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History Sheet

Rev	Date	Reason for revision	Revised by
0	15 December 2002	Issued for permitting use.	D Leaphart
1	14 May 2003	Issued for permitting use. Major revision to include Elevation 0 ft.	L Fong
2	8 October 2003	Issued for permitting use. Major revision to include all elevations.	L Fong
3	3 August 2004	Issued for permitting use.	J Medina

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Acronyms and Abbreviations

BNI	Bechtel National, Inc.
DMST	demister
Ellip	semi-ellipsoidal
F&D	flanged and dished
HCP	HLW concentrate receipt process system
HEME	high efficiency mist eliminators
HFP	HLW melter feed process system
HLW	high-level waste
HOP	melter offgas treatment process system
HSH	HLW melter cave support handling system
MLTR	melter
MTU	miscellaneous treatment unit
RLD	radioactive liquid waste disposal system
SBS	submerged bed scrubber
VSL	vessel
WESP	wet electrostatic precipitator
WAC	*Washington Administrative Code*

1 Introduction

The *Washington Administrative Code*, WAC 173-303-640(4)(e), requires a secondary containment be designed and operated that contains 100 % of the capacity of the largest vessel within its boundary for vessel systems containing dangerous waste. The containment, if applicable, shall be designed to contain the water from the fire-protection system over the minimum design area for a 20-minute period. This report discusses the assessment of the flooding volume that is required to be contained for the high-level waste (HLW) vitrification facility.

2 Applicable Documents

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

3 Description

3.1 Flooding Volume Description for HLW Facility at −21 Ft Elevation

The cells and respective vessels are shown on the *HLW Vitrification Building General Arrangement (Permit) Plan at El -21' -0"*, 24590-HLW-P1-P01T-P0001, Rev 6.

3.1.1 SBS Drain Collection Cell No 2

One vessel containing dangerous waste is located in the SBS drain collection cell no 2 (H-B005):

HOP-VSL-00904 melter 2 SBS condensate receiver vessel

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of the following:

- the total volume of the largest vessel
- 110 % of the maximum operating volume of the largest vessel
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel before the fluid overflows (up to the overflow nozzle).

The melter 2 SBS condensate receiver vessel has a total volume of 9941 US gal (1329 ft^3) and the 110 % maximum operating volume is 10,936 US gal (1462 ft^3). Another flooding source is from the floor drain of the west section of melter cave no 2 (H-0106), which is 4653 US gal (622 ft^3). This 4653 US gal is the melter 2 submerged bed scrubber's total volume as described in section 3.2.2. Since 110 % maximum operating volume of 10,936 US gal (1462 ft^3) is larger than the total volume and the source from the floor drain, this volume is used to calculate the cell liner height.

Fire sprinklers are not provided in this area and the above floor drain is the only contribution from other areas; therefore, a volume addition is not included in the flood volume. To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume is 11,482 US gal (1535 ft^3).

The available flood area of the room into which the liquid could flow is calculated to be 252 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/miscellaneous treatment units (MTUs) excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The minimum required liner height is calculated by dividing the flood volume of 11,482 US gal (1535 ft^3) by the available flood area of the room (252 ft^2). The minimum required liner height for the SBS drain collection cell no 2 (H-B005) is 6.1 ft. Details are provided in Appendix A.

3.1.2 Wet Process Cell (South)

The wet process cell (H-B014) floor area is divided into north and south sections by the drum transfer tunnel (H-B015). Four vessels containing dangerous waste are located in the south section of the wet process cell (H-B014):

RLD-VSL-00007	acidic waste vessel
RLD-VSL-00008	plant wash and drains vessel
HCP-VSL-00001*	HLW concentrate receipt vessel 1
HCP-VSL-00002*	HLW concentrate receipt vessel 2

* Note: HCP-VSL-00001 and HCP-VSL-00002 have been deleted from the design. However, for purpose of this report, the vessels are left in as a bounding minimum liner height dimension.

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of the following:

- the total volume of the largest vessel
- 110 % of the maximum operating volume of the largest vessel
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel before the fluid overflows (up to the overflow nozzle).

Both concentrate receipt vessels (HCP-VSL-00001 and HCP-VSL-00002) are of equal size and are the largest vessels in the room. The total volume (V_{TOT}) of one of the concentrate receipt vessels is 20,061 US gal (2682 ft^3), which is greater than 110 % of the maximum operating volume.

Fire sprinklers are not provided in this area, and there is no contribution from other areas; therefore, a volume addition is not included in the flood volume. To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume (V_{FL}) of 21,064 US gal (2816 ft^3) is used to calculate the south section minimum required liner height of the wet process cell.

The available flood area of the room into which the liquid could flow is calculated to be 725 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The liner height is calculated by dividing the flood volume of 21,064 US gal (2816 ft^3) by the available flood area of the room (725 ft^2). The minimum required liner height for the south section of the wet process cell is 3.9 ft. The details of the liner height determination are provided in Appendix A.

3.1.3 Wet Process Cell (North)

One vessel containing dangerous waste is located in the north section of the wet process cell (H-B014):

RLD-VSL-00002 offgas drains collection vessel

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of the following:

- the total volume of the largest vessel
- 110 % of the maximum operating volume of the largest vessel
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel before the fluid overflows (up to the overflow nozzle).

The offgas drains collection vessel (RLD-VSL-00002) has a total volume of 344 US gal (46 ft^3). Since the total volume is greater than 110 % of the maximum operating volume, the total volume is used to calculate the minimum required liner height.

Fire sprinklers are not provided in this area, and there is no contribution from other areas; therefore, a volume addition is not included in the flood volume. To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume of 359 US gal (48 ft^3) is used to calculate the north section of the wet process cell minimum required liner height.

The available flood area of the room into which the liquid could flow is calculated to be 306 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The minimum required liner height is calculated by dividing the flood volume of 359 US gal (48 ft^3) by the available flood area of the room (306 ft^2). The minimum required liner height for the north section of the wet process cell (H-B014) is 0.2 ft. Details are provided in Appendix A.

3.1.4 SBS Drain Collection Cell No 1

One vessel containing dangerous waste is located in the SBS drain collection cell no 1 (H-B021):

HOP-VSL-00903 SBS condensate receiver vessel

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of the following:

- the total volume of the largest vessel
- 110 % of the maximum operating volume of the largest vessel
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel before the fluid overflows (up to the overflow nozzle).

The SBS condensate receiver vessel (HOP-VSL-00903) has a total volume of 9941 US gal (1329 ft^3) and the 110 % maximum operating volume is 10,936 US gal (1462 ft^3). Another flooding source is from the floor drain of the west section of melter cave no 1 (H-0117), which is 4653 US gal (622 ft^3). This 4653 US gal is the melter 1 submerged bed scrubber's total volume as described in section 3.2.5. Since 110 % maximum operating volume of 10,936 US gal (1462 ft^3) is larger than the total volume and the source from the floor drain, this is the volume used to calculate the cell liner height.

Fire sprinklers are not provided in this area and the above floor drain is the only contribution from other areas; therefore, a volume addition is not included in the flood volume. To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume is 11,482 US gal (1535 ft^3).

The available flood area of the room into which the liquid could flow is calculated to be 252 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The minimum required liner height is calculated by dividing the flood volume of 11,482 US gal (1535 ft^3) by the available flood area of the room (252 ft^2). The minimum required liner height for the SBS drain collection cell no 1 (H-B021) is 6.1 ft. Details are provided in Appendix A.

3.1.5 Canister Decon Cave

Three vessels containing dangerous waste are located in the canister decon cave (H-B035):

HDH-VSL-00002	canister decon vessel 1
HDH-VSL-00004	canister decon vessel 2
HDH-VSL-00003	waste neutralization vessel

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of the following:

- the total volume of the largest vessel
- 110 % of the maximum operating volume of the largest vessel
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel before the fluid overflows (up to the overflow nozzle).

The waste neutralization vessel (HDH-VSL-00003) is the largest vessel, with a total volume of 5326 US gal (712 ft^3). The 110 % of the maximum operating volume for the vessel is 5356 US gal (716 ft^3), which is greater than the total volume, and used to calculate the cell liner height.

Fire sprinklers are not provided in this area; therefore, fire water is not added in the flood volume and there is no contribution from other areas. As a result, a volume addition is not included in the flood volume. To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume is 5625 US gal (752 ft^3).

The available flood area of the room into which the liquid could flow is calculated to be 227 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The minimum required liner height is calculated by dividing the flood volume of 5625 US gal (752 ft^3) by the available flood area of the room (227 ft^2). The minimum required liner height for the canister decon cave (H-B035) is 3.4 ft. Details are provided in Appendix A.

3.1.6 Canister Rinse-Bogie Maintenance Room

One vessel containing dangerous waste is located in the canister rinse-bogie maintenance room (H-B039A):

HDH-VSL-00001 rinse tunnel canister rinse vessel

The rinse tunnel canister rinse vessel (HDH-VSL-00001) could be moved on a bogie into the canister rinse-bogie maintenance room (H-B039A) to receive manual maintenance. The minimum secondary containment (protective coating) height is calculated assuming the rinse tunnel canister rinse vessel (HDH-VSL-00001) is transferred from the canister rinse tunnel (H-B039B) into the canister rinse-bogie maintenance room (H-B039A).

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of the following:

- the total volume of the largest vessel
- 110 % of the maximum operating volume of the largest vessel
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel before the fluid overflows (up to the overflow nozzle).

The rinse tunnel canister rinse vessel (HDH-VSL-00001) has a total volume of 3590 US gal (480 ft^3). The 110 % of the maximum operating volume for the vessel is 3949 US gal (528 ft^3), which is greater than the total volume, and used to calculate the cell liner height.

There is no contribution from other areas, but an automatic fire extinguishing system is provided in the canister rinse-bogie maintenance room (H-B039A). At the fire water (sprinkler discharge) flow density of 0.20 US gal/min/ft^2 for a 20-minute duration, the fire water volume is 3168 US gal (424 ft^3). To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume is 7480 US gal (1000 ft^3) for the canister rinse-bogie maintenance room (H-B039A). The canister rinse-bogie maintenance room (H-B039A) and canister rinse tunnel (H-B039B) are interconnected and flooding overflows from one room into the other room. The flood volume for the canister rinse-bogie maintenance room (H-B039A) is larger than canister rinse tunnel (H-B039B); therefore, the flood volume for the canister rinse-bogie maintenance room (H-B039A) of 7151 US gal (956 ft^3) is used to determine the liner height.

The available flood area is the sum of the cross-sectional areas of both rooms into which the liquid could flow; this is calculated to be 1349 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The liner height is calculated by dividing the flood volume of 7151 US gal (956 ft^3) by the available flood area of the room (1349 ft^2). The minimum secondary containment (protective coating) height for the canister rinse-bogie maintenance room (H-B039A) is 0.8 ft. Details are provided in Appendix A.

3.1.7 Canister Rinse Tunnel

One vessel containing dangerous waste is located in the canister rinse tunnel (H-B039B):

HDH-VSL-00001 rinse tunnel canister rinse vessel

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of the following:

- the total volume of the largest vessel
- 110 % of the maximum operating volume of the largest vessel
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel before the fluid overflows (up to the overflow nozzle).

The rinse tunnel canister rinse vessel (HDH-VSL-00001) has a total volume of 3590 US gal (480 ft^3). The 110 % of the maximum operating volume for the vessel is 3949 US gal (528 ft^3), which is greater than the total volume, and used to calculate the cell liner height.

