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DOCUMENT INFORMATION

Sheet 1 of 1

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- ☒ Pretreatment
- ☐ HLW Vitrification
- ☐ LAW Vitrification
- ☐ Analytical
- ☐ External Interfaces
- ☐ Across all areas

Document is applicable to ALARA? ☐ Yes ☒ No

Applicability to ALARA means that the item has the potential to affect doses, contamination levels, or releases to the environment. (See 24590-WTP-GPP-SRAD-002, *Application of ALARA in the Design Process*, sections 4.1 and 4.2 for more information.)

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Contents

Appendices

1 Introduction

The Washington Administrative Code [WAC 173-303-640(4)(e)] addresses tank systems containing dangerous waste. This code requires that secondary containment systems must be designed to contain 100 % of the capacity of the largest tank within its boundary. Also included in this report is the containment of the fire water discharge, where applicable, within the boundary of the secondary containment.

This report specifically addresses flooding scenarios to be contained within the pretreatment (PT) facility for elevation 0 ft, 0 in. and below and establishes the minimum requirements for secondary containment.

2 Applicable Documents

WAC 173-303. *Dangerous Waste Regulations*. Washington Administrative Code.

3 Description

The PT facility receives low-activity waste (LAW) and high-level waste (HLW) from the Hanford tank farms contractor (TFC). The TFC currently maintains mixed waste for the US Department of Energy (DOE). These wastes are stored in underground storage tanks at the Hanford Site.

The purpose of the PT facility is to prepare the waste received from the TFC and transfer it to the LAW and the HLW vitrification facilities. Within the LAW and HLW vitrification facilities the waste is formed into glass logs for final long-term disposal.

LAW and HLW are pumped through double-walled underground transfer lines to the PT facility. Within the PT facility, the LAW feed is transferred to the waste feed receipt (FRP) vessels (FRP-VSL-00002A/B/C/D), while the HLW feed is sent to the HLW feed receipt vessel (HLP-VSL-00022). These wastes are temporarily stored in the vessels before being pumped and treated by the PT processing equipment.

These vessels are located in "black cells" and are not accessible. The black cells are arranged in a "U" shape around a central "hot cell" in the PT facility, where major processing equipment is located.

The hot cell is remotely maintainable with the use of a crane system. Below the center of the hot cell are 2 adjacent rooms in the deep pit at the -45 ft, 0 in. elevation. This is the low point for the PT facility. Within these rooms are the plant wash and disposal (PWD) ultimate overflow vessel (PWD-VSL-00033) and the HLW effluent transfer vessel (PWD-VSL-00043).

The FRP vessels are the largest in the PT facility. The flood scenario addresses a postulated failure of 1 FRP vessel and the movement of its fluid from a black cell to the hot cell, and then to the -45 ft, 0 in. elevation pit. The flooding scenario also addresses the fire water pit at the -19 ft, 0 in. elevation and areas at the 0 ft, 0 in. elevation, as required, for secondary containment.

3.1 Flooding Volume for -45 ft, 0 in. Elevation Pit

There are 2 rooms at the -45 ft, 0 in. elevation pit; 1 room contains the PWD ultimate overflow vessel and 1 room contains the HLW effluent transfer vessel. Each vessel has a total volume of 5,567 ft^3 and a maximum operating volume of 3,954 ft^3(see Appendix A, section 2). The combined available flood volume of these 2 rooms below the pipe tunnel at the -21 ft, 0 in. elevation is 72,107 ft^3 (see Appendix A, section 7.1). The rooms are hydraulically connected by a 3 ft wide by 8 ft, 6 in. high opening. The 2 vessels are assumed to be full, up to the overflow line, at the time of the postulated flood scenario.

The flood scenario assessed is the postulated failure of a process line in a black cell, allowing material to flow into the hot cell from 1 FRP vessel at the 0 ft, 0 in. elevation. The total volume of 1 FRP vessel is 63,361 ft^3 (see Appendix A, section 2). The entire contents of 1 FRP vessel is assumed to flow into the hot cell, and to travel to a collection drain system. The quantity of liquid retained on the black cell and hot cell floors is ignored for conservatism. The slope of the hot cell floor and drain system divert the waste into the PWD ultimate overflow vessel and the HLW effluent transfer vessel. The volume available to contain the flood in the pit was adjusted to compensate for vessel volumes, grout (used to slope the cell floor), hydraulic connections, submerged equipment, and structures.

The -45 ft, 0 in. elevation rooms interface with 2 piping tunnels: a south tunnel, P-B001 and P-B001A, at the -21 ft, 0 in. elevation; and a north tunnel, P-B004, at the -18 ft, 0 in. elevation. The tunnels provide piping access from the underground transfer lines into the PT facility. The underground piping consists of a series of pipes, each with 2 concentric pipes providing primary and secondary containment. This double-walled pipe ends 1 ft inside the tunnel. Each tunnel is sloped (1 % grade) back to the pit at the -45 ft, 0 in. elevation. The tunnels are not within the secondary containment boundary for the flood scenario, and therefore no volume calculation is required for the tunnels.

Based on the volume available to contain the flood in the pit (72,107 ft^3) and the maximum postulated flood volume (63,361 ft^3), the recommended liner height is 23 ft, 0 in. ht. above top of concrete (see Appendix A, section 7.4).

To accommodate secondary containment of the piping tunnels and the -45 ft, 0 in. elevation pit (rooms P-B002 and P-B003), the stainless steel liner extends up to the tunnel openings. For further details refer to Appendix A.

3.2 Flooding Volume for -19 ft, 0 in. Elevation Pit

The C2 floor drain collection vessel (PWD-VSL-00045) and the C3 floor drain collection vessel (PWD-VSL-00046) each contain a volume of 666 ft^3 (see Appendix B, section 7), and are located in the pit at the -19 ft, 0 in. elevation. The available volume in the pit is approximately 18,026 ft^3 (see Appendix B, Figure B-1).

Flooding volume is calculated from fire water, since it represents a larger volume than either of the vessels in the pit. The drain collection vessels are assumed to be full at the time of a fire. A total of 4,679 ft^3 (see Appendix B, Figure B-1) of fire fighting water would flow into the pit, after overflowing from either of the C2 or C3 drain vessels. A fire fighting sprinkler duration of 30 minutes is used. A flooding volume of 4,679 ft^3 requires a minimum liner height of 4.5 ft (54 in.). The flood volume was adjusted to compensate for vessel volumes, submerged equipment, and structures. For further details refer to Appendix B.

3.3 Flooding Volume for 0 ft, 0 in. Elevation

3.3.1 Black Cells and Hot Cell

The black cells and hot cell are located at the 0 ft, 0 in. elevation and are identified on the PT facility general arrangement drawings. The black cells are located around the hot cell and provide enclosure for mixed waste vessels. Hydraulic connections between black cells, and between selected black cells and the hot cell, are used to cascade flow between cells once the black cell holdup volume is exceeded. The black cell floors and lower portions of the walls have stainless steel liners to provide secondary containment.

In order to evaluate the required liner height, a maximum proposed leak rate was established. The maximum leak rate scenario is the failure of the largest nozzle at the lowest point on the largest vessel in a containment area. Under this condition, the calculated leak rate is 885 gallons per minute (gpm) at the moment of the break (see Appendix C, section 7.1). As the level of the tank decreases, the leak rate decreases markedly. However, for conservatism, the peak flow rate is assumed throughout this scenario.

The calculated leak flow rate of 885 gpm will flow from one black cell to the next cell and finally into the hot cell. As the liquid level cascades from cell to cell, a liquid level differential occurs between the cells such that the flow of 885 gpm is maintained. This liquid differential is due to head losses through the hydraulic connections. The liquid level in the hot cell is lower than the level in the preceding black cells. To accommodate the maximum flow rate, each black cell-to-black cell and the black cell-to-hot cell hydraulic connections are provided with four 6 in. diameter pipes (see Appendix C, Figure C-3). The highest liquid level in the cells determines the height of the liner. Therefore, the top of the liner is at 2 ft, 1 in. (25 in.) elevation for both the hot cell and the black cells.

Each black cell is provided with a level detection sump and an emptying ejector. Fluids from all black cell sumps are pumped by a steam ejector into the plant wash vessel (PWD-VSL-00044) located at the 0 ft, 0 in. elevation.

The black cell floor liner is sloped toward several low-point sumps with level detection and steam ejectors. These ejectors discharge into the PWD plant wash vessel. There are 4 access openings from the hot cell floor into the -45 ft, 0 in. elevation. Around the perimeter of the hot cell access opening to the pit is a curb and gutter arrangement. Drain lines in the curbs around the access openings allow liquid to drain from the hot cell floor into the PWD ultimate overflow vessel. The top of the liner is at 2 ft, 1 in. (25 in.) elevation. The curb height around the opening in the hot cell floor also is at 2 ft, 1 in. (25 in.) elevation.

The maximum postulated flood considered is the total volume of 1 FRP vessel (63,361 ft^3) released to the associated black cell. After the liquid fills the cell, to the bottom of the hydraulic connections, it flows to the adjacent black cells and the hot cell. The liquid level in the hot cell, after reaching the top of the curb and gutter, cascades through the drain lines in the curbs around the access openings into the HLW effluent transfer vessel. Once the HLW effluent transfer vessel is full, liquid will flow into the PWD ultimate overflow vessel through the common overflow line between the vessels. With both vessels full, the liquid overflows into the pit. For further details refer to Appendices A and C.

3.3.2 Room P-0118

Room P-0118 is located in the northeast quadrant of the PT facility at elevation 0 ft, 0 in. It contains 3 vessels and associated pumps. The 3 vessels are the radioactive liquid waste disposal (RLD) alkaline effluent vessels (RLD-VSL-00017A/B) and the treated LAW evaporation process (TLP) condensate vessel (TLP-VSL-00002).

A stainless steel liner provides secondary containment to accommodate the total volume of the largest vessel (5,741 ft^3; see Appendix D, section 2) in the area, plus 20 minutes of fire sprinkler water. The liner height is 66 in. (5 ft, 6 in.) above the floor.

Sump PWD-SUMP-00036, which is provided with a level detection instrument and an emptying ejector to remove the contained liquid, is located in room P-0118. Fluid released or spilled into the room is detected in the low-point sump and pumped by an ejector to the PWD plant wash vessel, via a breakpot. The sump is located in the southeast corner of room P-0118. For further details refer to Appendix D.

3.3.3 Rooms P-0105, P-0105A, P-0105B, and P-0105C

Rooms P-0105, P-0105A, P-0105B, and P-0105C are located in the southwest quadrant of the PT facility and contain 1 waste feed evaporation process (FEP) condensate vessel (FEP-VSL-00005), a bulge, and various equipment. The area is composed of 4 connected rooms bordered by the black cells on one side and the corridor on the other side. Floor drains are provided to move any release or spill into the C3 floor drain collection vessel, located at the -19 ft, 0 in. elevation.

The postulated flood volume, for this containment area, is the total volume of the FEP vessel plus 20 minutes of fire sprinkler water. A curb has been provided between this containment area, the PC0101 corridor, room P-0107, and room P-0103. The floor and the curbing of the rooms are lined with an appropriate special protective coating to a minimum height of 3 in. For further details refer to Appendix E.

Appendix A

Flood Volume Calculation for PT Pit at -45 ft, 0 in. Elevation

1 Objective

Determine the liner elevation for rooms P-B001, P-B001A, P-B002, P-B003, and P-B004 in the pretreatment (PT) facility.

2 Inputs

The following inputs are used in the determination of the liner elevation for rooms P-B001, P-B001A, P-B002, P-B003, and P-B004.

- Total volume of 1 FRP vessel (FRP-VSL-00002A) is equal to 474,000 gallons (63,361 ft^3).
- Total volume of each of the PWD ultimate overflow and HLW effluent transfer vessels (PWD-VSL-00033 and PWD-VSL-00043) is equal to 41,650 gallons (5,567 ft^3). The maximum operating volume (MOV), or volume below the overflow level for each of the vessels is 29,580 gallons (3,954 ft^3).

