESP	Room L-0124	El. +3'

Location and size of the C3/C5 drain collection cell (room L-B001B) is based on drawing 24590-LAW-P1-P01T-P0001 (*LAW Vitrification Building General Arrangement Plan at El. -21' 0"*). Location and size of process rooms L-0123, and L-0124 and effluent room L-0126, at elevation 3 ft are shown on drawing 24590-LAW-P1-P01T-P0002 (*LAW Vitrification Building General Arrangement Plan at El. 3' 0"*).

2.2 Secondary Containment Vault Liner Height

The caustic collection tank (LVP-TK-00001) is located in the caustic scrubber blowdown tank room L-0218 at elevation +28'-0". The height of the special protective coating on the containment vault wall is sized to handle the volume of fire-protection water from the fire protection system over the design area for a period of 20 minutes, multiplied by a safety factor of 1.1, in addition to the 100 % capacity (or total volume) of the tank. The fire protection water automatic sprinkler design density is 0.17 gpm/sq. ft. Location and size of room L-0218 at elevation +28 ft is shown on drawing 24590-LAW-P1-P01T-P0004 (*LAW Vitrification Building General Arrangement Plan at El. 28' 0"*).

3 Assumptions

3.1 Assumptions Not Requiring Verification

3.1.1 To provide the worst case scenario, the vessels are conservatively assumed to be completely filled (including the top head) and sitting on the floor, and that the largest vessel total volume is used as the volume in determining the liner height. To allow for the worst case scenario, the volume of the vessel is assumed to leak completely onto the floor until it reaches equilibrium with surrounding fluid level.

3.2 Assumptions Requiring Verification

None

4 Methodology

As stated above in the criteria and design input section, to determine the required liner height for the worst case, the calculation methodology (per Assumption 3.1.1) considers that the vessels are completely filled and sitting on the floor and that the largest tank leaks completely into the room. For the C3/C5 drain collection cell (room L-B001B), the maximum leakage volume to the cell is fire water input from higher elevation floor drains to a filled C3/C5 drains/sump collection vessel (RLD-VSL-00004).

4.1 Basic Equations

$\pi = 3.14$

Area of a Rectangle = Length x Width

Inside cross-sectional area of the vessel = $\pi \dfrac{D_i^2}{4}$, outside cross-sectional area of the vessel = $\pi \dfrac{D_o^2}{4}$

Volume of Cylinder = $\dfrac{\pi}{4} \cdot D_i^2 \cdot h$

Volume of Rectangular Room = Length x Width x Height

Area of a Regular Polygon = 1/2 x a x p (where a = apothem and p = perimeter)

4.2 Room Dimensions, Equations and Symbology

L = length of room (ft)

W = width of room (ft)

H = height of room (ft)

A = area of room (ft^2)

Δ = height of high point slope above the top of sump (ft), if the room floor has sloping segments (if floor has no slope, $\Delta = 0$)

4.3 Volume and Liner Height Calculation

Volume of a vessel or tank is calculated by using the following equations:

$$V_S = \frac{\pi D_i^2}{4} L_{T-T}$$

where:

V_S = volume of the cylindrical portion of the vessel or tank

D_i = inside diameter, D_o = outer diameter

L_{T-T} = tangent to tangent length

Volume (V_h) of 1 F&D (flanged and dished) head is calculated using the following equation:

$$V_h = 0.0847 D_i^3$$

$d = 0.162\,D_i$, d = the depth of the F&D head

Refer to *Pressure Vessel Design Manual* (Moss, 1987).

Volume (V_c) of conical head is calculated using the following equation:

$V_c = (1/3)(\pi/4)(D_i^2)d$, d = the height of the conical head

V_V = total volume of the vessel (tank) = volume of the cylindrical portion + volume of top head + volume of bottom head.

V_F = Volume of Firewater = Area of Room x fire water spray density x 20 minutes x 1.1 safety factor
(this is calculated only if the room has automatic sprinkler system installed)

V_{SF} = volume of fluid in the space above the top of sump up to the high point slope
(This is calculated only if the floor has sloping segments. Otherwise, $V_{SF} = 0$. Calculation involves 3-D geometry, which is not included here)

H_L = required liner height (measured from top of sump)
= height of high point slope above top of sump + liner height above the high point slope

Total volume of fluid to be contained by the liner = $V_V + V_F$

Out of this volume, an amount of volume equal to V_{SF} is contained in the space between top of sump and high point slope. This height is equal to Δ.

The remaining volume of fluid = $V_V + V_F - V_{SF}$, which is contained by the portion of the liner above the high point slope.