There is no contribution from other areas, but an automatic fire extinguishing system is provided in canister rinse tunnel (H-B039B). At the fire water (sprinkler discharge) flow density of 0.20 US gal/min/ft^2 for a 20-minute duration, the fire water volume is 2228 US gal (298 ft^3). To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume is 6485 US gal (867 ft^3) for canister rinse tunnel (H-B039B). The canister rinse-bogie maintenance room (H-B039A) and canister rinse tunnel (H-B039B) are interconnected and flooding overflows from one room into the other room. The flood volume for the canister rinse-bogie maintenance room (H-B039A) is larger than canister rinse tunnel (H-B039B); therefore, the flood volume for the canister rinse-bogie maintenance room (H-B039A) of 7175 US gal (956 ft^3) is used to determine the liner height.

The available flood area of the room into which the liquid could flow is calculated to be 1349 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The minimum required liner height is calculated by dividing the flood volume of 7151 US gal (956 ft^3) by the available flood area of the room (1349 ft^2). The minimum required liner height required for the canister rinse tunnel (H-B039B) is 0.8 ft. Details are provided in Appendix A.

3.2 Flooding Volume Description for HLW Facility at 0 Ft Elevation

The cells and respective vessels or miscellaneous treatment units (MTUs) are shown on the *HLW Vitrification Building General Arrangement (Permit) Plan at El 0'- 0"*, 24590-HLW-P1-P01T-P0002, Rev 3.

3.2.1 Melter Cave No 2 (South)

Four vessels containing dangerous waste are located in the south section of melter cave no 2 (H-0106):

HFP-DMST-00003	melter 2 feed prep vessel demister
HFP-DMST-00004	melter 2 feed vessel demister
HFP-VSL-00005	melter 2 feed preparation vessel
HFP-VSL-00006	melter 2 feed vessel

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of the following:

- the total volume of the largest vessel
- 110 % of the maximum operating volume of the largest vessel
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel before the fluid overflows (up to the overflow nozzle).

The demisters (HFP-DMST-00003 and HFP-DMST-00004) are directly flanged to the top of melter feed and feed preparation vessels. These demisters are considered part of the connecting vessel. The melter 2 feed preparation vessel (HFP-VSL-00005) and melter 2 feed vessel (HFP-VSL-00006) are the same size. Each vessel with its connecting demister has a total volume of 8445 US gal (1129 ft^3). Each vessel's 110 % maximum operating volume is 8512 US gal (1138 ft^3), which is larger than the total volume; therefore, this volume is used to calculate the cell liner height.

Fire sprinklers are not provided in this area; therefore, fire water is not added in the flood volume and there is no contribution from other areas. As a result, a volume addition is not included in the flood volume. To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume for this room is 8939 US gal (1195 ft^3). This is the volume used to calculate the cell liner height.

The available flood area of the room into which the liquid could flow is calculated to be 315 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The minimum required liner height is calculated by dividing the flood volume of 8939 US gal (1195 ft^3) by the available flood area of the room (315 ft^2). The minimum required liner height for the south section of melter cave no 2 (H-0106) is 3.8 ft. Details are provided in Appendix A.

3.2.2 Melter Cave No 2 (West)

Three MTUs containing dangerous waste are located in the west section of melter cave no 2 (H-0106):

HOP-SCB-00002	melter 2 submerged bed scrubber
HOP-HEME-00002A	melter 2 high efficiency mist eliminator
HOP-HEME-00002B	melter 2 high efficiency mist eliminator

In the event of a line break or vessel/MTU failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of the following:

- the total volume of the largest vessel/MTU
- 110 % of the maximum operating volume of the largest vessel/MTU
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel/MTU before the fluid overflows (up to the overflow nozzle).

The largest vessel/MTU in the area is the melter 2 submerged bed scrubber (HOP-SCB-00002). The melter 2 submerged bed scrubber (HOP-SCB-00002) has a total volume of 4653 US gal (622 ft^3), which is greater than 110 % of its maximum operating volume.

Fire sprinklers are not provided in this area; therefore, fire water is not added in the flood volume and there is no contribution from other areas. To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume is 4884 US gal (653 ft^3).

The available flood area of the room into which the liquid could flow is calculated to be 340 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The minimum required liner height is calculated by dividing the flood volume of 4884 US gal (653 ft^3) by the available flood area of the room (340 ft^2). The minimum required liner height for the west section of melter cave no 2 (H-0106) is 2.0 ft. Details are provided in Appendix A.

3.2.3 Melter Cave No 2 (Central)

One MTU containing dangerous waste is located in the central section of melter cave no 2 (H-0106):

HMP-MLTR-00002	HLW melter 2

Because molten glass leaking from the melter (HMP-MLTR-00002) solidifies upon contact with the floor, neither a flood volume nor a minimum-required liner height needs to be calculated. Nevertheless, a stainless steel liner is provided to facilitate the containment of potential spills from either the jumpers or the feed lines. The minimum liner height is 0.5 ft. Fire sprinklers are not provided in this area.

3.2.4 Melter Cave No 1 (South)

Four vessels containing dangerous waste are located in the south section of melter cave no 1 (H-0117):

HFP-DMST-00001	melter 1 feed prep vessel demister
HFP-DMST-00002	melter 1 feed vessel demister
HFP-VSL-00001	melter 1 feed preparation vessel
HFP-VSL-00002	melter 1 feed vessel

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of the following:

- the total volume of the largest vessel
- 110 % of the maximum operating volume of the largest vessel
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel before the fluid overflows (up to the overflow nozzle).

The demisters (HFP-DMST-00001 and HFP-DMST-00002) are directly flanged to the top of melter feed vessel and feed preparation vessel. These demisters are considered part of the connecting vessel. The melter 1 feed preparation vessel (HFP-VSL-00001) and melter 1 feed vessel (HFP-VSL-00002) are the same size. Each vessel with its connecting demister has a total volume of 8445 US gal (1129 ft^3). Each vessel's 110 % maximum operating volume is 8512 US gal (1138 ft^3), which is larger than the total volume; therefore, this volume is used to calculate the cell liner height.

Fire sprinklers are not provided in this area; therefore, fire water is not added in the flood volume and there is no contribution from other areas. As a result, a volume addition is not included in the flood volume. To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume for this room is 8939 US gal (1195 ft^3). This is the volume used to calculate the cell liner height.

The available flood area of the room into which the liquid could flow is calculated to be 315 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The minimum required liner height is calculated by dividing the flood volume of 8939 US gal (1195 ft^3) by the available flood area of the room (315 ft^2). The minimum required liner height for the south section of melter cave no 1 (H-0117) is 3.8 ft. Details are provided in Appendix A.

3.2.5 Melter Cave No 1 (West)

Three MTUs containing dangerous waste are located in the west section of melter cave no 1 (H-0117):

HOP-SCB-00001	melter 1 submerged bed scrubber
HOP-HEME-00001A	melter 1 high efficiency mist eliminator
HOP-HEME-00001B	melter 1 high efficiency mist eliminator

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of the following:

- the total volume of the largest vessel/MTU
- 110 % of the maximum operating volume of the largest vessel/MTU
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel/MTU before the fluid overflows (up to the overflow nozzle).

The largest vessel/MTU in the area is the melter 1 submerged bed scrubber (HOP-SCB-00001). The melter 1 submerged bed scrubber (HOP-SCB-00001) has a total volume of 4653 US gal (622 ft^3), which is greater than 110 % of its maximum operating volume.

Fire sprinklers are not provided in this area; therefore, fire water is not added in the flood volume and there is no contribution from other areas. To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume is 4884 US gal (653 ft^3).

The available flood area of the room into which the liquid could flow is calculated to be 340 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The minimum required liner height is calculated by dividing the flood volume of 4884 US gal (653 ft^3) by the available flood area of the room (340 ft^2). The minimum required liner height for the west section of melter cave no 1 (H-0117) is 2.0 ft. Details are provided in Appendix A.

3.2.6 Melter Cave No 1 (Central)

One MTU containing dangerous waste is located in the central section of melter cave no 1 (H-0117):

HMP-MLTR-00001 HLW melter 1

Because molten glass that leaks from the melter (HMP-MLTR-00001) solidifies upon contact with the floor, neither a flood volume nor a minimum-required liner height needs to be calculated. Nevertheless, a stainless steel liner is provided to facilitate the containment of potential spills from either the jumpers or the feed lines. The minimum liner height is 0.5 ft. Fire sprinklers are not provided in this area.

3.2.7 Melter 2 Equipment Decontamination Pit

One vessel containing dangerous waste is located in the melter 2 equipment decontamination pit (H-0304A):

HSH-TK-00002 decontamination tank melter cave 2

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of the following:

- the total volume of the largest vessel
- 110 % of the maximum operating volume of the largest vessel
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel before the fluid overflows (up to the overflow nozzle).

The decontamination tank melter cave 2 (HSH-TK-00002) has a total volume of 3964 US gal (530 ft^3), and a 110 % maximum operating volume of 4361 US gal (583 ft^3). Since 110 % maximum operating volume of 4361 US gal (583 ft^3) is larger than the total volume, this is the volume used to calculate the cell liner height.

Fire sprinklers are not provided in this area; therefore, fire water is not added in the flood volume and there is no contribution from other areas. To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume is 4578 US gal (612 ft^3).

The available flood area of the room into which the liquid could flow is calculated to be 190 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The minimum required liner height is calculated by dividing the flood volume of 4578 US gal (612 ft^3) by the available flood area of the room (190 ft^2). The minimum required liner height for the melter 2 equipment decontamination pit (H-0304A) is 3.3 ft. Details are provided in Appendix A.

3.2.8 Melter 1 Equipment Decontamination Pit

One vessel containing dangerous waste is located in the melter 1 equipment decontamination pit (H-0310A):

HSH-TK-00001 decontamination tank melter cave 1

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of:

- the total volume of the largest vessel
- 110 % of the maximum operating volume of the largest vessel
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel before the fluid overflows (up to the overflow nozzle).

The decontamination tank melter cave 1 (HSH-TK-00001) has a total volume of 3964 US gal (530 ft^3), and a 110 % maximum operating volume of 4361 US gal (583 ft^3). Since 110 % maximum operating volume of 4361 US gal (583 ft^3) is larger than the total volume, this is the volume used to calculate the cell liner height.

Fire sprinklers are not provided in this area; therefore, fire water is not added in the flood volume and there is no contribution from other areas. To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume is 4578 US gal (612 ft^3).

The available flood area of the room into which the liquid could flow is calculated to be 190 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The minimum required liner height is calculated by dividing the flood volume of 4578 US gal (612 ft^3) by the available flood area of the room (190 ft^2). The minimum required liner height for the melter 1 equipment decontamination pit (H-0310A) is 3.3 ft. Details are provided in Appendix A.

3.3 Flooding Volume Description for HLW Facility at 37 Ft Elevation

The cells and respective vessels or miscellaneous treatment units (MTUs) are shown on the *HLW Vitrification Building General Arrangement (Permit) Plan at El. 37' -0"*, 24590-HLW-P1-P01T-P0004, Rev 0.

3.3.1 Active Services Cell Melter No 2

One MTU containing dangerous waste is located in the active services cell melter no 2 (H-0302):

HOP-WESP-00002 melter 2 wet electrostatic precipitator

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of the following:

- the total volume of the largest vessel
- 110 % of the maximum operating volume of the largest vessel
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel before the fluid overflows (up to the overflow nozzle).

The melter 2 wet electrostatic precipitator (HOP-WESP-00002) has a total volume of 6515 US gal (871 ft^3), and a 110 % maximum operating volume is 7166 US gal (958 ft^3). Since 110 % maximum operating volume of 7166 US gal (958 ft^3) is larger than the total volume, this is the volume used to calculate the cell liner height.

Fire sprinklers are not provided in this area, and there is no contribution from other areas; therefore, a volume addition is not included in the flood volume. To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume is 7525 US gal (1006 ft^3).

The available flood area of the room into which the liquid could flow is calculated to be 1860 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The minimum required liner height is calculated by dividing the flood volume of 7525 US gal (1006 ft^3) by the available flood area of the room (1860 ft^2). The minimum required liner height for the active service duct melter 2 (H-0302) is 0.6 ft. Details are provided in Appendix A.