Dimensions and details of the building.

- The dimensions of rooms P-B002 and P-B003 are 35.5 ft by 49 ft and 35.5 ft by 49 ft, respectively.
- The available volume is the space from the -45 ft, 0 in. elevation pit floor to the -21 ft, 0 in. elevation tunnel.
- The hydraulic opening connecting rooms P-B002 and P-B003 is 3 ft wide by 8 ft, 6 in. high in a 6 ft thick wall separating the 2 rooms.

3 Background

The black cells consist of the following rooms: P-0102, P-0102A, P-0104, P-0106, P-0108, P-0108A, P-0108B, P-0108C, P-0109, P-0111, P-0112, P-0113, P-0114, P-0117, and P-0117A.

The hot cell consists of only 1 room: P-0123.

The -45 ft, 0 in. elevation pit consists of rooms P-B002 and P-B003. Connecting to rooms P-B002 and P-B003 are 2 pipe tunnels. The south tunnel (rooms P-B001 and P-B001A) is located at the -21 ft, 0 in. elevation while the north tunnel (room P-B004) is located at the -18 ft, 0 in. elevation.

The secondary containment in the PT facility is designed and operated to contain 100 percent of the capacity of the largest tank within its boundary. This calculation determines the flood volume and assesses the effects on the PT facility. The liner height for rooms P-B001, P-B001A, P-B002, P-B003, and P-B004 is based on the calculated flood volumes.

The flood scenario assumes the total volume of 1 FRP vessel is released into 1 of the black cells. The postulated flood volume is determined by using the total volume (volume of the shell and both heads) for the largest vessel (FRP-VSL-00002A) in the containment area.

Hydraulic openings between the black cells and the hot cell allow the flood to move into the hot cell and travel to the -45 ft, 0 in. elevation pit.

A curb and gutter arrangement is provided in the hot cell that will allow liquid to move from the floor of the hot cell to the PWD vessels in the –45 ft, 0 in. elevation pit.

The flood travels from the black cells, into the hot cell, through the curb and gutter collection system, and into the HLW effluent transfer vessel (PWD-VSL-00043). Once the capacity of the vessel is reached, an overflow line allows the flood to move into the PWD ultimate overflow vessel (PWD-VSL-00033). When the maximum operating volume (MOV) of both vessels is reached, an overflow line directs the flood into rooms P-B002 and P-B003, where a sump and leak detection system are located. The full volume is assumed to move into rooms P-B002 and P-B003.

The tunnels provide containment for the waste transfer lines that are routed through the tunnels. These tunnels are sloped to the pit at a 1 % grade and are provided with stainless steel floor and wall lining for containment of leaks and spills.

4 Applicable Codes and Standards

- WAC 173-303. *Dangerous Waste Regulations.* Washington Administrative Code.
- UBC 1997. *Uniform Building Code,* International Conference of Building Officials, Whittier, California, USA.

5 Methodology

In order to calculate the liner elevations the following is determined:

1 The area and available volume for rooms P-B002 and P-B003.
2 The volume of the maximum postulated flood.
3 The depth of the maximum postulated flood in rooms P-B002 and P-B003.
4 The minimum liner height for rooms P-B002 and P-B003 from the depth of the maximum postulated flood.
5 The liner height for the pipe tunnels (rooms P-B001, P-B001A, and P-B004).

6 Assumptions

6.1 Assumptions Not Requiring Verification

- The postulated flood is the total volume (63,361 ft^3) for 1 of the FRP vessels (FRP-VSL-00002A).

- It is assumed that, at the time of the postulated flood, the 2 vessels (PWD-VSL-00033 and PWD-VSL-00043) in the -45 ft, 0 in. elevation pit are full up to the MOV.

6.2 Assumptions to be Verified

- Associated equipment, vessel shells, piping, and supports are estimated to displace 1 % of the postulated flood volume.

7 Calculations

7.1 Determine the Area and Available Volume of Rooms P-B002 and P-B003

The total combined area for rooms P-B002 and P-B003 is:

(35.5 ft × 49 ft) + (35.5 ft × 49 ft) = 3,479 ft^2.

The available height, at top of concrete, is:

(-21 ft, 0 in. el.) - (-45 ft, 0 in. el.) = 24 ft.

The volume of the connection opening between P-B002 and P-B003 (see Figure A-2) is:

3 ft × 8.5 ft × 6 ft = 153 ft^3.

The volume of the grout in the pit (see Figure A-2) is conservatively calculated as 2,760 ft^3. This is rounded up to 3,000 ft^3 (Note: This volume is not available for containment).

The displaced volume of submerged piping, vessel shells, supports, and equipment (1 % of the postulated flood volume of 63,361 ft^3) is 634 ft^3.

The maximum operating volume (MOV), or volume below the overflow level for each of the PWD vessels, is 3,954 ft^3. There are 2 vessels (PWD-VSL-00033 and PWD-VSL-00043).

The total available volume in rooms P-B002 and P-B003 below the -21 ft, 0 in. el. pipe tunnel is calculated by taking the combined area of rooms P-B002 and P-B003 multiplied by the available height to the tunnel, plus the volume of the connection opening, minus the grout volume, minus the displaced volume of submerged equipment, minus the maximum operating volume for the 2 vessels. This is calculated as:

(3,479 ft^2 × 24 ft) + 153 ft^3 - 3,000 ft^3 - 634 ft^3 – (2 × 3, 954 ft^3) = 72,107 ft^3.

7.2 Determine the Volume of the Maximum Postulated Flood

The maximum postulated flood volume is the total volume of 1 FRP vessel (FRP-VSL-0002A). This is:

63,361 ft^3.

7.3 Determine the Height of the Maximum Postulated Flood in Rooms P-B002 and P-B003

The differential volume between the total available volume and flood volume is:

(72,107 ft^3 - 63,361 ft^3) = 8,746 ft^3.

The differential height between the total available volume and the flood volume is:

(8,746 ft^3/3,479 ft^2) = 2 ft, 6 in. differential ht.

The flood elevation is:

(-21 ft, 0 in. el. - 2 ft, 6 in. differential ht.) = -23 ft, 6 in. el.

Therefore, the height of the maximum postulated flood, above top of concrete is:

(-23 ft, 6 in. el.) - (-45 ft, 0 in. el.) = 21 ft, 6 in. ht.

7.4 Determine the Liner Height for Rooms P-B002 and P-B003

The flood elevation is -23 ft., 6 in. el. For conservatism, it is recommended the liner elevation be -22 ft, 0 in. el. (liner height of 23 ft, 0 in. ht. above top of concrete). In addition, where the pit and tunnels interface, the pit liner will extend beyond this recommended height and join with the tunnel liners.

7.5 Determine the Recommended Liner Height for Rooms P-B001, P-B001A, and P-B004

The postulated flood level does not reach the pipe tunnel at the -21 ft, 0 in. elevation. Double containment of the transfer lines, located in the pipe tunnel, ends 1 ft into the building and single walled lines extend throughout the remainder of the tunnels and pit. As a result, secondary containment for leaks and spills from these lines is provided by a stainless steel liner. For these reasons, it is recommended that 100 percent of the floors and walls be lined for the south tunnel (rooms P-B001 and P-B001A) and the north tunnel (room P-B004).

8 Results and Conclusion

The maximum flood elevation for rooms P-B002 and P-B003 is -23 ft, 6 in. el. It is conservatively recommended that the liner height be 23 ft, 0 in. ht. above top of concrete. This corresponds to a liner elevation of -22 ft, 0 in. el.

The pit wall liner will be extended beyond this recommended height at the pit and tunnel interfaces to join with the tunnel liners.

The floors and walls of the south tunnel (rooms P-B001 and P-B001A) and the north tunnel (room P-B004) will be fully lined.

9 List of Figures and Tables

Figure A-1 Simplified PT Building Layout at -45 ft, 0 in. Elevation

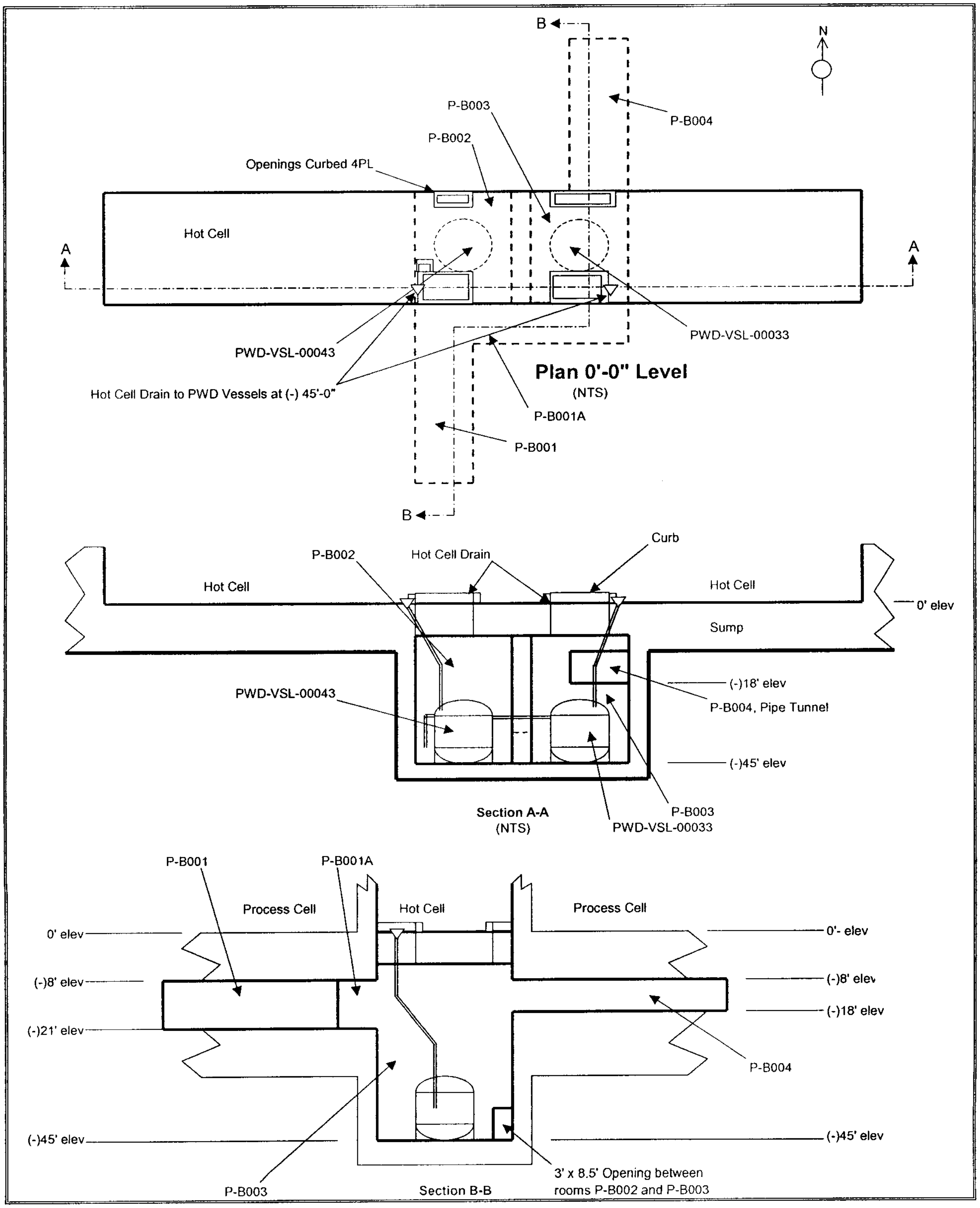
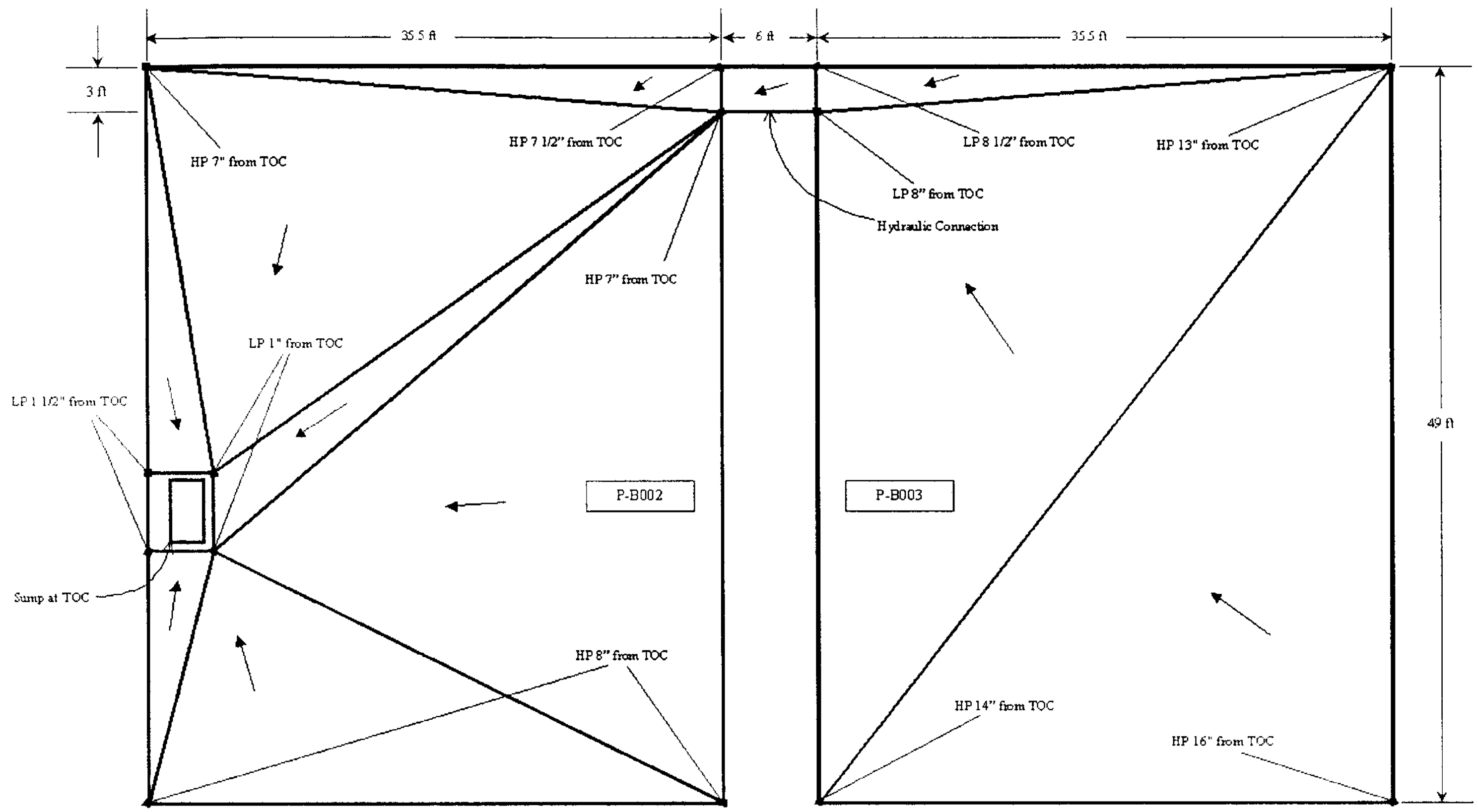