This height of liner above the high point slope = $\dfrac{V_V + V_F - V_{SF}}{Available\ Area\ of\ Room}$

H_L = required liner height above top of sump = $\Delta + \dfrac{V_V + V_F - V_{SF}}{Available\ Area\ of\ Room}$

4.4 Available Area for Liquid Containment

a) For Cells:

To calculate the possible (available) area that the liquid in the vessel could leak into, the sum of the cross sectional areas of the vessels (except the leaking or failing vessel) is subtracted from the cross sectional area of the room. Thus, the

Available area of the room = area of the room minus sum of the cross sectional areas of the vessels (except the leaking vessel) in the room (ft^2).

The height of liner is equal to the volume of the largest vessel divided by the available area of room.

Height of the liner (ft) = volume of the largest vessel / area available

b) For Room L-0218:

Room L-0218 contains 4 pumps and 1 tank. To calculate the possible area that the liquid could leak into, the available volume of the room and the volume of the firewater must be calculated. This is done in four steps, calculating available volume by height.

1. Calculate total (100%) volume of the tank
2. Calculate the volume of available secondary containment coating up to a height of 6"
3. Calculate additional height required to accommodate the remaining tank volume. Volume of the tank minus the volume calculated in step 2 is divided by the available area of the room. The available area of the room in this step is the area of the room above 6" high octagonal pedestal minus the combined cross-sectional area of the four pump pedestals.
4. Calculate the volume of 20 minutes of firewater from the sprinklers multiplied by a safety factor of 1.1. Calculate the height of the containment wall for firewater by dividing the volume of firewater by the available area of the room calculated in Step 3.

The secondary containment wall height required is then: 0.5 ft (= 6", from Step 2) plus additional height of wall (Step 3) plus height required for containment of firewater (Step 4).

5 Calculations

Complete calculations for the liner height are as follows for each individual cell:

5.1 C3/C5 Drain Collection Cell, Room L-B001B, Elevation -21 ft

Vessel Number	Diameter (D_i) ft	L_{T-T} ft	Head Type (Flange and Dished)	Total Height (including bottom and top head) ft	Remark
RLD-VSL-00004	10	11	F&D (bottom and top)	14.24	

Two scenarios are considered:

a Leakage and spillage of the C3/C5 drains/sump collection vessel RLD-VSL-00004

b Collection of fire water runoff when the vessel is full and intact with a safety factor of 1.1

5.1.1 Scenario a

In this scenario, liner height is calculated based on firewater discharge (from the in-cell sprinkler system, for a period of 20 minutes, at a discharge rate of 0.17 gpm / ft^2 using the total floor area of the cell i.e. including vessel cross-sectional area) with a safety factor of 1.1 plus 100% of the vessel volume.

V_V = total volume of vessel RLD-VSL-00004 (using formula given in Section 4.3 above)
= Volume of the cylindrical portion + volume of top head + volume of bottom
= $[\pi/4 \times (10)^2 \times 11] + [0.0847 \times (10)^3] + [0.0847 \times (10)^3]$
= 863.94 + 84.7 + 84.7 = 1033.34, rounded to 1034 ft^3

Available area of the room = (16.58 × 23.33) = 387 ft^2

V_F = volume of fire water from sprinkler system in the cell
= Area of room x fire water spray density x 20 minutes x 1.1 (= safety factor)
= 387 ft^2 × 0.17 gal/min/ft^2 x 20 min x 1.1 = 1447 gal = 193.5 ft^3

V_{SF} = volume of fluid in the space above the top of sump up to the high point slope = 7.9 ft^3

Δ = height of high point slope above the top of sump = 2 in $\approx$ 0.167 ft

$$H_L = \text{required liner height above top of sump} = 0.167\text{ ft} + \frac{1034 + 193.5 - 7.9}{387}\text{ ft} = 3.318\text{ ft}$$

= 3 ft 4 in (rounded to nearest inch).

5.1.2 Scenario b

The firewater runoff volume is conservatively calculated using an area of 3,000 ft^2, sprinkler discharge density of 0.17 gpm / ft^2, for a duration of 20 minutes, with a safety factor of 1.1. (NFPA 13, Standard for the Installation of Sprinkler Systems, 1999).

V_{RF} = Runoff firewater volume = (3,000 ft^2) x (0.17 gpm / ft^2) x (20 minutes) x (1.1) = 11,220 gallons
= 1,500 ft^3.

Using the values of Δ, V_{SF}, and available area of the room from Sec 5.1.1,

H_L = required liner height above top of sump = Δ (= 0.167 ft) + $\dfrac{V_{RF} - V_{SF}}{available\ area\ of\ room}$

$= 0.167 \text{ ft} + \dfrac{1{,}500 - 7.9}{387} \text{ ft} = 0.167 \text{ ft} + 3.855 \text{ ft} = 4.022 \text{ ft} = 4 \text{ ft } 1 \text{ in}$ (rounded to nearest inch).

The greater of the two values (of required liner height) from Sections 5.1.1 and 5.1.2 is taken as the minimum required liner height in this room.