3.3.2 Active Services Cell Melter No 1

One MTU containing dangerous waste is located in the active services cell melter no 1 (H-0308):

HOP-WESP-00001	melter 1 wet electrostatic precipitator

In the event of a line break or vessel failure, flooding could occur in the cell. The flood volume (V_{FL}) is the fire water volume plus the largest of:

- the total volume of the largest vessel
- 110 % of the maximum operating volume of the largest vessel
- the other flooding source

The total volume is defined as the internal volume of the vessel/MTU including the shell and both heads. For conservatism, the displaced volume of the vessel internals is neglected. The maximum operating volume is the volume of the vessel before the fluid overflows (up to the overflow nozzle).

The melter 1 wet electrostatic precipitator (HOP-WESP-00001) has a total volume of 6515 US gal (871 ft^3), and a 110 % maximum operating volume is 7166 US gal (958 ft^3). Since 110 % maximum operating volume of 7166 US gal (958 ft^3) is larger than the total volume, this is the volume used to calculate the cell liner height.

Fire sprinklers are not provided in this area, and there is no contribution from other areas; therefore, a volume addition is not included in the flood volume. To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Thus, the flood volume is 7525 US gal (1006 ft^3).

The available flood area of the room into which the liquid could flow is calculated to be 1860 ft^2. The available flood area of the room is the area of the room minus the cross-sectional area (footprint) of the vessels/MTUs excluding the failed vessel/MTU in the room, and miscellaneous piping and equipment that would be submerged in the flood volume. The minimum required liner height is calculated by dividing the flood volume of 7525 US gal (1006 ft^3) by the available flood area of the room (1860 ft^2). The minimum required liner height for the active service duct melter 1 (H-0308) is 0.6 ft. Details are provided in Appendix A.

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 determine the secondary containment (liner or protective coating) heights in the dangerous waste permit regulated process cells for the high-level waste (HLW) vitrification facility.

2 Criteria and Design Input

The criteria and design input with their sources are listed below.

1 Liners are used as secondary containment and are all stainless steel except for H-B039A (canister rinse-bogie maintenance room), which has a protective coating.

2 The containment liner is sized to contain 100 % of the total volume (V_{TOT}) of the largest vessel/MTU in the respective cell, or 110 % of the maximum operating volume (V_{Max}) of the largest vessel/MTU. The maximum operating volume is the volume of the vessel/MTU up to the overflow nozzle. The larger of the two is used to size the minimum required liner height.

3 As applicable, the secondary containment shall be designed to handle the volume of fire water from the fire-protection system over the minimum design area for 20 minutes, in addition to 100 % capacity of the largest vessel.

4 The room dimensions are based on the following drawings. The equipment and vessels identified for permitting are also shown on these drawings.

 24590-HLW-P1-P01T-P0001, Rev 5
 24590-HLW-P1-P01T-P0002, Rev 3
 24590-HLW-P1-P01T-P0004, Rev 0

5 The wet process cell (H-B014) floor area is divided into north and south sections by the drum transfer tunnel (H-B015) as shown in the following drawings:

 24590-HLW-P1-P01T-P0008, Rev 7
 24590-HLW-P1-P01T-P0009, Rev 6
 24590-HLW-P1-P01T-P0010, Rev 6
 24590-HLW-P1-P01T-P0011, Rev 7

6 The melter cave no 1 (H-0117) and melter cave no 2 (H-0106) floor areas are divided into north, south, and central sections as shown in the following drawings:

24590-HLW-P1-P01T-P0008, Rev 7

24590-HLW-P1-P01T-P0009, Rev 6

24590-HLW-P1-P01T-P0010, Rev 6

24590-HLW-P1-P01T-P0011, Rev 7

7 The automatic fire extinguishing system provides fire water (sprinkler discharge) flow density of 0.20 US gal/min/ft^2 for ordinary hazard occupancies for areas less than 1500 ft^2, as specified in the *Automatic Sprinkler System Handbook*, Figure 7-2.3.1.2.

8 The canister rinse-bogie maintenance room (H-B039A) and canister rinse tunnel (H-B039B) are interconnected and flooding overflows from one room into the other room.

9 The minimum liner height is the calculated liner height rounded up.

3 Assumptions

The following assumptions were used to develop this calculation.

1 To calculate the liner heights conservatively, all vessels/MTUs are supported on the floor as depicted on the following drawings:

24590-HLW-P1-P01T-P0008, Rev 7

24590-HLW-P1-P01T-P0009, Rev 6

24590-HLW-P1-P01T-P0010, Rev 6

24590-HLW-P1-P01T-P0011, Rev 7

2 The liquid level of the failed vessel/MTU empties or leaks down to the liner height. No verification is required for this assumption since this is the maximum volume that can leak out of a vessel/MTU.

3 This calculation assumes that the area beneath the non-failed vessel/MTU does not contain any spilled liquids. This assumption does not need verification, since applying this assumption results in a conservative value for the minimum required liner height.

4 The total volume calculated without any vessel internals is the largest volume for a vessel/MTU; therefore, verification is not required for this assumption.

5 To account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. This assumption requires verification after final design.

6 The floor is sloped, and the calculated minimum liner height is from the high point of the floor to the top of the liner, which neglects the accumulated volume below the high point. No verification is needed since applying this assumption results in a conservative value for the minimum required liner height.

7 Automatic fire suppression systems are not provided in areas of high radiation and low combustible loading. The permitted rooms (H-B005, H-B014, H-B021, H-B035, H-0106, H-0117, H-0302, H-

0304A, H-308 and H-0310A) are assumed high radiation and low combustible loading areas. This assumption requires verification after final design.

8 Total volume is the total internal vessel/MTU volume including shell and both vessel heads. The displaced volume of the vessel/MTU internals is neglected for conservatism.

9 HCP-VSL-00001 and HCP-VSL-00002 are the largest vessels in the south portion of the wet process cell (H-B014 South) and the basis for determining the minimum required liner height for that cell. The vessels have been deleted from the HLW design, however the liner height as shown in this calculation will still include them. This represents a bounding minimum liner height. This is a conservative assumption and does not require verification.

4 Methodology

The total volume and the maximum operating volume for each vessel/MTU are calculated based on their respective vessel/MTU data. As stated in the Assumptions and the Criteria and Design Input sections, the vessels/MTUs are completely filled. The largest vessel/MTU leaks into the room up to the minimum required liner height. For areas with fire extinguishing systems, the fire water volume is added to the flood volume.

4.1 Nomenclature

A_C	available flood area, ft^2
A_{Eq}	equipment cross-sectional area (footprint) of vessel or miscellaneous treatment unit (MTU), ft^2
A_{Rm}	area of the room, ft^2
d	depth of vessel or MTU head, ft
D	inside vessel or MTU diameter, ft
D_{Eq}	maximum vessel or MTU overall diameter (includes vessel jacket), ft
L	room length, ft
LH	calculated liner or protective coating height (inside distance of the secondary containment between the high point of the sloped floor to the top of the liner), ft
LH_{min}	minimum required liner or protective coating height is the calculated liner height rounded up
L_{OF}	distance from bottom tangent line of the vessel to the bottom of the overflow nozzle, ft
L_{OV}	overall length of the vessel or MTU, ft
L_{T-T}	tangent-to-tangent distance of the vessel or MTU, ft
MTU	miscellaneous treatment unit
N	number of ellipsoidal (Ellip) or flanged and dished (F&D) or right-circular cone heads
V_{FL}	flood volume, ft^3
V_{FW}	fire water volume, ft^3

V_{HD}	volume of the vessel or MTU head, ft^3
V_{Max}	maximum operating volume, ft^3
V_S	volume of the tangent-to-tangent portion of the vessel, ft^3
V_{TOT}	total volume, ft^3
V_{XMax}	110 % of maximum operating volume, ft^3
W	room width, ft
ΣA_{Eq}	sum of the cross-sectional areas of all vessels/equipment in the room, ft^2

4.2 Vessel/MTU Calculation

Calculations are based on vessel/MTU input design parameters, diameter, shell length, and head type. The calculations are as follows:

1 Shell volume

$V_S = \pi/4\ D^2\ L_{T\text{-}T}$, ft^3

2 Vessel/MTU head volume, from the *Pressure Vessel Design Manual* (Moss, 1987)

a 2:1 semi-ellipsoidal (Ellip) head

$V_{HD} = \pi D^3/24$, ft^3

b 100 % to 6 % flanged and dished (F&D) head

$V_{HD} = 0.0847\ D^3$, ft^3

c Right circular cone head (*Mark's Handbook for Mechanical Engineers*, 9th Edition, page 2-10)

$V_{HD} = (1/3)\ \pi\ (D/2)^2\ d$, ft^3

where $d = 0.289\ D$ for 30° right cone (section 4.2.3.c)

$V_{HD} = (1/3)\ \pi\ (D/2)^2\ (0.289\ D)$

$V_{HD} = 0.0757\ (D^3)$, ft^3

3 Depth of vessel head, from the *Pressure Vessel Design Manual*

a 2:1 semi-ellipsoidal head

$d = 0.25\ D$, ft

b 100 % – 6 % F&D head

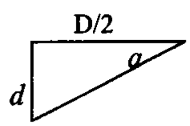
$d = 0.162\ D$, ft

c. 30° right circular cone head

$d = (D/2)\tan a$

$d = (D/2)\tan 30^\circ$

$d = 0.289\ d$, ft



4 Total volume

$$V_{TOT} = V_S + N\,V_{HD},\ ft^3$$

5 Maximum operating volume

$$V_{Max} = V_{HD} + \pi/4\,D^2\,(L_{OF}),\ ft^3$$

6 110 % of maximum operating volume

$$V_{XMax} = 1.1V_{Max},\ ft^3$$

4.3 Fire Water Volume

The fire water volume is based on fire water flow density (worst case) of 0.20 US gal/min/ft^2 for 1500 ft^2 of fire area for 20 minutes in accordance with section 2, Criteria and Design Input, item 9.

Thus, the fire water (V_{FW}) is:

$$V_{FW} = (0.20\ \text{US gal/min/ft}^2)\,(A_{Rm}\ ft^2)\,(20\ \text{min})$$
$$V_{FW} = 4.0A_{Rm}\ \text{US gal}$$

4.4 Flood Volume

The flood volume (V_{FL}) is the fire water volume (section 2, Input, item 3) plus the largest of:

- the total volume of the largest vessel (section 2, Input, item 2)
- 110 % of the maximum operating volume of the largest vessel (section 2, Input, item 2)
- the other flooding source

In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume (section 3, Assumptions, item 5).

4.5 Equipment Cross-Sectional Area of Vessel/MTU

The equipment cross-sectional area (footprint) (A_{Eq}) for each vessel/MTU in the room and sum of the equipment cross-sectional footprints (ΣA_{Eq}) are calculated as follows:

equipment cross-sectional area $(A_{Eq}) = (\pi/4)D_{Eq}^{\ 2},\ ft^2$

where D_{Eq} is the maximum vessel or MTU overall diameter (includes vessel jacket)

sum of major equipment $\Sigma A_{Eq} = (A_{Eq})_1 + (A_{Eq})_2 + (A_{Eq})_3 + \ldots + (A_{Eq})_n,\ ft^2$

where subscript $_{1,2,3,}$ and $_n$ are 1^{st}, 2^{nd}, 3^{rd}, and n^{th} vessel/MTU

4.6 Room Area

The room area (A_{Rm}) is calculated as follows:

room area (A_{Rm}) = WL, ft^2

where *W* is the room width and *L* is the room length

4.7 Available Flood Area

The available flood area (A_C) is equal to the room area (A_{Rm}) minus the sum of the equipment cross-sectional area footprint (ΣA_{Eq}), excluding the failed vessel/MTU. **Note:** the liquid level of the failed vessel is reduced to the liner height:

$$A_C = A_{Rm} - \Sigma A_{Eq}\text{ , ft}^2$$

4.8 Calculated Liner Height (LH)

LH = flood volume/available flood area

or, $LH = V_{FL}/A_C$, ft

4.9 Minimum Required Liner Height (LHmin)

The minimum required liner height is the calculated liner height in feet rounded up.