Figure A-2 Grout Volume for Rooms P-B002 and P-B003



<u>Estimated Average Grout Depth</u>
Room P-B002: 2/3 × (8 in. – 1 in.) + 1 in. = 5.67 in. = 0.47 ft
Hydraulic Connection: 8.00 in. = 0.67 ft
Room P-B003: 2/3 × (16 in. – 8 in.) + 8 in. = 13.33 in. = 1.11 ft

<u>Volume of Grout</u>
(35.5 ft × 49 ft × 0.47 ft) + (3 ft × 6 ft × 0.67 ft) + (35.5 ft × 49 ft × 1.11 ft) = **2,760 ft^2**

Appendix B

Flood Volume Calculation for PT Pit at -19 ft, 0 in. Elevation

1 Objective

Determine the minimum liner height for room P-B005 at the -19 ft, 0 in. elevation C2/C3 floor drain pit within the pretreatment (PT) facility.

2 Inputs

- Room P-B005 is 49 ft long by 22 ft wide, and 8 ft long by 17 ft wide (see Figure B-1).
- The floor-to-ceiling height is 16 ft.

From the PT vessel data sheets and equipment assembly drawings:

- C2 floor drain collection vessel (PWD-VSL-00045) has a total volume of 4,982 gallons, 8 ft ID by 10 ft, 7 in. Tan/Tan, with 2:1 semi-elliptical heads.
- C3 floor drain collection vessel (PWD-VSL-00046) has a total volume of 4,982 gallons, 8 ft ID by 10 ft, 7 in. Tan/Tan, with 2:1 semi-elliptical heads.
- The saddles for both vessels maintain vessel bottom elevations of 1 ft, 0 in. above the floor.

3 Background

Fire-fighting sprinklers are to be located in the C2 and C3 areas of the PT facility. In the event of a fire, a large amount of fire fighting water must be collected and contained within the building. The floor drain system will route the water into the -19 ft, 0 in. elevation pit. This pit will be lined with an appropriate special protective coating.

The C2 floor drain collection vessel (PWD-VSL-00045) and the C3 floor drain collection vessel (PWD-VSL-00046) are provided to collect water from fire fighting. During normal operating conditions, the floor drains collect other surface water such as from a safety shower. Both are located in the -19 ft, 0 in. elevation pit. The capacity of both these vessels is adequate for normal operations. During the design basis fire accident, the volume of fire fighting water is estimated to be 35,000 gallons. This exceeds the capacities of both vessels, therefore each vessel is provided with an overflow into the -19 ft, 0 in. elevation pit. For conservatism, this calculation assumes these vessels will be full at the time of the event. This calculation demonstrates that this pit has ample capacity to contain this volume of fire fighting water.

4 Applicable Codes and Standards

- WAC 173-303. *Dangerous Waste Regulations*. Washington Administrative Code.
- UBC 1997. *Uniform Building Code,* International Conference of Building Officials, Whittier, California, USA.
- NFPA 801. *Standard for Fire Protection for Facilities Handling Radioactive Materials,* National Fire Protection Association, 1998 Edition.

5 Methodology

- The total flood volume is divided by the floor area to obtain the height of the flood water.
- The total flood volume is adjusted to account for both the submerged portions of the vessels and the estimated volume of the submerged piping, supports, and equipment.
- To determine the volume of the submerged portion of the vessels, the height of the total flood volume must be known. Therefore, an iterative calculation method will be used to solve for the height.
- The calculated height, once determined, is rounded up to the nearest 1/2 ft.

6 Assumptions

6.1 Assumption Not Requiring Verification

- The C2 floor drain collection vessel (PWD-VSL-00045) and the C3 floor drain collection vessel (PWD-VSL-00046) are assumed to be full at the time of the event.
- The duration of sprinklers operating is 30 minutes. This is based on the requirements for drainage of the effected area of the facility to be sized to accommodate this duration of time.

6.2 Assumption to be Verified

- The volume of the submerged piping, supports, and equipment is estimated to be 5 % of the combined vessel volumes.
- The sprinkler flow rate density is 0.2 gallons per minute (gpm) per ft^2. This is conservative and bounding, based on engineering judgement for the entire facility.
- The operating area for sprinklers is 3,000 ft^2.
- An estimated hydraulic imbalance factor of 1.4 is used for the sprinkler density. This is conservative and bounding, based on engineering judgement.
- Additional water from a hose stream is 250 gpm for the sprinklers operating duration.

7 Calculations

The volume of each vessel is 4,982 gallons (see Appendix B, page B-4). This converts to:
(4,982 gal) / (7.48 gal/ft^3) = 666 ft^3.

The total fire-fighting water collection volume is calculated as follows:

- Sprinklers: (0.2 gpm per ft^2) × (3000 ft^2) × (30 min) × (1.4 factor for hydraulic imbalance) = 25,200 gallons
- Hose Stream: (250 gpm) × (30 min) = 7,500 gallons

Total = 32,700 gallons

Rounded up to = 35,000 gallons

This converts to 4,679 ft^3 (see Appendix B, page B-4).

The combined floor surface area of room P-B005 is 1,214 ft^2 (see Appendix B, page B-4).

The volume of the submerged portions of piping, supports, and equipment, 67 ft^3 (498 gallons), is 5% of the total combined volume for vessels PWD-VSL-00045 and PWD-VSL-00046 (see Appendix B, page B-4).

Using an iterative calculation method, the submerged volume of the vessels is calculated to be 521 ft^3 (3,872 gallons).

The adjusted total volume is the sum of these 3 volumes: 4,679 ft^3 + 67 ft^3 + 521 ft^3 = 5,267 ft^3.

This adjusted total volume divided by the combined floor surface area of room P-B005 yields the calculated flood height: (5,267 ft^3) / (1,214 ft^2) = 4.3 ft. Rounding up to the nearest 1/2 ft yields 4.5 ft or 54 in. for the calculated flood height.

8 Results and Conclusion

The minimum required liner height for room P-B005 at the -19 ft, 0 in. elevation is 54 in.

9 List of Figures

Figure B-1. Estimate of Liquid Level in the C2/C3 Floor Drain Pit Room P-B005.

Figure B-1 Estimate of Liquid Level in the C2/C3 Floor Drain Pit Room P-B005

Assumptions:
Design fire load = 35,000 gal
1 ft^3 = 7.481 gal

Room Dimensions 49'-0" X 22'-0",
and 17'-0" X 8'-0", see Figure (1)
All Vessels and piping full at time of fire

Volume of Fire Water:

35,000	gal =
4,679	ft^3

Flooded Area Dimensions:

49	ft Length 1
22	ft Wide 1
8	ft Length 2
17	ft Wide 2
1,214	ft^2 (Pit Area)
16	ft Height

Vessel Data: (one vessel)

4,982	gal = Vessel total volume
96	in = Vessel diameter (D)
175	in = Vessel length (Crown to Crown)
127	in = Vessel length (Tan to Tan)
12	in = Height of vessel saddle

Estimated deduction of submerged piping, supports, and equip.:

66.6	ft^3 (5% of the Total combined volume of
498	gal each vessel; 2 x 666 ft^3)

18,026	ft^3 equal the available volume in the pit

Estimates:

52.02	(in) = Estimated height of water in Pit
52.02	(in) = Calculated height of water in Pit

Determine deductions for submerged vessels:

40.02	(in) = h of vessel under water
362,919	(in^3) = Volume of a Shell under water
43,620	(in^3) = Volume of a Head under water

900,318	(in^3) = Total volume of vessels under water	(two vessels)
3,898	(gal) = Total volume of vessels under water	(two vessels)
521	(ft^3) = Total volume of vessels under water	(two vessels)

588	(ft^3) = Total deductions
4,396	gal

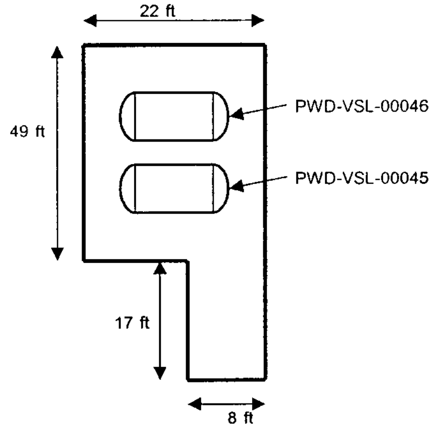


Figure (1), C2/C3 Floor Drain Pit (Plan)
NTS

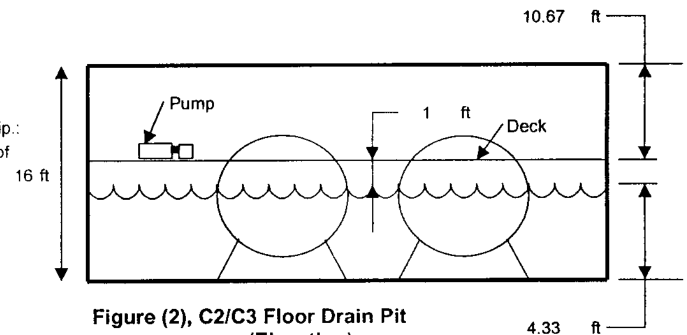


Figure (2), C2/C3 Floor Drain Pit (Elevation)
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Appendix C

Flood Volume Calculation for PT (Hot Cell and Black Cells) at 0 ft, 0 in. Elevation

1 Objective

Determine the minimum required liner elevation in the hot cell, the black cells, and curbing around the access openings in the hot cell floor of the pretreatment (PT) facility at elevation 0 ft, 0 in. Verify the design of the hydraulic connections, as shown in Figure C-3, are adequate to account for the flooding case analyzed.