Therefore, the minimum required liner height in the room L-B001B = 4 ft 1 in.

The installed liner height in room L-B001B = 9 ft 6 in.

5.2 Melter 1 and 2 Process Cells, Rooms L-0123 and L-0124, Elevation +3 ft

Room Number	Vessel Number	Outside Diameter (D_o) ft,	Inside Diameter (D_i) ft	$L_{T\text{-}T}$ ft	Total Height (including bottom and top head) ft	Remark
L-0123	LCP-VSL-00001	14.13	14	12.75	17.29	Largest vessel in the room
	LFP-VSL-00001	11.13	11	10.46	14.02	
	LFP-VSL-00002	11.13	11	10.46	14.02	
	LOP-VSL-00001	12.10	12	8.12	12	
	LOP-WESP-00001	8.08	8	17	19	
	LOP-SCB-00001	10.10	10	6.5	9.74	
L-0124	LCP-VSL-00002	14.13	14	12.75	17.29	Largest vessel in the room
	LFP-VSL-00003	11.13	11	10.46	14.02	
	LFP-VSL-00004	11.13	11	10.46	14.02	
	LOP-VSL-00002	12.10	12	8.12	12	
	LOP-WESP-00002	8.08	8	17	19	
	LOP-SCB-00002	10.10	10	6.5	9.74	

note: All vessels have F&D type bottom and top heads.

V_V = volume of largest vessel from table above = volume of cylindrical portion + volume of heads
= [π/4 × $(14)^2$ × 12.75] + [0.0847 × $(14)^3$] + [0.0847 × $(14)^3$]
= 1962.71 + 232.41 + 232.41 = 2427.6 ft^3

Available area of the room = (38.33 × 48.33) – [π/4 × {$(8.08)^2$ + $(11.13)^2$ + $(12.10)^2$ + $(10.10)^2$ + $(11.13)^2$]
= 1411.5 ft^2

V_F = 0 (no sprinklers installed in these rooms)

V_{SF} = volume of fluid in the space above the top of sump up to the high point slope
= 62.1 ft^3

Δ = height of high point slope above the top of sump = 2 ⅞ in ≈ 0.24 ft

H_L = required liner height above top of sump= 0.24 ft + $\frac{2427.6 + 0 - 62.1}{1411.5}$ ft = 1.916 ft
= 1 ft 11 in (rounded to nearest inch).

5.3 Effluent Cell Calculations, Room L-0126, Elevation +3

Room Number	Vessel Number	Diameters (D_o) ft, (D_i) ft	L_{T-T} ft	Head Type	Total Height (including bottom and top head) ft	Remark
L-0126	RLD-VSL-00003	16.13, 16	14.66	Flat top and F&D bottom	18	Both vessels in this room
	RLD-VSL-00005	16.13, 16	14.66	Flat top and F&D bottom	18	

V_V = volume of largest vessel (from the table above)
= volume of the plant wash/SBS condensate collection vessel (RLD-VSL-00003/RLD-VSL-00005)
= volume of cylindrical portion + volume of F&D bottom + volume of flat head (cylindrical) portion
= [π/4 × $(16)^2$ × 14.66] + [0.0847 × $(16)^3$] + [π/4 × $(16)^2$ × {18 –14.66 – (0.162 × 16)}]
= 2947.57 + 346.93 + 150.39
= 3445 ft^3

Available area of the room = (38.33 × 31.33) – [(π/4) $(16.13)^2$}] = 996.54 ft^2

V_F = 0 (no sprinklers installed in these rooms)

V_{SF} = volume of fluid in the space above the top of sump up to the high point slope
= 11.4 ft^3

Δ = height of high point slope above the top of sump = 2 ⅛ in ≈ 0.177 ft

H_L = required liner height above top of sump= 0.177 ft + $\frac{3445+0-11.4}{996.54}$ ft = 3.622 ft
= 3 ft 8 in (rounded to nearest inch).

5.4 Caustic Scrubber Blowdown Pump Room, Room L-0218, Elevation + 28

Caustic Collection Tank, Room L-0218, Elevation +28

Room Number	Tank Number	Diameter (D_i) ft	L_{T-T} ft	Head Type
L-0218	LVP-TK-00001	13	14.33	Flat bottom and conical top with 1: 6 slope

Step 1. Tank volume.

Volume of the tank using the table above
= Volume of the Caustic Collection Tank (LVP-TK-00001)
= Volume of cylindrical portion + Volume of conical head portion
= [(π/4) (13 ft)^2 (14.33 ft)] + [(1/3) (π/4) (13 ft)^2 (1.083 ft)]
= 1,902.054 ft^3 + 47.916 ft^3 = 1,950 ft^3 (rounded to)

Step 2. Containment volume for 6" high wall.