4.10 Precision of the Calculated Values

a Calculated volume to nearest ft^3 or gal

b Calculated area to the nearest ft^2

c Calculated liner height or depth of the vessel head to the nearest 0.01 ft

d Minimum required liner height to be rounded up to the next 0.1 ft

5 Calculation

The complete calculations for vessel volumes and liner height are as follows for each process cell.

5.1 SBS Drain Collection Cell No 2 (H-B005)

The area of the SBS drain collection cell no 2 (H-B005) is 14.8 ft × 17 ft. This cell contains one vessel with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	$L_{T\text{-}T}$ Tangent to tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HOP-VSL-00904	12	12.36	7.75	no overflow	Ellip	Ellip

1 Vessel HOP-VSL-00904 Calculation

shell volume, $V_S = \pi/4\ D^2\ L_{T\text{-}T}$

$V_S = (\pi/4)\ (12)^2\ (7.75) = 877\ ft^3$

vessel head volume for semi-ellipsoidal head

$V_{HD} = \pi\ D^3/24$

$V_{HD} = \pi\ (12)^3/24 = 226\ ft^3$

depth of vessel head for semi-ellipsoidal head

$d = 0.25\ D$

$d = 0.25\ (12) = 3.00\ ft$

total volume

$V_{TOT} = V_S + N\ V_{HD}$

$V_{TOT} = 877 + 2(226) = 1329\ ft^3$

$V_{TOT} = 1329\ ft^3\ (7.48\ gal/ft^3) = 9941$ US gal

maximum operating volume

$V_{Max} = V_{TOT}$ since there is no overflow nozzle, thus

$V_{Max} = 1329\ ft^3$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (1329) = 1462\ ft^3$

$V_{XMax} = 1462\ ft^3\ (7.48\ gal/ft^3) = 10{,}936$ US gal

vessel footprint or area

$A_{Eq} = (\pi/4)D_{Eq}^{\ 2} = (\pi/4)(12.36)^2 = 120\ ft^2$

2 Room Area = WL = 14.8 ft (17 ft) = 252 ft²

3 Room is in a C5/R5 area therefore no fire water is required. Thus $V_{FW} = 0\ ft^3$.

4 Another flood source is from the floor drain in cell H-0106 (west) that overflows 4653 US gal (622 ft³) into this cell (section 5.9.1a).

5 The flood volume is the larger of the total volume, or 110 % of the maximum operating volume of the largest vessel or other flooding source plus fire water. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{XMax} is larger than V_{TOT} for the HOP-VSL-00904 and the other flooding source:

$V_{FL} = 1.05\ (V_{XMax} + V_{FW}) = 1.05\ (1462 + 0) = 1535\ ft^3$

$V_{FL} = 1535\ ft^3\ (7.48\ gal/ft^3) = 11{,}482$ US gal

6 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU:

$A_C = A_{Rm} = 252\ ft^2$

7 The liner height is calculated as follows:

LH = flood volume/available flood area
$LH = V_{FL}/A_C$
LH = 1535/252 = 6.09 ft

8 The minimum required liner height is the calculated liner height rounded up, or:

$LH_{min} = 6.1$ ft

5.2 Wet Process Cell - South (H-B014 South)

The area of the wet process cell (H-B014 South) is 18 ft × 64 ft and contains four vessels with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF}, Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
RLD-VSL-00007	13	13.12	15.5	14.35	F&D	F&D
RLD-VSL-00008	13	13.12	9.75	8.60	Ellip	Ellip
HCP-VSL-00001*	13.5	14.12	15.83	14.35	F&D	F&D
HCP-VSL-00002*	13.5	14.12	15.83	14.35	F&D	F&D

* Note: HCP-VSL-00001 and HCP-VSL-00002 have been deleted from the design. However, for purpose of this calculation, the vessels are left in as a bounding minimum liner height dimension.

1 Vessel Calculations

a RLD-VSL-00007

shell volume, $V_S = \pi/4\ D^2\ L_{T-T}$

$V_S = (\pi/4)\ (13)^2\ (15.5) = 2057\ ft^3$

vessel head volume for F&D head

$V_{HD} = 0.0847\ D^3$

$V_{HD} = 0.0847\ (13)^3 = 186\ ft^3$

depth of vessel head for F&D head

$d = 0.162\ D$

$d = 0.162\ (13) = 2.11$ ft

total volume

$V_{TOT} = V_S + N\ V_{HD}$

$V_{TOT} = 2057 + 2\ (186) = 2429\ ft^3$

maximum operating volume

$V_{Max} = V_{HD} + \pi/4\ D^2\ (L_{OF})$, ft^3

$V_{Max} = 186 + (\pi/4)\ (13)^2\ (14.35) = 2091\ ft^3$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (2091) = 2300\ ft^3$

vessel footprint or area
$A_{Eq} = (\pi/4)D_{Eq}^2 = (\pi/4)(13.12)^2 = 135\ ft^2$

b RLD-VSL-00008
shell volume, $V_S = \pi/4\ D^2\ L_{T\text{-}T}$
$V_S = (\pi/4)\ (13)^2\ (9.75) = 1294\ ft^3$

vessel head volume for semi-ellipsoidal head
$V_{HD} = \pi D^3/24,\ ft^3$
$V_{HD} = \pi\ (13)^3/24 = 288\ ft^3$

depth of vessel head for semi-ellipsoidal head
$d = 0.25\ D$
$d = 0.25\ (13) = 3.25\ ft$

total volume
$V_{TOT} = V_S + N\ V_{HD}$
$V_{TOT} = 1294 + 2\ (288) = 1870\ ft^3$

maximum operating volume
$V_{Max} = V_{HD} + \pi/4\ D^2\ (L_{OF}),\ ft^3$
$V_{Max} = 288 + (\pi/4)\ (13)^2\ (8.60) = 1429\ ft^3$

110 % of maximum operating volume
$V_{XMax} = 1.1\ V_{Max} = 1.1\ (1429) = 1572\ ft^3$

vessel footprint or area
$A_{Eq} = (\pi/4)D_{Eq}^2 = (\pi/4)13.12^2 = 135\ ft^2$

c HCP-VSL-00001 or HCP-VSL-00002
shell volume, $V_S = \pi/4\ D^2\ L_{T\text{-}T}$
$V_S = (\pi/4)\ (13.5)^2\ (15.83) = 2266\ ft^3$

vessel head volume for F&D head
$V_{HD} = 0.0847\ D^3$
$V_{HD} = 0.0847\ (13.5)^3 = 208\ ft^3$

depth of vessel head for F&D head
$d = 0.162\ D$
$d = 0.162\ (13.5) = 2.19\ ft$

total volume
$V_{TOT} = V_S + N\ V_{HD}$
$V_{TOT} = 2266 + 2\ (208) = 2682\ ft^3$
$V_{TOT} = 2682\ ft^3\ (7.48\ gal/ft^3) = 20{,}061$ US gal

maximum operating volume

$V_{Max} = V_{HD} + \pi/4\ D^2\ (L_{OF})$, ft^3
$V_{Max} = 208 + (\pi/4)\ (13.5)^2\ (14.35) = 2262$ ft^3

110 % of maximum operating volume
$V_{XMax} = 1.1\ V_{Max} = 1.1\ (2262) = 2488$ ft^3

vessel footprint or area
$A_{Eq} = (\pi/4)D_{Eq}^2 = (\pi/4)14.12^2 = 157$ ft^2

2 Room Area = WL = 18 ft (64 ft) = 1152 ft^2

3 Room is in a C5/R5 area therefore no fire water is required. Thus $V_{FW} = 0$ ft^3.

4 The flood volume is the larger of the total volume or 110 % of the maximum operating volume of the largest vessel plus fire water. The largest vessel in this room is HCP-VSL-00001 or HCP-VSL-00002. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{TOT} is larger than V_{XMax} and fire water was not added to the flood volume:

$V_{FL} = 1.05\ (V_{TOT} + V_{FW}) = 1.05\ (2682 + 0) = 2816$ ft^3
$V_{FL} = 2816$ ft^3 (7.48 gal/ft^3) = 21,064 US gal

5 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU, or:

$A_C = A_{Rm} - A_{Eq1} - A_{Eq2} - A_{Eq3}$

where A_{Eq1} for RLD-VSL-00007 footprint
A_{Eq2} for RLD-VSL-00008 footprint
A_{Eq3} for HCP-VSL-00001 footprint

Assuming HCP-VSL-00002 is the leaking vessel, thus

$A_C = 1152 - 135 - 135 - 157 = 725$ ft^2

6 The liner height is calculated as follows:

LH = flood volume/available flood area
LH = V_{FL}/A_C
LH = 2816/725 = 3.88 ft

7 The minimum required liner height is the calculated liner height rounded up, or:

$LH_{min} = 3.9$ ft

5.3 Wet Process Cell - North (H-B014 North)

The area of wet process cell (H-B014 North) is 18 ft × 17 ft and contains one vessel with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
RLD-VSL-00002	3.5	3.56	4	3.33	F&D	F&D

1 Vessel RLD-VSL-00002 Calculation

shell volume, $V_S = \pi/4\ D^2\ L_{T-T}$

$$V_S = (\pi/4)\ (3.5)^2\ (4.0) = 38\ ft^3$$

vessel head volume for F&D head

$$V_{HD} = 0.0847\ D^3$$
$$V_{HD} = 0.0847\ (3.5)^3 = 4\ ft^3$$

depth of vessel head for F&D head

$$d = 0.162\ D$$
$$d = 0.162\ (3.5) = 0.57\ ft$$

total volume

$$V_{TOT} = V_S + N\ V_{HD}$$
$$V_{TOT} = 38 + 2\ (4) = 46\ ft^3$$
$$V_{TOT} = 46\ ft^3\ (7.48\ gal/ft^3) = 344\ gal$$

maximum operating volume

$$V_{Max} = V_{HD} + \pi/4\ D^2\ (L_{OF}),\ ft^3$$
$$V_{Max} = 4 + (\pi/4)\ (3.5)^2\ (3.33) = 36\ ft^3$$

110 % of maximum operating volume

$$V_{XMax} = 1.1\ V_{Max} = 1.1\ (36) = 40\ ft^3$$

vessel footprint or area

$$A_{Eq} = (\pi/4) D_{Eq}^2 = (\pi/4)(3.56)^2 = 10\ ft^2$$

2 Room Area = WL = 18 ft (17 ft) = 306 ft^2

3 Room is in a C5/R5 area therefore no fire water is required. Thus $V_{FW} = 0\ ft^3$.

4 The flood volume is the larger of the total volume or 110 % of the maximum operating volume of the largest vessel plus fire water. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{TOT} is larger than V_{XMax} and fire water was not added to the flood volume:

$$V_{FL} = 1.05\ (V_{TOT} + V_{FW}) = 1.05\ (46 + 0) = 48\ ft^3$$

$V_{FL} = 48\ ft^3\ (7.48\ gal/ft^3) = 359\ gal$

5 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU, or:

$A_C = A_{Rm} = 306\ ft^2$

6 The liner height is calculated as follows:

LH = flood volume/available flood area
$LH = V_{FL}/A_C$
$LH = 48/306 = 0.16\ ft$