2 Inputs

The following general inputs apply to the physical dimensions of the cell and vessel data

- The width of the wall between rooms P-108A and P-108B is 2 ft, 3 in.
- The width of the wall between rooms P-108 and P-108A is 4 ft.
- The width of the wall between room P-108B and the hot cell is 3 ft.
- The largest side-mounted nozzle on vessel FRP-VSL-00002A (N63) is a 4 in. sch 160 pipe connection with an inside diameter (d) of 3.438 in. (0.2865 ft).

The following general inputs apply to physical constants and properties:

- The acceleration of gravity (g) is 32.2 feet per second-second (ft/s^2).
- The absolute viscosity (μ) and weight density (ρ) of water at 60 °F and 1 atm are 1 centipoise (cp) and 62.4 lbs/ft^3, respectively.

3 Background

Secondary containment in the black cells and hot cell areas is designed with hydraulic connections. The purpose of these connections is to allow large amounts of fluid to move from the black cells into the hot cell and subsequently drain into the – 45 ft, 0 in. elevation pits. The size of the postulated flood is defined as the total volume (capacity of the shell and both heads) of the largest vessel in the containment area.

The cell-to-cell hydraulic connections in the PT Facility have been placed to create black cell containment areas (see Figure C-1). Should a leak occur, the spill will spread into each room of the black cell containment areas before eventually spreading into the hot cell. The cells on the south side of the hot cell, P-0102, P-0102A, P-0104, and P-0106, are connected to create one black cell containment area. The cells on the north side of the hot cell, P-0109, P-0111, P-0112, P-0113, P-0114, P-0117, and P-0117A, form another containment area. The cells containing the FRP vessels, P-0108, P-0108A, P-0108B, and

P-0108C, also form a containment area. The pits below the 0 ft, 0 in. elevation form a collection area for major leaks and spills.

A curb and gutter system is provided to facilitate the flow of fluid from the hot cell into the drains that convey the fluid to the vessels in the –45 ft, 0 in. elevation pits. See Figure C-1 for an illustration of a typical configuration of the curb and gutter system.

The black cells consist of rooms P-0102, P-0102A, P-0104, P-0106, P-0108, P-0108A, P-0108B, P-0108C, P-0109, P-0111, P-0112, P-0113, P-0114, P-0117, and P-0117A. The hot cell consists of only room P-0123.

This calculation determines the minimum liner height for the black cells and hot cell by addressing a steady-state condition for the emptying of the postulated flood volume. A minimum curb height will also be determined and verification of the hydraulic connections between cells.

4 Applicable Codes and Standards

- NA

5 Methodology

5.1 Determine a Maximum Leak Rate

The first step in determining the steady-state condition, which dictates the liner height for the hot cell and black cells, is to calculate the maximum flow rate entering the greater containment area. The flood scenario is the emptying of the total volume of the largest vessel in the containment area (1 FRP vessel FRP-VSL-00002A)).

The greatest flow rate entering the containment area is the maximum leak rate from FRP-VSL-00002A (see Figure C-2). The solution for the leak rate is an iterative process, where first the velocity of the flow is estimated, and then the Reynolds number is calculated using equation 1.

$$Re := 123.9\frac{\rho \cdot v \cdot d}{\mu}$$ Reynolds number (Equation 1).

The friction factor is then derived from the Reynolds number using Figure C-4 and the resistance coefficient for flow through the pipe (Equation 2) is solved.

$$K := f \cdot \frac{L}{D}$$ resistance coefficient (Equation 2).

Next, the resistance coefficients for flow through the pipe, entrance and exit losses, are summed to determine the total resistance coefficient (Equation 3). The result of equation 3 is the maximum leak rate from FRP-VSL-00002A.

Maximum leak rate (Equation 3).

$$Q := 19.65 \cdot d^2 \cdot \sqrt{\frac{h}{K}}$$

Lastly, the flow rate is divided by the pipe area, using consistent units, to verify the initial estimated velocity and iterated as required.

The following nomenclatures are defined for equations 1, 2, and 3 above:

- Q = flow rate through a failed nozzle (gpm).
- K = resistance coefficient.
- d = internal diameter of nozzle or pipe (in).
- h = static head of the fluid above the outlet nozzle (ft).
- ρ = weight density of fluid (lbs/ft^3).
- v = mean velocity of flow (ft/s).
- μ = absolute (dynamic) viscosity (cp).
- f = friction factor.
- D = internal diameter of pipe (ft).
- L = length of pipe (ft).

5.2 Determine the Maximum Level of Fluid in Black Cells and Hot Cell

The maximum level of fluid in the black cells and hot cells is the level at which the fluid migrates through the hydraulic connections, the curb and gutter system, and into the pit at a flow rate equal to the maximum leak rate.

The details of the black cell-to-hot cell connections are shown in Figure C-3. The required velocity through the connections is solved by converting the leak rate from gpm to ft^3/sec. Next divide by the total area of the hydraulic connection openings. Solve for the fluid depth as required. Solve equation 4 for the entrance and exit losses and equation 5 for the loss in the length of pipe. The sum of these losses, when added to the elevation of the center of the black cell to hot cell connections, then determines the maximum fluid depth that the flood will reach in room P-108B.

$$h := K \cdot \frac{v^2}{2g}$$ The entrance and exit losses (Equation 4).

$$h := f \cdot \frac{L}{D} \cdot \frac{v^2}{2g}$$ Darcy's equation for losses in piping (Equation 5).

The following are defined for the above equations 4 and 5:

- h = static head of the fluid above the outlet nozzle (ft).
- K = resistance coefficient.
- v = mean velocity of flow through pipe (ft/s).
- f = friction factor
- D = internal diameter of pipe (ft).

L = length of pipe (ft).
g = acceleration of gravity (32.2 ft/s^2).

Due to the pressure drops for flow through the black cell to black cell connections, a higher level is present in room P-108A. Because of the similarities between connections, the velocity, friction factor, diameter, and the results of equation 4 remain the same. Input of the correct wall width as the length of pipe to equation 5 gives the head loss due to flow. Adding the results of equation 4 and 5 to the elevation of fluid in room P-108B will yield the elevation of fluid in room P-108A. These steps are repeated to find the elevation of fluid in room P-108, the maximum flood elevation in the hot cell and black cells.

6 Assumptions

6.1 Assumptions Not Requiring Verification

- The maximum postulated flood is the total volume of 1 of the FRP vessels (FRP-VSL-00002A/B/C/D).
- The nature of the leak calculated is the shearing of the largest nozzle (N63) at the lowest part of the FRP vessel FRP-VSL-00002A. The leak rate is assumed to be sustained as the vessel empties.
- The liquid fluid properties has the same properties as water. Using fluid properties of water instead of the waste properties entail less flow resistance and therefore higher flow rate.
- All piping have properties similar to commercial steel pipe with a relative roughness of 0.00052 for 4 in sch 160 pipe and a relative roughness of 0.0003 for 6 in sch 40 pipe.
- The flow path neglects those hydraulic connections which would carry additional fluid to room P-108C.

6.2 Assumptions to be Verified

- The amount of liquid head (h) across the failed nozzle, where the leak takes place, is the height from the nozzle to the top of the vessel shell is 34.7 ft.
- The length of pipe extending into FRP-VSL-00002A from nozzle N63 is estimated (see Figure C-2) at a length (L) of 10 ft.
- The Hydraulic connection configuration is illustrated in Figures C-1 and C-3.
- The elevations of the center line of the hydraulic connections are 19 in. for black cell to hot cell and 16 in. for other black cell to black cell connections.
- Inside diameter (d_h) of the hydraulic connections from cell to cell is 6.065 in. (6 in. sch 40).

7 Calculations

7.1 Maximum Leak Rate

The initial flow velocity through the pipe and nozzle is v_1 = 30.6 ft/s. This is verified through iteration, as required. The inside diameter (d) of the 4 in sch 160 pipe and properties of the liquid are stated in the inputs and assumptions, sections 2 and 6, respectively.

The Reynolds number (Equation 1) is calculated as follows:

$$Re := 123.9\frac{\rho \cdot v_1 \cdot d}{\mu}$$ Hence, Re = 8.134 x 10^5

This corresponds to a friction factor (f) of 0.0175 using the above Reynolds number and Figure C-4.

The resistance coefficient (Equation 2) for flow through the hydraulic connection pipe is determined using the length of pipe extending into FRP-VSL-00002A from nozzle N63 of 10 ft, the internal diameter of the FRP nozzle 0.2865 ft (4 in. sch 160), and a friction factor of 0.0175 (as stated above).

$$K_p := f \cdot \frac{L}{D}$$ Hence, $K_p = 0.611$

The resistance coefficient for entrance losses with an inward projecting pipe is equal to $K_0 = 0.78$, while the exit losses is $K_1 = 1$.

The sum of the resistance coefficients is $K = K_p + K_0 + K_1 = 2.39$

Using the fluid head (h) of 34.7 ft and the diameter of the FRP nozzle (N63), the maximum leak rate (equation 3) is as follows:

$$Q := 19.65 \cdot d^2 \cdot \sqrt{\frac{h}{K}}$$

Hence, Q = 884.81 gpm. Converting (Q) to ft^3/s results in q = 1.97 ft^3/s.

Dividing the maximum leak rate by the internal area of the 4 in sch 160 (area is 0.0645 ft^2), the flow velocity is calculated and compared against an initial estimate of 30.6 ft/s.

$$v := \frac{q}{A}$$ Hence, v = 30.5 ft/s.

Therefore, the calculated maximum leak rate matches the original assumption and is the solution.

7.2 Maximum Fluid Level

The flow velocity through the hydraulic connections is determined using the calculated flow rate (q = 1.97 ft^3/s) and dividing by the internal area of the 6 in sch 40 pipe ($A_h = 0.2006$ in) and the number of pipes connecting one black cell containment area to the hot cell (n = 4).

$$v_h := \frac{q}{n \cdot A_h}$$ Flow velocity through are hydraulic connection is $v_h = 2.5$ ft/s.

Summing the entrance loss coefficient for sharp entrances ($K_{0h} = 0.5$) and exit loss ($K_{1h} = 1$) results in the loss through the four hydraulic connections as $K_h = K_{0h} + K_{1h} = 1.5$.

The head loss due to the entrance and exit losses (Equation 4) is then determined as follows:

$$h_0 := K_h \cdot \frac{v_h^2}{2g}$$

Hence, $h_0 = 0.15$ ft.