Containment area has 6-in high octagonal pedestal for tank LVP-TK-00001. The distance between the parallel sides of the tank pedestal is 15ft. Each side of the pedestal is 6 ft 2 9/16 in.

Area of the tank pedestal is = 0.5 x 7.5 x 8 x 6.214 = 186.42 ft^2.

Area of the room available for containment up to a height of 6-in is
= Area of the room - Area of the Pump Pedestals - Area of the Tank Pedestal.

Area of the room = (9ft- 2 1/4in) x (21ft- 3in) + (15ft- 3in) x (22ft- 4in) + (5ft- 4 1/4in) x (19ft-3in)
= (110.25in) x (255in) + (183in) x (268in) + (64.25in) x (231in)
= 638.89 ft^2

Area of the Pump Pedestals = 4 x ((2ft- 1in) x (5ft- 3in))
= 4 x (25in x 63in) = 43.75 ft^2

Area of the room available for containment up to a height of 6-in is
= 638.89 ft^2 - 43.75 ft^2 - 186.42 ft^2 = 408.72 ft^2

Volume of liquid contained by 6" high wall = 408.72 ft^2 x 0.5 ft = 204.4 ft^3

Step 3. Containment wall height needed for remaining fluid.

(Note: VSL is credited for containing volume up to a height equal to the wall height i.e. vessel area is included in the available area of the room)

Volume of tank = 1,950 ft^3

Remaining volume of tank to be contained = Volume tank - Volume contained by 6" high wall (7.2)
= 1,950 ft^3 - 204.4 ft^3
= 1745.6 ft^3

Area of the room available for containment is,
= Area of the room above 6in octagonal pedestal - Cross sectional area of the Pump Pedestals
= 638.89 ft^2 - 43.75 ft^2
= 595.14 ft^2

Height of wall needed to contain remaining volume of fluid from the tank
= 1745.6 ft^3 / 595.14 ft^2
= 2.933 ft

The wall height required to contain the leaking fluid from the tank to a height where the balance of fluids remain inside the tank, or a massive failure of the vessel where the leaking fluids flow back into the area of the ruptured tank.

Wall height for fluid containment = 0.5 ft + 2.933 ft = 3.433 ft.

Step 4. Additional wall height required for firewater.

In the event of a fire in the area and the sprinklers come on, the volume of water added to the containment will be based on the firewater spray density of 0.17 gal/min/ft^2 for a time of 20 minutes multiplied by a safety factor of 1.1.

Volume of firewater = Area of containment in ft^2 x 0.17 gal/min/ft^2 x 20 minutes x 1.1
= 638.89 ft^2 x 0.17 gal/min/ft^2 x 20 minutes x 1.1
= 2389.449 gallons
= 319.423 ft^3

Therefore, additional height of wall required to accommodate firewater volume
= Volume of firewater / (Area of the room - area of pump pedestals)

$= 319.423\ ft^3 / (638.89\ ft^2 - 43.75\ ft^2)$
$= 319.423\ ft^3 / (595.14\ ft^2)$
$= 0.537\ ft$

Wall height required to accommodate for firewater = 0.537 ft

Total wall height for worst-case scenario.
Worst-case scenario includes both a rupture of the tank and the accumulation of 20 minutes of firewater.

Containment wall height required = 0.5 ft + 2.933 ft + 0.537 ft = 3.97 ft ≅ 4 ft.

6 Summary

The minimum required liner heights using the method above for the rooms are as follows:

Table of Liner Height

Cell	Room	Required Liner Height above Top of sump (rounded to nearest inch)	Installed Liner Height
C3/C5 Drain Collection Cell	L-B001B	4 ft 1 in	9 ft 6 in
Melter 1 Process Cell	L-0123	1 ft 11 in	2 ft 2 in
Melter 2 Process Cell	L-0124	1 ft 11 in	2 ft 2 in
Effluent Cell	L-0126	3 ft 8 in	4 ft 8 in

Table of Secondary Containment Wall Height with Special Protective Coating

Room	Room Number	Required Liner Height above Top of sump (rounded to nearest inch)	Installed Liner/ Coating Height
Caustic Scrubber Blowdown Pump Room	L-0128	4 ft 0 in	4 ft 0 in

7 References

24590-LAW-P1-P01T-00001, *LAW Vitrification Building General Arrangement Plan at El. -21'0" Rev. 3*

24590-LAW-P1-P01T-00002, *LAW Vitrification Building General Arrangement Plan at El. 3'0" Rev. 5*

24590-LAW-P1-P01T-00004, *LAW Vitrification Building General Arrangement Plan at El. 28'0" Rev. 4*

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Moss, Dennis R. 1987. *Pressure Vessel Design Manual*, Gulf Publishing Co.

24590-WTP-3PS-AFPS-TP006, Engineering *Specification for Field Applied Special Protective Coatings for Secondary Containment.*