7 The minimum required liner height is the calculated liner height rounded up, or:

$LH_{min} = 0.2\ ft$

5.4 SBS Drain Collection Cell No 1 (H-B021)

The area of the SBS drain collection cell no 1 (H-B021) is 14.8 ft × 17 ft. This cell contains one vessel with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HOP-VSL-00903	12	12.36	7.75	no overflow	Ellip	Ellip

1 Vessel HOP-VSL-00903 Calculation

shell volume, $V_S = \pi/4\ D^2\ L_{T-T}$
$V_S = (\pi/4)\ (12)^2\ (7.75) = 877\ ft^3$

vessel head volume for semi-ellipsoidal head
$V_{HD} = \pi\ D^3/24$
$V_{HD} = \pi\ (12)^3/24 = 226\ ft^3$

depth of vessel head for semi-ellipsoidal head
$d = 0.25\ D$
$d = 0.25\ (12) = 3.00\ ft$

total volume
$V_{TOT} = V_S + N\ V_{HD}$
$V_{TOT} = 877 + 2(226) = 1329\ ft^3$
$V_{TOT} = 1329\ ft^3\ (7.48\ gal/ft^3) = 9941\ US\ gal$

maximum operating volume
$V_{Max} = V_{TOT}$ since there is no overflow nozzle, thus
$V_{Max} = 1329\ ft^3$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (1329) = 1462\ ft^3$

$V_{XMax} = 1462\ ft^3\ (7.48\ gal/ft^3) = 10{,}936$ US gal

vessel footprint or area

$A_{Eq} = (\pi/4)D_{Eq}{}^2 = (\pi/4)(12.36)^2 = 120\ ft^2$

2 Room Area = WL = 14.8 ft (17 ft) = 252 ft^2

3 Room is in a C5/R5 area therefore no fire water is required. Thus $V_{FW} = 0\ ft^3$.

4 Another flood source is from floor drain in cell H-0117 (west) that overflows 4653 US gal (622 ft^3) into this cell (section 5.11.1a).

5 The flood volume is the larger of the total volume or 110 % of the maximum operating volume of the largest vessel or other flood source plus fire water. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{XMax} is larger than V_{TOT} for the HOP-VSL-00903 and the other flooding source:

$V_{FL} = 1.05\ (V_{XMax} + V_{FW}) = 1.05\ (1462 + 0) = 1535\ ft^3$

$V_{FL} = 1535\ ft^3\ (7.48\ gal/ft^3) = 11{,}482$ US gal

6 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU:

$A_C = A_{Rm} = 252\ ft^2$

7 The liner height is calculated as follows:

LH = flood volume/available flood area

$LH = V_{FL}/A_C$

LH = 1535/252 = 6.09 ft

8 The minimum required liner height is the calculated liner height rounded up, or:

$LH_{min} = 6.1$ ft

5.5 Canister Decon Cave (H-B035)

The area of canister decon cave (H-B035) is 11 ft × 21.5 ft and contains three vessels with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HDH-VSL-00002	2.5	2.55	16.75	15.24	Ellip	Flat

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HDH-VSL-00004	2.5	2.55	16.75	15.24	Ellip	Flat
HDH-VSL-00003	7	7.1	17.0	16.17	F&D	F&D

1 Vessel Calculations

a HDH-VSL-00002 or HDH-VSL-00004

shell volume, $V_S = \pi/4\ D^2\ L_{T-T}$

$V_S = (\pi/4)\ (2.5)^2\ (16.75) = 82\ ft^3$

vessel head volume for semi-ellipsoidal head

$V_{HD} = \pi D^3/24,\ ft^3$

$V_{HD} = \pi(2.5)^3/24 = 2\ ft^3$

depth of vessel head for semi-ellipsoidal head

$d = 0.25\ D$

$d = 0.25\ (2.5) = 0.63\ ft$

total volume

$V_{TOT} = V_S + N\ V_{HD}$

$V_{TOT} = 82 + 2 = 84\ ft^3$

maximum operating volume

$V_{Max} = V_{HD} + \pi/4\ D^2\ (L_{OF}),\ ft^3$

$V_{Max} = 2 + (\pi/4)(2.5)^2\ (15.24) = 77\ ft^3$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (77) = 85\ ft^3$

vessel footprint or area

$A_{Eq1} = (\pi/4)\ D_{Eq}^2 = (\pi/4)(2.55)^2 = 5\ ft^2$ for HDH-VSL-00002

$A_{Eq2} = (\pi/4)\ D_{Eq}^2 = (\pi/4)(2.55)^2 = 5\ ft^2$ for HDH-VSL-00004

b HDH-VSL-00003

shell volume, $V_S = \pi/4\ D^2\ L_{T-T}$

$V_S = \pi/4\ (7)^2\ (17) = 654\ ft^3$

vessel head volume for F&D head

$V_{HD} = 0.0847\ D^3$

$V_{HD} = 0.0847\ (7)^3 = 29\ ft^3$

depth of vessel head for F&D head

$d = 0.162\ D$

$d = 0.162\ (7) = 1.13\ ft$

total volume

$V_{TOT} = V_S + N\ V_{HD}$
$V_{TOT} = 654 + 2\ (29) = 712\ ft^3$
$V_{TOT} = 712\ ft^3\ (7.48\ gal/ft^3) = 5326$ US gal

maximum operating volume

$V_{Max} = V_{HD} + \pi/4\ D^2\ (L_{OF})ft^3$
$V_{Max} = 29 + (\pi/4)\ (7)^2\ (16.17) = 651\ ft^3$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (651) = 716\ ft^3$
$V_{TOT} = 716\ ft^3\ (7.48\ gal/ft^3) = 5356$ US gal

vessel footprint or area

$A_{Eq3} = (\pi/4)D_{Eq}^{\ 2} = (\pi/4)(7.1)^2 = 40\ ft^2$

2 Room Area = WL = 11 ft (21.5 ft) = $237\ ft^2$

3 Room is in a C5/R5 area therefore no fire water is required. Thus $V_{FW} = 0\ ft^3$.

4 The flood volume is the larger of the total volume, or 110 % of the maximum operating volume of the largest vessel plus fire water. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. The largest vessel in this room is HDH-VSL-00003. Since V_{XMax} is greater than V_{TOT}:

$V_{FL} = 1.05\ (V_{XMax} + V_{FW}) = 1.05\ (716 + 0) = 752\ ft^3$
$V_{FL} = 752\ ft^3\ (7.48\ gal/ft^3) = 5625$ US gal

5 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU, or:

$A_C = A_{Rm} - A_{Eq1} - A_{Eq2}$

where A_{Eq1} for HDH-VSL-00002 footprint
A_{Eq2} for HDH-VSL-00004 footprint

$A_C = 237 - 5 - 5 = 227\ ft^2$

6 The liner height is calculated as follows:

LH = flood volume/available flood area
$LH = V_{FL}/A_C$
LH = 752/227 = 3.31 ft

7 The minimum required liner height is the calculated liner height rounded up, or:

$LH_{min} = 3.4$ ft

5.6 Canister Rinse- Bogie Maintenance Room (H-B039A)

The canister rinse-bogie maintenance room (H-B039A) and canister rinse tunnel (H-B039B) are interconnected and flood from one room into the other room. The canister rinse-bogie maintenance room (H-B039A) is 23.3 ft × 34 ft and canister rinse tunnel (H-B039B) is 11.3 ft × 49.3 ft. The canister rinse-bogie maintenance room and the canister rinse tunnel are considered as one area and contain one vessel with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	$L_{T\text{-}T}$ Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HDH-VSL-00001	5.83	5.92	17.0	no overflow	Ellip	Flat

1 Vessel HDH-VSL-00001 Calculation

shell volume, $V_S = \pi/4\ D^2\ L_{T\text{-}T}$

$V_S = (\pi/4)\ (5.83)^2\ (17.0) = 454\ ft^3$

vessel head volume for semi-ellipsoidal head

$V_{HD} = \pi D^3/24,\ ft^3$

$V_{HD} = \pi(5.83)^3/24 = 26\ ft^3$

depth of vessel head for semi-ellipsoidal head

$d = 0.25\ D$

$d = 0.25\ (5.83) = 1.46\ ft$

total volume

$V_{TOT} = V_S + N\ V_{HD}$

$V_{TOT} = 454 + 26 = 480\ ft^3$

$V_{TOT} = 480\ ft^3\ (7.48\ gal/ft^3) = 3590$ US gal

maximum operating volume

with no overflow and flat top head, V_{Max} is

$V_{Max} = V_{Tot}$

$V_{Max} = 480\ ft^3$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (480) = 528\ ft^3$

$V_{XMax} = 528\ ft^3\ (7.48\ gal/ft^3) = 3949$ US gal

vessel footprint or area

$A_{Eq} = (\pi/4)D_{Eq}^{\ 2} = (\pi/4)(5.92)^2 = 28\ ft^2$

2 Room areas, where each room area (A_{Rm}) = WL

a Room H-B039A

$A_{Rm1} = (23.3\ ft)\ (34\ ft) = 792\ ft^2$

b Room H-B039B

$A_{Rm2} = (11.3 \text{ ft}) (49.3 \text{ ft}) = 557 \text{ ft}^2$

c Rooms H-B039A and H-B039B

$A_{Rm} = A_{Rm1} + A_{Rm2} = 792 \text{ ft}^2 + 557 \text{ ft}^2 = 1349 \text{ ft}^2$

3 An automatic fire protection system is provided in the canister rinse-bogie maintenance room (H-B039A). The fire water volume is based on fire water flow density (worst case) of 0.2 US gpm/ft² for 1500 ft² of fire area for 20 minutes. Thus, the fire water is:

$V_{FW} = (0.2 \text{ US gpm/ft}^2) (A_{Rm} \text{ ft}^2) (20 \text{ min})$
$V_{FW} = 4.0A_{Rm} = 4.0 (792) = 3168 \text{ US gal}$
$V_{FW} = 3168 \text{ gal} / (7.48 \text{ gal/ ft}^3) = 424 \text{ ft}^3$

4 The flood volume is the larger of the total volume or 110 % of the maximum operating volume of the largest vessel plus fire water. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{XMax} is larger than V_{TOT}:

$V_{FL} = 1.05 (V_{XMax} + V_{FW}) = 1.05 (528 + 424) = 1000 \text{ ft}^3$
$V_{FL} = 1000 \text{ ft}^3 (7.48 \text{ gal/ft}^3) = 7480 \text{ US gal}$

5 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU. Since the canister rinse-bogie maintenance room (H-B039A) and canister rinse tunnel (H-B039B) are interconnected and flood from one room into the other room, the available flood area is the sum of both rooms:

$A_C = A_{Rm1} + A_{Rm2} = 792 \text{ ft}^2 + 557 \text{ ft}^2 = 1349 \text{ ft}^2$

6 The calculated secondary containment (protective coating) height is calculated as follows:

LH = flood volume/available flood area
$LH = V_{FL}/A_C$
$LH = 1000/1349 = 0.74 \text{ ft}$

7 The minimum required protective coating height is the calculated height rounded up, or:

$LH_{min} = 0.8 \text{ ft}$

5.7 Canister Rinse Tunnel (H-B039B)

The canister rinse tunnel (H-B039B) and the canister rinse-bogie maintenance room (H-B039A) are interconnected and flood from one room into the other room. The canister rinse-bogie maintenance room (H-B039A) is 23.3 ft × 34 ft and canister rinse tunnel (H-B039B) is 11.3 ft × 49.3 ft. The canister rinse-bogie maintenance room and the canister rinse tunnel are considered to be one area and contain one vessel with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HDH-VSL-00001	5.83	5.92	17.0	no overflow	Ellip	Flat