Using the same methodology as for the FRP nozzle, the Reynolds number (Equation 1) of flow through the hydraulic connections is determined. The inside diameter (d_h) and properties of the liquid are stated in the inputs and assumptions sections 2 and 6, respectively.

$$Re_h := 123.9 \frac{\rho \cdot v_h \cdot d_h}{\mu}$$

Hence, Re = 1.172×10^5.

This corresponds to a friction factor (f_h) of 0.0192 using the above Reynolds number and Figure C-4.

The head loss (Equation 5) through the hydraulic connections is determined using the friction factor (f_h), the width of wall between P-108B and the hot cell ($L_h = 3$ ft), the hydraulic pipe diameter ($D_h = 0.5054$ ft), gravity, and the flow velocity ($v_h = 2.5$ ft/s).

$$h_p := f_h \cdot \frac{L_h}{D_h} \cdot \frac{v_h^2}{2g}$$

Hence, $h_p = 0.011$ ft.

The elevation at the center line of black cell to hot cell connections, see section 6, is $E_{hc} = 19$ in. The fluid elevation relative to 0 ft, 0 in. in cell P-108B required to sustain flow to the hot cell is then calculated as follows:

$E = (h_0 + h_p) \times 12$ in. $+ E_{hc} =$ 20.9 in.

The head loss (Equation 5) between walls P-108A and P-108B (width of wall is $L_{8a} = 2.25$ ft) through the pipe is:

$$h_{8a} := f_h \cdot \frac{L_{8a}}{D_h} \cdot \frac{v_h^2}{2g}$$

Hence, $h_{8a} = 0.008$ ft.

The fluid elevation relative to 0 ft, 0 in. in cell P-108A required to sustain flow to P-108B at level calculated above is $E_{8a} = (h_0 + h_{8a}) \times 12$ in. + E = 22.7 in.

By changing only the width of the wall ($L_8 = 4$ ft), the head loss between P-108 and P-108A is determined using Equation 5.

$$h_8 := f_h \cdot \frac{L_8}{D_h} \cdot \frac{v_h^2}{2g}$$

Hence, $h_8 = 0.015$ ft.

The fluid elevation relative to 0 ft, 0 in. in cell P-108 required to sustain flow to P-108A at a level calculated above is $E_8 = (h_0 + h_8) \times 12$ in. $+ E_8 = 24.7$ in.

8 Results and Conclusion

The maximum fluid elevation has been calculated to be approximately 24.7 in. above the top of the concrete floor at elevation 0 ft, 0 in. It is recommended that the liner for the black cells and hot cell extend to 25 in from elevation 0 ft, 0 in. In addition, the curbs, which interface with the liner, are also recommended to be placed at an elevation of 25 in. Therefore, the minimum required liner elevation in the hot cell, the black cells, and required curb height for the PT facility is 25 in. above the 0 ft, 0 in. elevation.

The adequacy of the hydraulic connections to dissipate a potential flood has been demonstrated. The design of the hydraulic connections are recommended to be configured as shown in Figures C-1 and C-3.

9 List of Figures

Figure C-1 Hydraulic Connections at Elevation 0'-0"

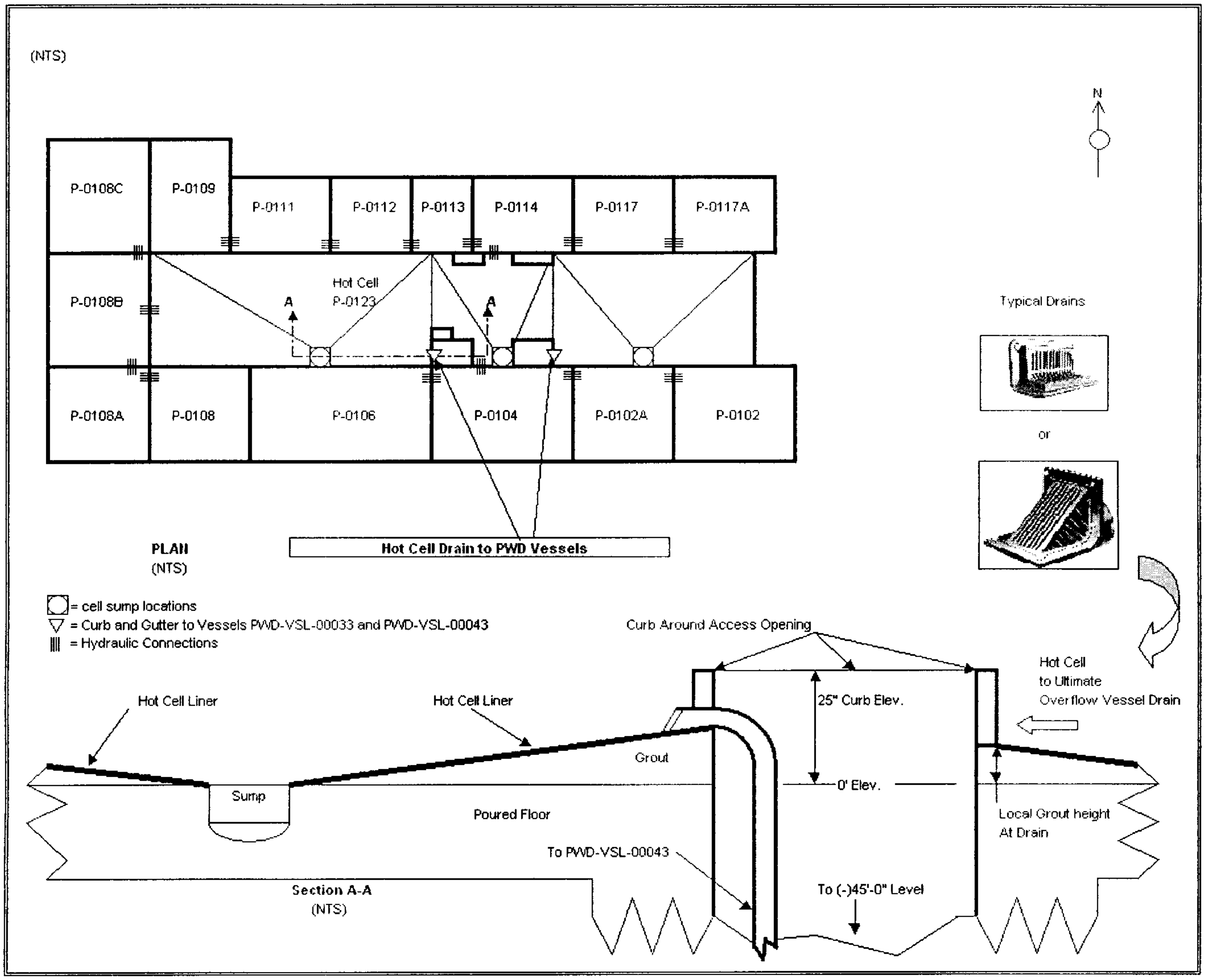

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Figure C-2 Simplified Vessel Configuration for FRP-VSL-00002A/B/C/D.

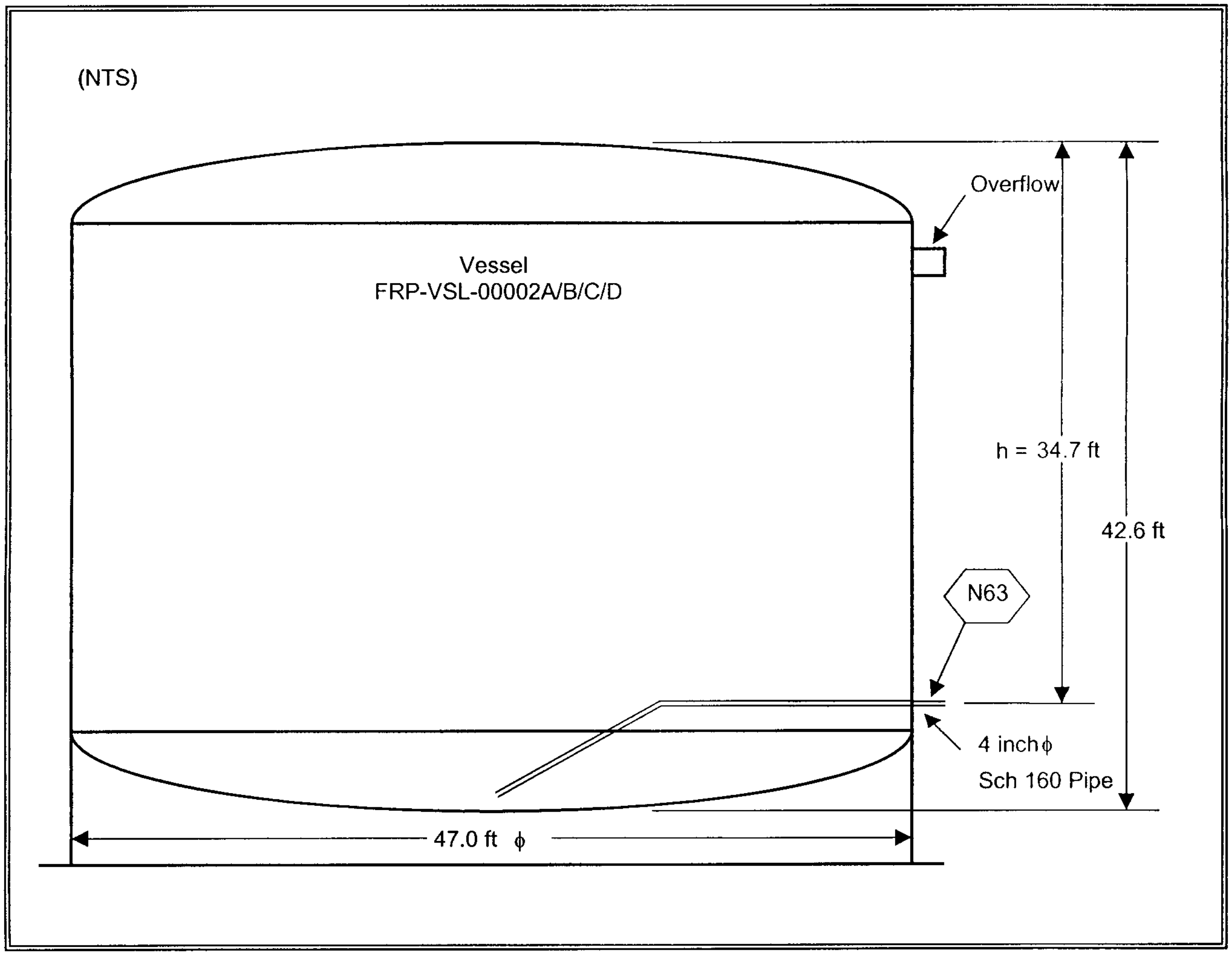
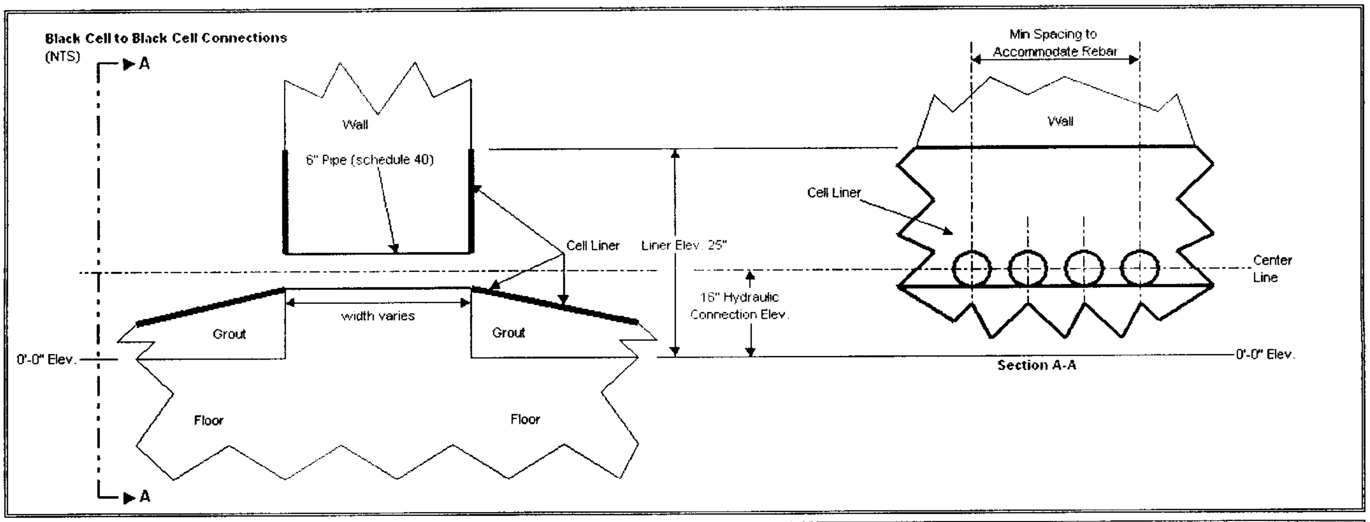