1 Vessel HDH-VSL-00001 Calculation

shell volume, $V_S = \pi/4\ D^2\ L_{T-T}$

$$V_S = (\pi/4)\ (5.83)^2\ (17.0) = 454\ ft^3$$

vessel head volume for semi-ellipsoidal head

$$V_{HD} = \pi D^3/24,\ ft^3$$
$$V_{HD} = \pi(5.83)^3/24 = 26\ ft^3$$

depth of vessel head for semi-ellipsoidal head

$$d = 0.25\ D$$
$$d = 0.25\ (5.83) = 1.46\ ft$$

total volume

$$V_{TOT} = V_S + N\ V_{HD}$$
$$V_{TOT} = 454 + 26 = 480\ ft^3$$
$$V_{TOT} = 480\ ft^3\ (7.48\ gal/\ ft^3) = 3590\ US\ gal$$

maximum operating volume

with no overflow and flat top head, V_{Max} is

$$V_{Max} = V_{TOT}$$
$$V_{Max} = 480\ ft^3$$

110 % of maximum operating volume

$$V_{XMax} = 1.1\ V_{Max} = 1.1\ (480) = 528\ ft^3$$
$$V_{XMax} = 528 ft^3\ (7.48\ gal/ft^3) = 3949\ US\ gal$$

vessel footprint or area

$$A_{Eq} = (\pi/4)D_{Eq}^{\ 2} = (\pi/4)(5.92)^2 = 28\ ft^2$$

2 Room area, where each room area (A_{Rm}) = WL

a Room H-B039A

$$A_{Rm1} = (23.3\ ft)\ (34\ ft) = 792\ ft^2$$

b Room H-B039B

$$A_{Rm2} = (11.3\ ft)\ (49.3\ ft) = 557\ ft^2$$

c Rooms H-B039A and H-B039B

$$A_{Rm} = A_{Rm1} + A_{Rm2} = 792\ ft^2 + 557\ ft^2 = 1349\ ft^2$$

3 An automatic fire protection system is provided in canister rinse tunnel (H-B039B). The fire water volume is based on fire water flow density (worst case) of 0.2 US gpm/ft^2 for 1500 ft^2 of fire area for 20 minutes. Thus, the fire water is:

$$V_{FW} = (0.2 \text{ US gpm/ft}^2)(A_{Rm} \text{ ft}^2)(20 \text{ min})$$
$$V_{FW} = 4.0A_{Rm} = 4.0\ (557) = 2228 \text{ US gal}$$
$$V_{FW} = 2228 \text{ gal}/(7.48 \text{ gal/ft}^3) = 298 \text{ ft}^3$$

4 The flood volume is the larger of the total volume, or 110 % of the maximum operating volume of the largest vessel plus fire water. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{XMax} is larger than V_{TOT}:

$$V_{FL} = 1.05\ (V_{XMax} + V_{FW}) = 1.05\ (528 + 298)$$
$$V_{FL} = 867 \text{ ft}^3 \text{ for H-B039B}$$
$$V_{FL} = 867 \text{ ft}^3\ (7.48 \text{ gal/ft}^3) = 6485 \text{ US gal}$$

The canister rinse tunnel (H-B039B) and the canister rinse-bogie maintenance room (H-B039A) are interconnected and flood from one room into the other room. Since the flood volume for room H-B039A is larger than H-B039B, the flood volume for H-B039A is used in calculating the liner height:

$$V_{FL} \text{ for H-B039A} = V_{FL} = 1000 \text{ ft}^3$$
$$V_{FL} = 1000 \text{ ft}^3\ (7.48 \text{ gal/ft}^3) = 7480 \text{ US gal}$$

5 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU. Since the canister rinse-bogie maintenance room (H-B039A) and the canister rinse tunnel (H-B039B) are interconnected and flooding overflows from one room into the other room, the available flood area is the sum of both rooms:

$$A_C = A_{Rm1} + A_{Rm2} = 792 \text{ ft}^2 + 557 \text{ ft}^2 = 1349 \text{ ft}^2$$

6 The liner height is calculated as follows:

$$LH = \text{flood volume/available flood area}$$
$$LH = V_{Fl}/A_C$$
$$LH = 1000/1349 = 0.74 \text{ ft}$$

7 The minimum required liner height is the calculated liner height rounded up, or:

$$LH_{min} = 0.8 \text{ ft}$$

5.8 Melter Cave No 2 - South (H-0106 South)

The south area of the melter cave no 2 (H-0106 South) is 14.75 ft x 30.5 ft - 3 ft x 6 ft - 1.67 ft x 7.5 ft. This cell contains four vessels with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HFP-DMST-00003	0.530	0.552	1.75	na	flat	flat
HFP-DMST-00004	0.530	0.552	1.75	na	flat	flat
HFP-VSL-00005	11	11.52	9.5	9.70	F&D	F&D
HFP-VSL-00006	11	11.52	9.5	9.70	F&D	F&D

1 Vessel Calculations

The HFP-DMST-00003 is directly flanged to HFP-VSL-00005, and HFP-DMST-00005 is directly flanged to HFP-VSL-00006. These demisters are considered part of the connecting vessel. Thus, the volumes from the demisters are added to their connecting vessel (HFP-VSL-00005 or 00006) total tank volume:

a HFP-DMST-00003 or HFP-VSL-00004

$V_{TOT} = V_S = \pi/4\ D^2\ L_{T-T}$

demister volume = $V_{Dem} = (\pi/4)\ (0.530)^2\ (1.75) = 0.4\ ft^3$

b HFP-VSL-00005 or HFP-VSL-00006

shell volume, $V_S = \pi/4\ D^2\ L_{T-T}$

$V_{TOT} = (\pi/4)\ (11)^2\ (9.5) = 903\ ft^3$

vessel head volume for F&D head

$V_{HD} = 0.0847\ D^3$

$V_{HD} = 0.0847\ (11)^3 = 113\ ft^3$

depth of vessel head for F&D head

$d = 0.162\ D$

$d = 0.162\ (11) = 1.78\ ft$

c HFP-VSL-00005 with HFP-DMST-00003 or HFP-VSL-00006 with HFP-DMST-00004

total vessel volume for the HFP vessel with its demister is:

V_{TOT} = [HFP – VSL volume] + [demister volume]

$V_{TOT} = [V_S + N\ V_{HD}] + [V_{Dem}]$

$V_{TOT} = [903 + 2(113)] + [(\pi/4)\ (0.530)^2\ (1.75)]$

$V_{TOT} = [1129] + [0.4]$

$V_{TOT} = 1129\ ft^3$ (with demister)

$V_{TOT} = 1129\ ft^3\ (7.48\ gal/ft^3) = 8445$ US gal

maximum operating volume

$V_{Max} = V_{HD} + \pi/4\ D^2\ (L_{OF}),\ ft^3$

$V_{Max} = 113 + (\pi/4)(11)^2\ (9.7) = 1035\ ft$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (1035) = 1138\ ft^3$

$V_{XMax} = 1138\ ft^3\ (7.48\ gal/ft^3) = 8512$ US gal vessel footprint or area

$$A_{Eq} = (\pi/4)D_{Eq}^2 = (\pi/4)(11.52)^2 = 104 \text{ ft}^2$$

2 Room Area = WL = 14.75 ft (30.5 ft) - 3 ft (6 ft) - 1.67 ft (7.5 ft) = 419 ft^2

3 Room is in a C5/R5 area therefore no fire water is required. Thus $V_{FW} = 0 \text{ ft}^3$.

4 The flood volume is the larger of the total volume, or 110 % of the maximum operating volume of the largest vessel plus fire water. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{XMax} is larger than V_{TOT}:

$$V_{FL} = 1.05 (V_{XMax} + V_{FW}) = 1.05 (1138 + 0) = 1195 \text{ ft}^3$$
$$V_{FL} = 1195 \text{ ft}^3 (7.48 \text{ gal/ft}^3) = 8939 \text{ US gal}$$

5 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU. In addition, the demisters footprints are immaterial since they are located above the HFP vessels:

$$A_C = A_{Rm} - A_{Eq1}$$

where A_{Eq1} for HFP-VSL-00005 footprint

Assuming HFP-VSL-00006 is the leaking vessel, thus
$A_C = 419 - 104 = 315 \text{ ft}^2$

6 The liner height is calculated as follows:

LH = flood volume/available flood area
$LH = V_{FL}/A_C$
LH = 1195/315 = 3.79 ft

7 The minimum required liner height is the calculated liner height rounded up, or:

$LH_{min} = 3.8$ ft

5.9 Melter Cave No 2 - West (H-0106 West)

The west area of the melter cave no 2 (H-0106 west) is 13.08 ft x 30.58 -8 ft x 1.5 ft. This cell contains three MTUs with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HOP-SCB-00002	10	10.36	5.75	4.5	F&D	F&D
HOP-HEME-00002A	5.5	5.58	12.17	no overflow	F&D	F&D
HOP-HEME-00002B	5.5	5.58	12.17	no overflow	F&D	F&D

1 MTU Calculations

a HOP-SCB-00002

shell volume, $V_S = \pi/4\ D^2\ L_{T\text{-}T}$

$V_S = \pi/4\ (10)^2\ (5.75) = 452\ ft^3$

vessel head volume for F&D head

$V_{HD} = 0.0847\ D^3$

$V_{HD} = 0.0847\ (10)^3 = 85\ ft^3$

depth of vessel head for F&D head

$d = 0.162\ D$

$d = 0.162\ (10) = 1.62\ ft$

total volume

$V_{TOT} = V_S + N\ V_{HD}$

$V_{TOT} = 452 + 2\ (85) = 622\ ft^3$

$V_{TOT} = 622\ ft^3\ (7.48\ gal/ft^3) = 4653$ US gal

maximum operating volume

$V_{Max} = V_{HD} + \pi/4\ D^2\ (L_{OF}),\ ft^3$

$V_{Max} = 85 + \pi/4\ (10)^2\ (4.5) = 438\ ft^3$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (438) = 482\ ft^3$

vessel footprint or area

$A_{Eq} = (\pi/4)D_{Eq}^2 = (\pi/4)(10.36)^2 = 84\ ft^2$

b HOP-HEME-00002A or HOP-HEME-00002B

shell volume, $V_S = \pi/4\ D^2\ L_{T\text{-}T}$

$V_S = \pi/4\ (5.5)^2\ (12.17) = 289\ ft^3$

vessel head volume for F&D head

$V_{HD} = 0.0847\ D^3$

$V_{HD} = 0.0847\ (5.5)^3 = 14\ ft^3$

depth of vessel head for F&D head

$d = 0.162\ D$

$d = 0.162\ (5.5) = 0.89\ ft$

total volume

$V_{TOT} = V_S + N\ V_{HD}$

$V_{TOT} = 289 + 2\ (14) = 317\ ft^3$

maximum operating volume

$V_{Max} = V_{TOT}$ since there is no overflow nozzle, thus

$V_{Max} = 317\ ft^3$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (317) = 349\ ft^3$

vessel footprint or area

$A_{Eq} = (\pi/4)D_{Eq}^2 = (\pi/4)(5.58)^2 = 24\ ft^2$

2 Room Area = WL = (13.08 ft) (30.58 ft) - (8 ft) (1.5 ft) = 388 ft^2

3 Room is in a C5/R5 area therefore no fire water is required. Thus $V_{FW} = 0\ ft^3$.

4 Flood volume is the larger of the total volume or 110 % of the maximum operating volume of the largest vessel plus fire water. The largest vessel/MTU in this room is HOP-SCB-00001. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{TOT} is larger than V_{XMax} and fire water was not added to the flood volume:

$V_{FL} = 1.05\ V_{TOT} = 1.05\ (622) = 653\ ft^3$

$V_{FL} = 653\ ft^3\ (7.48\ gal/ft^3) = 4884$ US gal

5 Available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU, or:

$A_C = A_{Rm} - A_{Eq1} - A_{Eq2}$

where A_{Eq1} for HOP-HEME-00002A footprint
A_{Eq2} for HOP-HEME-00002B footprint