Figure C-3 Hydraulic Connection Details



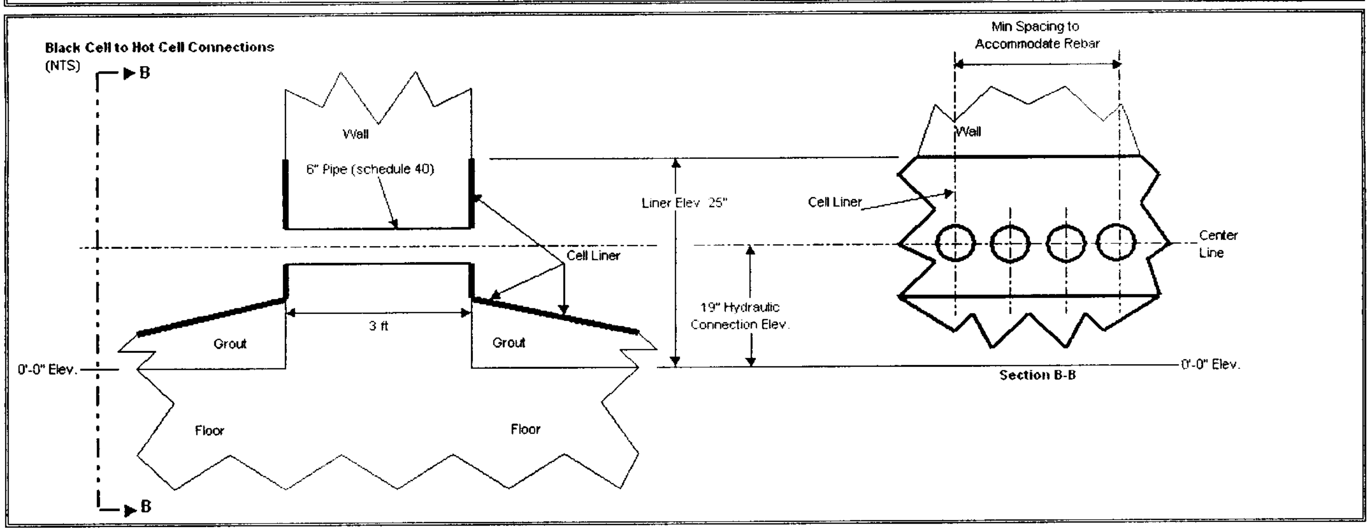
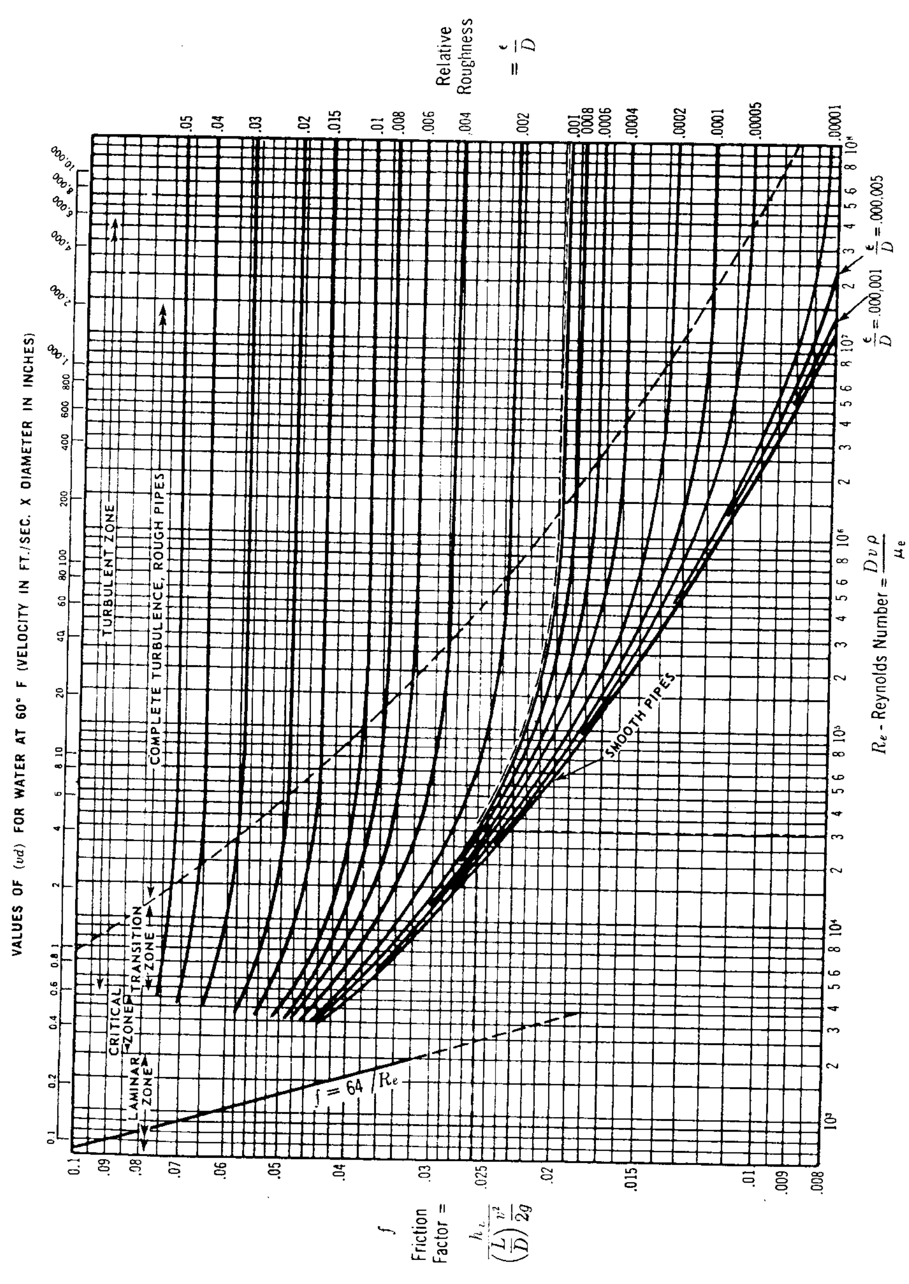


Figure C-4 Friction Factors

Friction Factors for Any Type of Commercial Pipe[18]



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Appendix D

Flood Volume Calculation for PT (Room P-0118) at 0 ft, 0 in. Elevation

1 Objective

Determine the minimum required liner elevation of room P-0118 in the pretreatment (PT) facility at elevation 0 ft, 0 in.

2 Inputs

The total volume for 1 of the radioactive liquid waste disposal (RLD) alkaline effluent vessels is equal to 42,950 gallons (5,741 ft^3).

The diameter of the RLD alkaline effluent vessels (RLD-VSL-0017A/B) is 16 ft.

The diameter of the TLP treated LAW evaporator condensate vessel (TLP-VSL-00002) is 6 ft.

The dimension of room P-0118 is 54 ft, 4 in. long by 30 ft, 6 in. wide, with a 21 ft, 0 in. by 4 ft, 6 in. corner removed.

3 Background

The location of room P-0118 per the general arrangement drawings is in the northeast section of the PT facility. The secondary containment for Room P-0118 is designed to include a low point sump and stainless steel liner. Room P-0118 does not have floor drains and when flooded, the method of removal of liquid from the room is through steam ejectors provided at the floor sump. The room is also protected by a fire protection system in case of fire.

The largest vessel in the containment area is one of the RLD alkaline effluent vessels (RLD-VSL-00017A/B).

This calculation supports the design of the cell liner and documents the method used to estimate the minimum liner elevation and requirements.

4 Applicable Codes and Standards

- WAC 173-303. *Dangerous Waste Regulations.* Washington Administrative Code.
- UBC 1997. *Uniform Building Code,* International Conference of Building Officials, Whittier, California, USA.

5 Methodology

The minimum required liner elevation for room P-0118 is determined as follows:

1 Calculate the area of room P-0118.
2 Calculate the maximum flood volume (combination of the largest vessel content and fire sprinkler protection system).
3 Estimate the volume of the submerged piping and supports.
4 Calculate the liner elevation.

Figure D-1 shows a representation of a typical room liner and defines the terms "grout height", "liner height", and "liner elevation". The configuration and dimensions of room P-0118 are provided in Figure D-2. Areas within the room that reduce the available volume for the flood are subtracted from the total volume. The total postulated flood is determined by calculating the total volume for one of the RLD alkaline effluent vessels and adding the accumulation of 20 minutes of fire sprinkler system. The volume of the internal equipment within the vessel is ignored. The total content of vessel RLD-VSL-00017A is released into the cell, while vessel RLD-VSL-00017B maintains its content.

The largest postulated flood is then defined as the total volume of the largest vessel in the containment area plus the accumulation of 20 minutes of fire protection sprinkler discharge water.

6 Assumptions

6.1 Assumptions Not Requiring Verification

- The duration of a sprinkler discharge is 20 minutes.
- Figure D-1 represents a simplified liner configuration of room P-0118. The liner height is defined as the cladding on the walls. The grout height is defined as the depth of grout necessary to maintain a 1 % slope for the longest leak path in the room. The liner elevation is the sum of the liner height and the grout height. This represents the elevation of the liner above the 0 ft, 0 in. elevation.
- The flood liquid has the same properties as water.
- Vessel TLP-VSL-00002 is full at the beginning of the flood scenario.

6.2 Assumptions to be Verified

- The sprinkler flow rate density is 0.17 gallons per minute (gpm) per ft^2.
- The room contains equipment and piping that would be submerged during flooding. To account for this, the postulated flood volume is increased by 5 %.

7 Calculations

7.1 Calculate the Area of the Room

The longest path for the waste to travel in the room is from the northwest corner to the sump. The distance to the sump is 60.2 ft. With a 1 % slope, the maximum grout height is 0.602 ft (~8 in.).

The floor area is equal to: (54.33 ft × 30.5 ft) - (21 ft × 4.5 ft) = ~1,563 ft^2.

Vessel TLP-VSL-00002 is assumed to be full at the time of the event. Excluding the footprint of the vessel from the area of the room will ensure that the calculation is conservative.

The vessel footprint area is then equal to $\pi/4 \times d^2 = \sim 29$ ft^2. (Where d = 6 ft)

The volume of vessel RLD-VSL-00017B must be excluded from the calculation; it is assumed that the vessel is intact at the time of the event. The bottom head of the vessel is 44 in. (3 ft, 8 in.) above the 0 ft, 0 in. level of the cell. The area beneath the head will be flooded.