$A_C = 388 - 24 - 24 = 340\ ft^2$

6 Liner height is calculated as follows:

LH = flood volume/available flood area

$LH = V_{FL}/A_C$

LH = 653/340 = 1.92 ft

7 The minimum required liner height (LH_{min}) is the calculated liner height rounded up, or:

$LH_{min} = 2.0$ ft

5.10 Melter Cave No 1 - South (H-0117 South)

The south area of the melter cave no 1 (H-0117 South) is 14.75 ft x 30.5 ft - 3 ft x 6 ft - 1.67 ft x 7.5 ft. This cell contains four vessels with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HFP-DMST-00001	0.530	0.552	1.75	na	flat	flat
HFP-DMST-00002	0.530	0.552	1.75	na	flat	flat
HFP-VSL-00001	11	11.52	9.5	9.70	F&D	F&D
HFP-VSL-00002	11	11.52	9.5	9.70	F&D	F&D

1 Vessel Calculations

The HFP-DMST-00001 is directly flanged to HFP-VSL-00001 and HFP-DMST-00002 is directly flanged to HFP-VSL-00002. These demisters are considered part of the connecting vessel. Thus, the volumes of the demisters are included to their connecting vessel (HFP-VSL-00001 or 00002) total tank volume.

a HFP-DMST-00001or 00002

$V_{TOT} = V_S = \pi/4\ D^2\ L_{T-T}$

$V_{TOT} = (\pi/4)\ (0.530)^2\ (1.75) = 0.4\ ft^3$

b HFP-VSL-00001 or HFP-VSL-00002

shell volume, $V_S = \pi/4\ D^2\ L_{T-T}$

$V_S = (\pi/4)\ (11)^2\ (9.5) = 903\ ft^3$

vessel head volume for F&D head

$V_{HD} = 0.0847\ D^3$

$V_{HD} = 0.0847\ (11)^3 = 113\ ft^3$

depth of vessel head for F&D head

$d = 0.162\ D$

$d = 0.162\ (11) = 1.78\ ft$

c HFP-VSL-00001 with HFP-DMST-00001 or HFP-VSL-00002 with HFP-DMST-00002

total vessel volume for HFP vessel with its demister is:

$V_{TOT} = [\text{HFP} - \text{VSL volume}] + [\text{demister volume}]$

$V_{TOT} = [V_S + N\ V_{HD}] + [\text{demister volume}]$

$V_{TOT} = [903 + 2(113)] + [(\pi/4)\ (0.530)^2\ (1.75)]$

$V_{TOT} = [1129] + [0.4]$

$V_{TOT} = 1129\ ft^3$ (with demister)

$V_{TOT} = 1129\ ft^3\ (7.48\ gal/ft^3) = 8445$ US gal

maximum operating volume

$V_{Max} = V_{HD} + \pi/4\ D^2\ (L_{OF}),\ ft^3$

$V_{Max} = 113 + (\pi/4)(11)^2\ (9.7) = 1035\ ft^3$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (1035) = 1138\ ft^3$

$V_{XMax} = 1138\ ft^3\ (7.48\ gal/ft^3) = 8512$ US gal

vessel footprint or area

$A_{Eq} = (\pi/4)D_{Eq}^2 = (\pi/4)(11.52)^2 = 104\ ft^2$

2 Room area = WL = 14.75 ft (30.5 ft) - 3 ft (6 ft) - 1.67 ft (7.5 ft) = 419 ft^2

3 Room is in a C5/R5 area therefore no fire water is required. Thus $V_{FW} = 0\ ft^3$.

4 The flood volume is the larger of the total volume or 110 % of the maximum operating volume of the largest vessel plus fire water. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{XMax} is larger than V_{TOT}:

$V_{FL} = 1.05\ (V_{XMax} + V_{FW}) = 1.05\ (1138 + 0) = 1195\ ft^3$

$V_{FL} = 1195\ ft^3\ (7.48\ gal/ft^3) = 8939$ US gal

5 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU, or:

$A_C = A_{Rm} - A_{Eq1}$

where, A_{Eq1} for HFP-VSL-00001 footprint

Assuming HFP-VSL-00002 is the leaking vessel, thus

$A_C = 419 - 104 = 315\ ft^2$

6 The liner height is calculated as follows:

LH = flood volume/available flood area

$LH = V_{FL}/A_C$

LH = 1195/315 = 3.79 ft

7 The minimum required liner height (LH_{min}) is the calculated liner height rounded up, or:

$LH_{min} = 3.8$ ft

5.11 Melter Cave No 1 - West (H-0117 West)

The west area of the melter cave no 1 (H-0117 West) is 13.08 ft x 30.58 -8 ft x 1.5 ft. This cell contains three MTUs with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HOP-SCB-00001	10	10.36	5.75	4.5	F&D	F&D

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	$L_{T\text{-}T}$ Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HOP-HEME-00001A	5.5	5.58	12.17	no overflow	F&D	F&D
HOP-HEME-00001B	5.5	5.58	12.17	no overflow	F&D	F&D

1 MTU Calculations

a HOP-SCB-00001

shell volume, $V_{Sb} = \pi/4\ D^2\ L_{T\text{-}T}$

$$V_{Sb} = \pi/4\ (10)^2\ (5.75) = 452\ ft^3$$

vessel head volume for F&D head

$$V_{HD} = 0.0847\ D^3$$
$$V_{HD} = 0.0847\ (10)^3 = 85\ ft^3$$

depth of vessel head for F&D head

$$d = 0.162\ D$$
$$d = 0.162\ (10) = 1.62\ ft$$

total volume

$$V_{TOT} = V_S + N\ V_{HD}$$
$$V_{TOT} = 452 + 2\ (85) = 622\ ft^3$$
$$V_{TOT} = 622\ ft^3\ (7.48\ gal/ft^3) = 4653\ US\ gal$$

maximum operating volume

$$V_{Max} = V_{HD} + \pi/4\ D^2\ (L_{OF})\ ft^3$$
$$V_{Max} = 85 + \pi/4\ (10)^2\ (4.5) = 438\ ft^3$$

110 % of maximum operating volume

$$V_{XMax} = 1.1\ V_{Max} = 1.1\ (438) = 482\ ft^3$$

vessel footprint or area

$$A_{Eq} = (\pi/4) D_{Eq}^{\ 2} = (\pi/4)(10.36)^2 = 84\ ft^2$$

b HOP-HEME-00001A or HOP-HEME-00001B

shell volume, $V_S = \pi/4\ D^2\ L_{T\text{-}T}$

$$V_S = \pi/4\ (5.5)^2\ (12.17) = 289\ ft^3$$

vessel head volume for F&D head

$$V_{HD} = 0.0847\ D^3$$
$$V_{HD} = 0.0847\ (5.5)^3 = 14\ ft^3$$

depth of vessel head for F&D head

$$d = 0.162\ D$$
$$d = 0.162\ (5.5) = 0.89\ ft$$

total volume

$V_{TOT} = V_S + N\ V_{HD}$
$V_{TOT} = 289 + 2\ (14) = 317\ ft^3$

maximum operating volume

$V_{Max} = V_{TOT}$ since there is no overflow nozzle, thus,
$V_{Max} = 317\ ft^3$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (317) = 349\ ft^3$

vessel footprint or area

$A_{Eq} = (\pi/4)D_{Eq}^2 = (\pi/4)(5.58)^2 = 24\ ft^2$

2 Room Area (A_{Rm}) = WL = (13.08 ft) (30.58 ft) - (8 ft) (1.5 ft) = 388 ft^2

3 Room is in a C5/R5 area therefore no fire water is required. Thus $V_{FW} = 0\ ft^3$.

4 The flood volume is the larger of the total volume or 110 % of the maximum operating volume of the largest vessel plus fire water. The largest vessel/MTU in this room is HOP-SCB-00001. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{TOT} is larger than V_{XMax} and fire water was not added to the flood volume:

$V_{FL} = 1.05\ V_{TOT} = 1.05\ (622) = 653\ ft^3$
$V_{FL} = 653\ ft^3\ (7.48\ gal/ft^3) = 4884$ US gal

5 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU, or:

$A_C = A_{Rm} - A_{Eq1} - A_{Eq2}$

where A_{Eq1} for HOP-HEME-00001A footprint
A_{Eq2} for HOP-HEME-00001B footprint

$A_C = 388 - 24 - 24 = 340\ ft^2$

6 The liner height is calculated as follows:

LH = flood volume/available flood area
LH = V_{FL}/A_C
LH = 653/340 = 1.92 ft

7 The minimum required liner height is the calculated liner height rounded up to the next half-foot, or:

$LH_{min} = 2.0$ ft

5.12 Melter 2 Equipment Decontamination Pit (H-0304A)

The melter 2 tank area (H-0304A) is 9.5 ft × 20 ft and contains one vessel with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HSH-TK-00002	6	6.1	18.17	na	cone	flat

1 Vessel HSH-TK-00002 Calculation

shell volume, $V_S = \pi/4\ D^2\ L_{T-T}$

$V_S = (\pi/4)\ (6)^2\ (18.17) = 514\ ft^3$

vessel head volume for right circular cone head

$V_{HD} = 0.0757\ (D^3),\ ft^3$

$V_{HD} = 0.0757\ (6^3)$

$V_{HD} = 16\ ft^3$

total volume

$V_{TOT} = V_S + N\ V_{HD}$

$V_{TOT} = 514 + 16 = 530\ ft^3$

$V_{TOT} = 530\ ft^3\ (7.48\ gal/ft^3) = 3964$ US gal

maximum operating volume

with no overflow and flat top head, V_{Max} is:

$V_{Max} = V_{TOT}$

$V_{Max} = 530 ft^3$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (530) = 583\ ft^3$

$V_{XMax} = 583\ ft^3\ (7.48\ gal/ft^3) = 4361$ US gal

vessel footprint or area

$A_{Eq} = (\pi/4) D_{Eq}^2 = (\pi/4)(6.1)^2 = 29\ ft^2$

2 Room Area = WL

$A_{Rm1} = (9.5\ ft)\ (20\ ft) = 190\ ft^2$

3 Room is in a C5/R5 area therefore no fire water is required. Thus $V_{FW} = 0\ ft^3$.

4 The flood volume is the larger of the total volume or 110 % of the maximum operating volume of the largest vessel plus fire water. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{XMax} is larger than V_{TOT}:

$V_{FL} = 1.05\ (V_{XMax} + V_{FW}) = 1.05\ (583) = 612\ ft^3$

$V_{FL} = 612\ ft^3\ (7.48\ gal/ft^3) = 4578$ US gal

5 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU:

$A_C = 190\ ft^2$

6 The liner height is calculated as follows:

LH = flood volume/available flood area
$LH = V_{FL}/A_C$
$LH = 612/190 = 3.22$ ft

7 The minimum required liner height is the calculated liner height rounded up, or:

$LH_{min} = 3.3$ ft

5.13 Melter 1 Equipment Decontamination Pit (H-0310A)

The melter 1 tank area (H-0310A) is 9.5 ft × 20 ft and contains one vessel with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HSH-TK-00001	6	6.1	18.17	na	cone	flat

1 Vessel HSH-TK-00001 Calculation

shell volume, $V_S = \pi/4\ D^2\ L_{T-T}$
$V_S = (\pi/4)\ (6)^2\ (18.17) = 514\ ft^3$

vessel head volume for right circular cone head
$V_{HD} = 0.0757\ (D^3),\ ft^3$
$V_{HD} = 0.0757\ (6^3)$
$V_{HD} = 16\ ft^3$

total volume
$V_{TOT} = V_S + N\ V_{HD}$
$V_{TOT} = 514 + 16 = 530\ ft^3$
$V_{TOT} = 530\ ft^3\ (7.48\ gal/ft^3) = 3964$ US gal

maximum operating volume
with no overflow and flat top head, V_{Max} is:
$V_{Max} = V_{TOT}$
$V_{Max} = 530\ ft^3$