The vessel footprint area is then equal to: $\pi/4 \times d^2 = \sim 201$ ft^2. (Where d = 16 ft)

To determine the available flood areas, the following values are used:

- The volume of the depression in the liner below the grout height (0 ft, 8 in. level) is calculated in Figure D-3.
- The volume of the sump is calculated in Figure D-4.
- The volume of the room below the 0 ft, 8 in. level is 342 ft^3. See Figure D-3.
- For the zone above the 0 ft, 8 in. level and below the 3 ft, 8 in. level, the area available is the area of the room minus the footprint of vessel TLP-VSL-00002. The room area is equal to the following: (1,563 ft^2 - 29 ft^2) = 1,534 ft^2. This area is shown shaded in Figure D-1.
- For the zone above the 3 ft, 8 in. level, the volume of RLD-VSL-00017B is excluded. The displaced vessel area is 201 ft^2. The room area is then equal to the following: (1,534 ft^2 - 201 ft^2) = 1,333 ft^2. Note that this volume of the vessel is for a flat bottom cylinder, which is conservative.

7.2 Calculate the Flood Volume

- The total volume of RLD-VSL-00017A is equal to 42,952 gallons (5,741 ft^3).
- The flow rate of the fire protection system is equal to: (0.17 gpm/ft^2) × (1,563 ft^2) = 266 gpm.
- The total volume accumulated over the duration of the fire suppression event is then the following: (266 gpm) × (20 min) = 5,320 gallons (711 ft^3).

Therefore, the total volume of the vessel flood volume is equal to (711 ft^3) + (5,741 ft^3) = 6,451 ft^3.

7.3 Add the Design Allowances

To account for other auxiliary components (submerged piping and equipment) that are not inside the main vessels, a design allowance of 5 % is applied to the total volume. Therefore, the maximum postulated flood volume is the following: 6,452 ft^3 + 5 % (6,452 ft^3) = 6,775 ft^3.

7.4 Calculate the Liner Elevation Dimension

- The volume within the room below the 0 ft, 8 in. level is 342 ft^3 (see Figure D-3).
- The volume above the 0 ft, 8 in. level and below the 3 ft, 8 in. level is equal to 1,534 $ft^2 \times 3$ ft = 4,602 ft^3.
- The total volume of the room below the 3 ft, 8 in. level is equal to 4,602 ft^3 + 342 ft^3 = 4,944 ft^3.
- The remaining volume is the following: 6,775 ft^3 - 4,944 ft^3 = 1,831 ft^3.
- Dividing the remaining volume by the area available in the cell above the 3 ft, 8 in. level is then equal to: (1,831 ft^3) / (1,333 ft^2) = 1.37 ft or ~1 ft, 5 in.

Therefore, the liner elevation is equal to the following: (0 ft, 8 in.) + (3 ft, 0 in.) + (1 ft, 5 in.) = 5 ft, 1 in. or 61 in. Rounded to the nearest 1/2 foot equals 5 ft, 6 in. (66 in.).

8 Results and Conclusion

The minimum liner elevation is 66 in. or 5 ft, 6 in.

9 List of Figures

Figure D-1 Simplified Room Liner Detail for Room P-0118 in the PT Facility

(NTS)

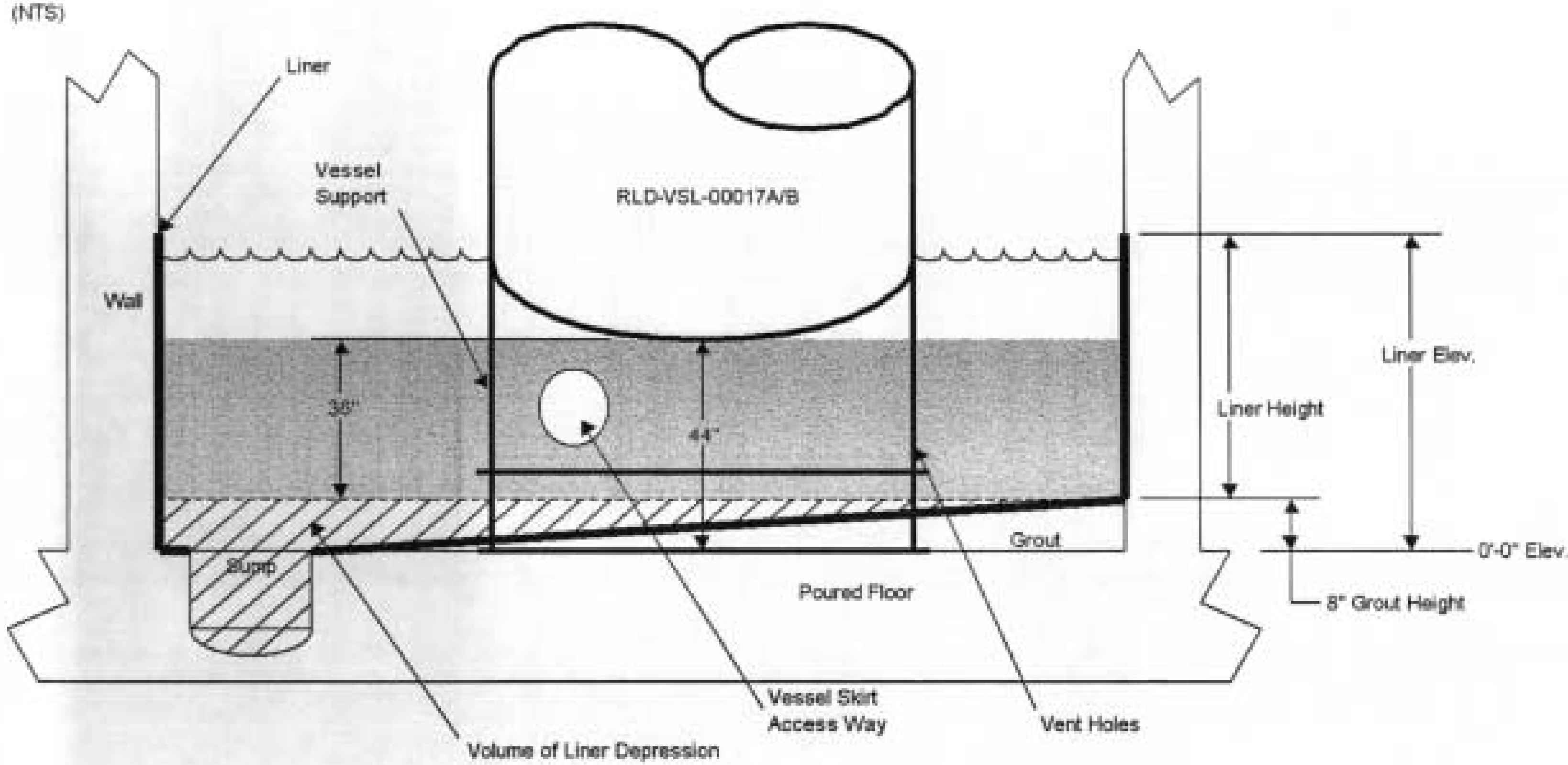

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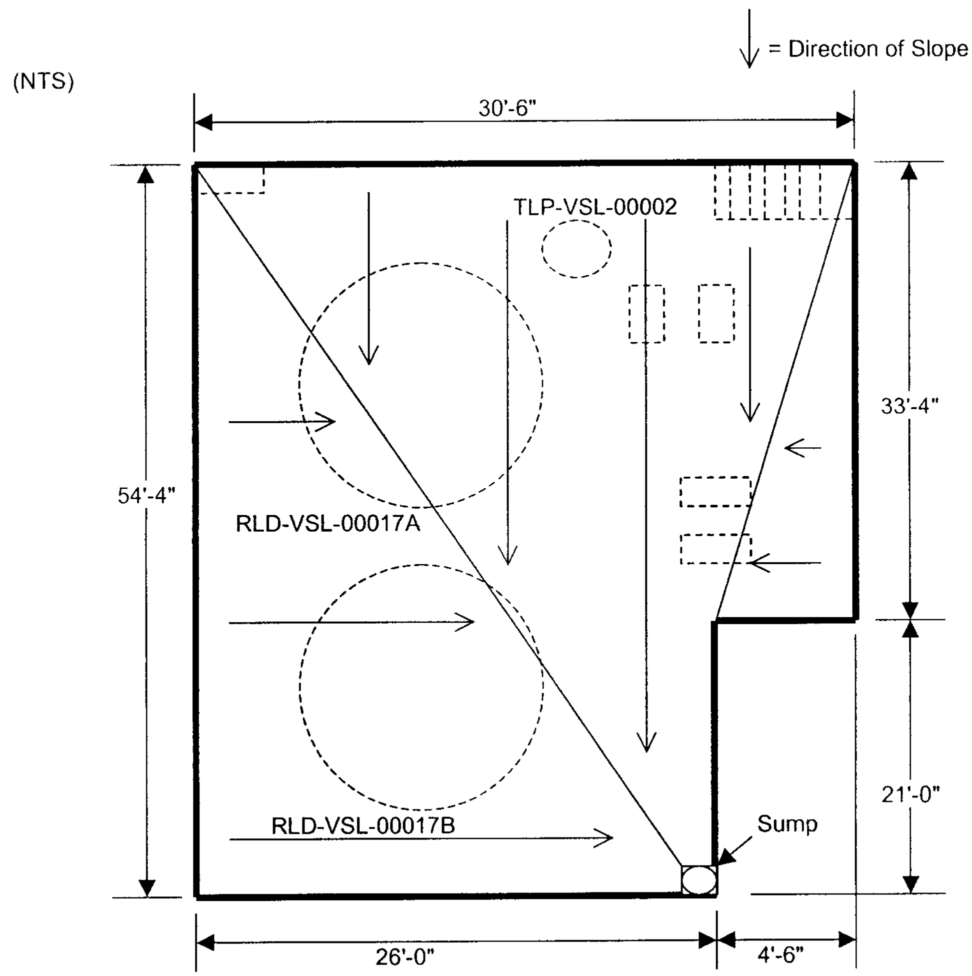
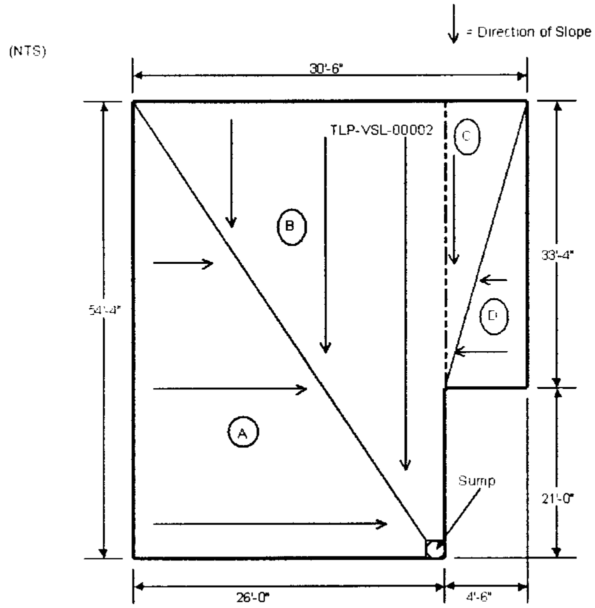
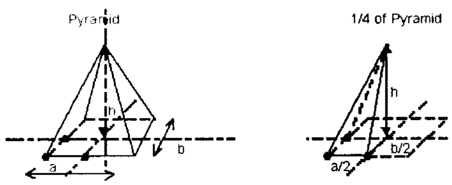
Figure D-2 Room P-0118 Floor and Sump Configuration



The Area of room P-0118 = 1,563 ft^2

Figure D-3 Room P-0118 Grout Estimation



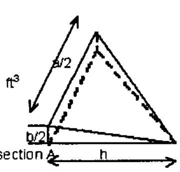


V =(abh)/3

Vx = V/4 = (ab)(h)/12

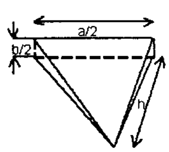
A

a/2 = 54.33 ft
a = 108.66 ft Va = 315.48 ft³
b/2 = 0.67 ft
b = 1.34 ft
h = 26.00 ft
Va = Volume of Grout in section A



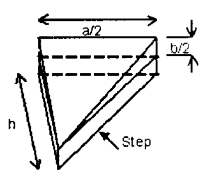
B

a/2 = 26.00 ft
a = 52.00 ft Vb = 315.48 ft³
b/2 = 0.67 ft
b = 1.34 ft
h = 54.33 ft
Vb = Volume of Grout in section B



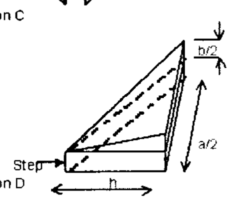
C

a/2 = 4.50 ft
a = 9.00 ft Vw = 17.00 ft³
b/2 = 0.34 ft
b = 0.68 ft Vstep = 24.75 ft³
h = 33.33 ft
Vc = Vw + Vstep = 41.75 ft³
Vc = Volume of Grout in section C



D

a/2 = 33.33 ft
a = 66.66 ft Vw = 17.00 ft³
b/2 = 0.34 ft
b = 0.68 ft Vstep = 24.75 ft³
h = 4.50 ft
Vd = Vw + Vstep = 41.75 ft³
Vd = Volume of Grout in section D



V total = Va + Vb + Vc + Vd = 714 ft³ = Total Volume of the Grout

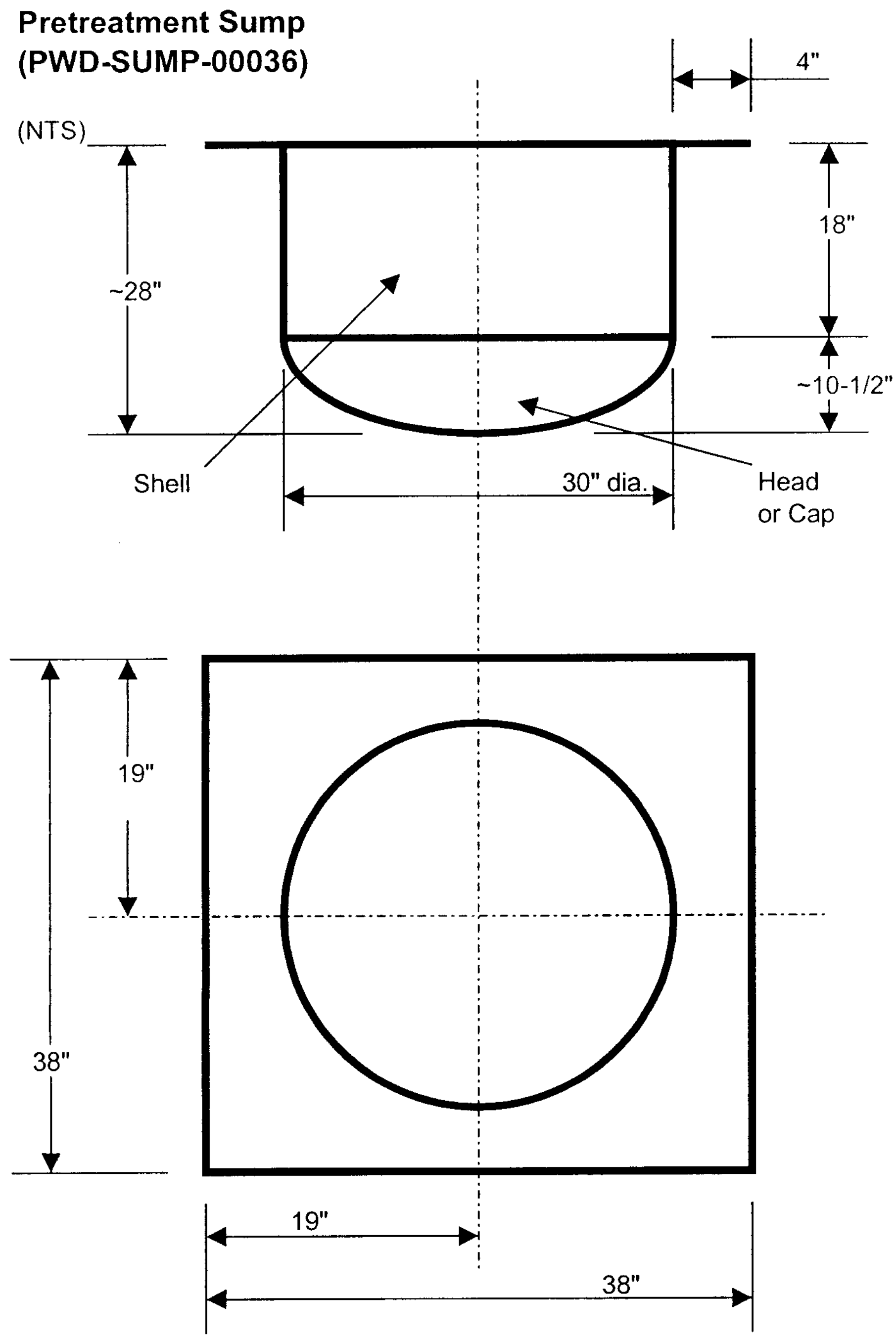
The Volume of the Sump is: (See Figure D-4)
Vsump = 9.41 ft³

The Volume of the room below the Maximum Grout Height is:
Vroom = Floor Area x Maximum Grout Height
Vroom = 1,047 ft³

The Total Volume of the Grout is:
V total = Va + Vb + Vc + Vd
V total = 714 ft³

The Volume of the Void Space below the Maximum Grout Height is equal to:
Vvoid = (Vroom - V total) + Vsump
Vvoid = 342 ft³

Figure D-4 Pretreatment Sump



Volume of Shell = 7.36 $ft^3 = \pi R^2 L$

Volume of Head or Cap = 2.05 $ft^3 = \pi D^3/24$

Total Sump Volume = 9.41 ft^3

Appendix E

Flood Volume Calculation for PT (Rooms P-0105, P-0105A, P-0105B, and P-0105C) 0 ft, 0 in. Elevation

1 Objective

Determine the minimum liner elevation and minimum required curb height for rooms P-0105, P-0105A, P-0105B, and P-0105C at elevation 0 ft, 0 in. of the pretreatment (PT) facility.

2 Inputs

The combined dimension of rooms P-0105, P-0105A, P-0105B, and P-0105C is 252.5 ft long by 22.67 ft wide. The length and width of the walls between the rooms are as follows (rounded to the nearest 1 foot):

- At column line 4 the wall is 4 ft × 18 ft
- At column line 7.2 the wall is 4 ft × 18 ft
- At column line 12.4 the wall is 7 ft × 18 ft
- At column line 17 the wall is 3 ft × 18 ft

The waste feed evaporator process system (FEP) condensate vessel (FEP-VSL-00005) has a total volume of 5,022 gallons (671 ft^3).

The maximum drainage rate with all floor drains open is 987 gallons per minute (gpm), at a depth of 2 inches.

3 Background

Rooms P-0105, P-0105A, P-105B, and P-105C have flat floors and floor drains. The floor for each room is coated with an appropriate special protective coating.

A curb is provided between rooms P-0107 and P-0105C (column line 3, from row L to row M.8), and between rooms P-0105, P-0105A, P-0105B, P-0105C and corridor PC0101, (row M.8, from column line 3 to column 17). A curb is also provided between rooms P-0105 and P-0103.

The postulated flooding scenario is the combination of the largest vessel rupturing plus the discharge of the fire protection sprinkler system. The only vessel within this area is the FEP condensate vessel.

This calculation supports the design of the curb and documents the method used to estimate the curb heights and requirements.

4 Applicable Codes and Standards

- WAC 173-303. *Dangerous Waste Regulations.* Washington Administrative Code.
- UBC 1997. *Uniform Building Code*, International Conference of Building Officials, Whittier, California, USA.

5 Methodology

The minimum liner and curb elevation is determined as follows:

1 Calculate the floor area of the affected rooms.
2 Calculate the maximum flood volume (combination of the largest vessel and fire protection system).
3 Estimate the volume of the submerged piping and supports.
4 Determine the curb elevation with the floor drains working.

6 Assumptions

6.1 Assumptions not Requiring Verification

- The duration of a sprinkler discharge is 20 minutes.
- The flood liquid has the same properties as water.

6.2 Assumptions to be Verified

- The sprinkler flow rate density is 0.17 gpm per ft^2.
- The room includes equipment and piping which will be submerged during flooding. To account for this, the postulated flood volume is increased by 5 %.

7 Calculations

7.1 Calculate the Floor Area

The floor area for rooms P-0105, P-0105A, P-0105B, and P-0105C is determined as follows:

$A_{P\text{-}0105,\ P\text{-}0105A,\ P\text{-}0105B,\ P\text{-}0105C} = (252.5\ ft) \times (22.67\ ft) = 5{,}724\ ft^2$.

There are 4 walls occupying floor space within the above rooms. The area of occupied floor space for the 4 walls is determined as follows:

$A_{4Walls} = [(4\ ft) \times (18\ ft) + (4\ ft) \times (18\ ft) + (7\ ft) \times (18\ ft) + (3\ ft) \times (18\ ft)] = 324\ ft^2$.

Therefore, the total floor area is equal to the area of the room minus the wall protrusions:

$(5{,}724\ ft^2) - (324\ ft^2) = 5{,}400\ ft^2$

7.2 Calculate the Postulated Flood

The maximum flood volume is a combination of the total volume of the largest vessel in the containment area and the volume added by the discharge of the fire protection system.

The flood volume equals:
$(671\ ft^3) + (0.17\ gpm/ft^2) \times (5{,}400\ ft^2) \times (20\ min) / (7.481\ gallon/ft^3) = 3{,}125\ ft^3$.

7.3 Calculate the Contingency for Submerged Equipment

The room includes equipment and piping that may be submerged during flooding. To account for this, 5 % of the postulated flood volume is added: $(3{,}125\ ft^3) \times 5\% = \sim 156\ ft^3$.

The maximum postulated flood volume is 3,125 ft^3 plus 156 ft^3, which equals 3,281 ft^3.

7.4 Determine the Curb and Liner Elevation without Floor Drains

According to section 7.1 and section 7.3, the floor area is equal to 5,400 ft^2 and the maximum postulated flood is equal to 3,281 ft^3, respectively.

Therefore, the curb and liner height without floor drains operational is:
$(3{,}281\ ft^3)/(5{,}400\ ft^2) = 0.61\ ft\ (7.3\ in.)$.

7.5 Determine the Curb and Liner Elevation with Floor Drains

It is assumed that the total volume of the waste feed evaporator condensate vessel (FEP-VSL-00005) is released and distributed into the rooms.

The flood height in the room is then equal to $(671\ ft^3)/(5{,}400\ ft^2) = 0.12\ ft\ (1.5\ in.)$

The fire suppression system will then contribute $(0.17\ gpm/ft^2) \times (5{,}400\ ft^2) = 918$ gpm over the next 20 minutes.

As the depth of the liquid in the rooms increases, so does the flow rate through the drain system. The main drain header is designed to accommodate 987 gpm at a depth of 2 in. The depth or head over the drains will increase until the flow through the drains matches the flow into the rooms. Due to the instantaneous vessel rupture, a sustained inflow of 918 gpm (sprinklers flow rate), and a drain capacity of 987 gpm (at a depth of 2 in.), the level in the room does not exceed 2 in.

Therefore, the minimum recommended liner and curb height, with a 50 % contingency, is 3 in. (see Figure E-1). This recommendation is based on a fully operational floor drain system during the postulated flooding scenario.

8 Results and Conclusion

The minimum curb and liner elevation for rooms P-0105, P-0105A, P-0105B, and P-0105C is 3 in.

9 List of Figures

Figure E-1 Dimensions and Details for Rooms P-0105, P-0105A, P-0105B, and P-0105C