110 % of maximum operating volume
$V_{XMax} = 1.1\ V_{Max} = 1.1\ (530) = 583\ ft^3$
$V_{XMax} = 583\ ft^3\ (7.48\ gal/ft^3) = 4361$ US gal

vessel footprint or area

$A_{Eq} = (\pi/4)D_{Eq}{}^2 = (\pi/4)(6.1)^2 = 29\ ft^2$

2 Room area = WL

$A_{Rm1} = (9.5\ ft)\ (20\ ft) = 190\ ft^2$

3 Room is in a C5/R5 area therefore no fire water is required. Thus $V_{FW} = 0\ ft^3$.

4 The flood volume is the larger of the total volume or 110 % of the maximum operating volume of the largest vessel plus fire water. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{XMax} is larger than V_{TOT}:

$V_{FL} = 1.05\ (V_{XMax} + V_{FW}) = 1.05\ (583 + 0) = 612\ ft^3$
$V_{FL} = 612\ ft^3\ (7.48\ gal/ft^3) = 4578$ US gal

5 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU:

$A_C = 190\ ft^2$

6 The liner height is calculated as follows:

LH = flood volume/available flood area
$LH = V_{FL}/A_C$
LH = 612/190 = 3.22 ft

7 The minimum required liner height is the calculated liner height rounded up, or:

$LH_{min} = 3.3$ ft

5.14 Active Services Cell Melter No 2 (H-0302)

The area of the active services cell melter no 2 is 20 ft × 93 ft. This cell contains one MTU with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HOP-WESP-00002	7	7.1	21.87	none	F&D	Flat

1 HOP-WESP-00002 Calculation

shell volume, $V_S = \pi/4\ D^2\ L_{T-T}$

$V_S = (\pi/4)\ (7)^2\ (21.87) = 842\ ft^3$

vessel head volume for F&D head

$V_{HD} = 0.0847\ D^3$
$V_{HD} = 0.0847\ (7)^3 = 29\ ft^3$

depth of vessel head for F&D head

$d = 0.162\ D$

$d = 0.162\ (7) = 1.13$ ft

total volume

$V_{TOT} = V_S + N\ V_{HD}$

$V_{TOT} = 842 + 1(29) = 871\ ft^3$

$V_{TOT} = 871\ ft^3\ (7.48\ gal/ft^3) = 6515$ US gal

maximum operating volume

Since the vessel has no overflow, thus assumed:

$V_{Max} = V_{TOT},\ ft^3$

$V_{Max} = 871\ ft^3$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (871) = 958\ ft^3$

$V_{XMax} = 958\ ft^3\ (7.48\ gal/ft^3) = 7166$ US gal

vessel footprint or area

$A_{Eq} = (\pi/4)D_{Eq}^2 = (\pi/4)(7.1)^2 = 40\ ft^2$

2 Room area = WL = 20 ft (93 ft) = 1860 ft^2

3 Room is in a C5/R5 area therefore no fire water is required. Thus $V_{FW} = 0\ ft^3$.

4 The flood volume is the larger of the total volume or 110 % of the maximum operating volume of the largest vessel plus fire water. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{XMax} is larger than V_{TOT}:

$V_{FL} = 1.05\ (V_{XMax} + V_{FW}) = 1.05\ (958 + 0) = 1006\ ft^3$

$V_{FL} = 1006\ ft^3\ (7.48\ gal/ft^3) = 7525$ US gal

5 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU, or:

$A_C = A_{Rm} - A_{Eq1} = A_{Rm}$

where, $A_{Eq1} = 0$

$A_C = 1860\ ft^2$

6 The liner height is calculated as follows:

LH = flood volume/available flood area

$LH = V_{FL}/A_C$

LH = 1006/1860 = 0.54 ft

7 The minimum required liner height is the calculated liner height rounded up, or:

$LH_{min} = 0.6$ ft

5.15 Active Services Cell Melter No 1 (H-0308)

The area of the active services cell melter no 1 is 20 ft × 93 ft. This cell contains one MTU with the following vessel/MTU data:

Vessel/MTU	D Inside Diameter, ft	D_{Eq} Max Equip Diameter, ft	L_{T-T} Tangent to Tangent, ft	L_{OF} Overflow Nozzle Height, ft	Bottom Vessel Head	Top Vessel Head
HOP-WESP-00001	7	7.1	21.87	none	F&D	Flat

1 HOP-WESP-00001 Calculation

shell volume, $V_S = \pi/4\ D^2\ L_{T-T}$

$V_S = (\pi/4)\ (7)^2\ (21.87) = 842\ ft^3$

vessel head volume for F&D head

$V_{HD} = 0.0847\ D^3$

$V_{HD} = 0.0847\ (7)^3 = 29\ ft^3$

depth of vessel head for F&D head

$d = 0.162\ D$

$d = 0.162\ (7) = 1.13$ ft

total volume

$V_{TOT} = V_S + N\ V_{HD}$

$V_{TOT} = 842 + 1(29) = 871\ ft^3$

$V_{TOT} = 871\ ft^3\ (7.48\ gal/ft^3) = 6515$ US gal

maximum operating volume

Since the vessel has no overflow:

$V_{Max} = V_{TOT},\ ft^3$

$V_{Max} = 871\ ft^3$

110 % of maximum operating volume

$V_{XMax} = 1.1\ V_{Max} = 1.1\ (871) = 958\ ft^3$

$V_{XMax} = 958\ ft^3\ (7.48\ gal/ft^3) = 7166$ US gal

vessel footprint or area

$A_{Eq} = (\pi/4)D_{Eq}^2 = (\pi/4)(7.1)^2 = 40\ ft^2$

2 Room area = WL = 20 ft (93 ft) = 1860 ft^2

3 Room is in a C5/R5 area therefore no fire water is required. Thus $V_{FW} = 0\ ft^3$.

4 The flood volume is the larger of the total volume or 110 % of the maximum operating volume of the largest vessel plus fire water. In addition, to account for other auxiliary components (piping and equipment) in the room, a design allowance of 5 % is applied to the flood volume. Since V_{XMax} is larger than V_{TOT}:

$$V_{FL} = 1.05\ (V_{XMax} + V_{FW}) = 1.05\ (958 + 0) = 1006\ ft^3$$
$$V_{FL} = 1006\ ft^3\ (7.48\ gal/ft^3) = 7525\ US\ gal$$

5 The available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU, or:

$$A_C = A_{Rm} - A_{Eq1} = A_{Rm}$$

where $A_{Eq1} = 0$

$$A_C = 1860\ ft^2$$

6 The liner height is calculated as follows:

LH = flood volume/available flood area
$$LH = V_{FL}/A_C$$
$$LH = 1006/1860 = 0.54\ ft$$

7 The minimum required liner height is the calculated liner height rounded up, or:

$$LH_{min} = 0.6\ ft$$

6 Summary

The summary of the minimum required liner height is as follows for each process cell.

Room	Vessel/MTU	Vessel Inside Diameter, ft	Vessel T-T length, ft	Flood Volume ft^3 (gal)	Room Size W ft × L ft (Area ft^2)	Available Flood Area [a], ft^2	Minimum Required Liner Height, ft
H-B005	HOP-VSL-00904	12	7.75	1535 (11,482)	14.8 × 17 (252)	252	6.1
H-B014 South	RLD-VSL-00007 RLD-VSL-00008 HCP-VSL-00001 HCP-VSL-00002	13 13 13.5 13.5	15.5 9.75 15.83 15.83	2816 (21,064)	18 ft × 64 (1152)	725	3.9
H-B014 North	RLD-VSL-00002	3.5	4	48 (359)	18 × 17 (306)	306	0.2
H-B021	HOP-VSL-00903	12	7.75	1535 (11,482)	14.8 × 17 (252)	252	6.1
H-B035	HDH-VSL-00002 HDH-VSL-00004 HDH-VSL-00003	2.5 2.5 7	16.75 16.75 17.0	752 (5625)	11 × 21.5 (237)	227	3.4

Room	Vessel/MTU	Vessel Inside Diameter, ft	Vessel T-T length, ft	Flood Volume ft^3 (gal)	Room Size W ft × L ft (Area ft^2)	Available Flood Area [a], ft^2	Minimum Required Liner Height, ft
H-B039A	HDH-VSL-00001	5.83	15.6	956 (7151)	23.3 × 34 + 11.3 × 49.3 (1349)	1349	0.8
H-B039B	HDH-VSL-00001	5.83	15.6	956 (7151)	23.3 × 34 + 11.3 × 49.3 (1349)	1349	0.8
H-0106 South	HFP-VSL-00005 w/ HFP-DMST-00003 HFP-VSL-00006 w/HFP-DMST-00004	11 11	9.5 9.5	1195 (8939)	14.75 x 30.5 - 3 x 6 - 1.67 x 7.5 (419)	315	3.8
H-0106 West	HOP-SCB-00002 HOP-HEME-00002A HOP-HEME-00002B	10 5.5 5.5	5.75 12.17 12.17	653 (4884)	13.08 x 30.58 - 8 x 1.5 (388)	340	2.0
H-0106 Central	HMP-MLTR-00002	Liner height is not calculated. The liner is provided to facilitate the containment of potential spills from jumpers and piping.					0.5
H-0117 South	HFP-VSL-00001 w/ HFP-DMST-00001 HFP-VSL-00002 w/ HFP-DMST-00002	11 11	9.5 9.5	1195 (8939)	14.75 x 30.5 - 3 x 6 - 1.67 x 7.5 (419)	315	3.8
H-0117 West	HOP-SCB-00001 HOP-HEME-00001A HOP-HEME-00001B	10 5.5 5.5	5.75 12.17 12.17	653 (4884)	13.08 x 30.58 - 8 x 1.5 (388)	340	2.0
H-0117 Central	HMP-MLTR-00001	Liner height is not calculated. The liner is provided to facilitate the containment of potential spills from jumpers and piping.					0.5
H-304A	HSH-TK-00002	6	18.17	612 (4578)	9.5 × 20 (190)	190	3.3
H-310A	HSH-TK-00001	6	18.17	612 (4578)	9.5 × 20 (190)	190	3.3
H-0302	HOP-WESP-00002	7	21.87	1006 (7525)	20 × 93 (1860)	1860	0.6
H-0308	HOP-WESP-00001	7	21.87	1006 (7525)	20 × 93 (1860)	1860	0.6

[a] Available flood area is equal to the room area minus the sum of the equipment footprint excluding the leaking vessel/MTU.

7 References

Project Documents

24590-HLW-P1-P01T-P0001, Rev 6, *HLW Vitrification Building General Arrangement (Permit) Plan at El –21 Ft -0 In.*

24590-HLW-P1-P01T-P0002, Rev 3, *HLW Vitrification Building General Arrangement (Permit) Plan at El 0 Ft -0 In.*

24590-HLW-P1-P01T-P0004, Rev 0, *HLW Vitrification Building General Arrangement (Permit) Plan at El 37 Ft -0 In.*

24590-HLW-P1-P01T-P0008, Rev 7, *HLW Vitrification Building General Arrangement (Permit) Sections A-A, B-B, & C-C.*

24590-HLW-P1-P01T-P0009, Rev 6, *HLW Vitrification Building General Arrangement (Permit) Sections D-D, E-E & F-F.*

24590-HLW-P1-P01T-P0010, Rev 6, *HLW Vitrification Building General Arrangement (Permit) Sections G-G & H-H.*

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Other Documents

Puchovsky M. 1999. *Automatic Sprinkler System Handbook.* National Fire Protection Association.

Moss D. 1987. *Process Vessel Design Manual.* Gulf Publishing Co.

Avallone, Eugene A. and Baumeister III, Theodore. *"Marks' Handbook for Mechanical Engineer"*, 9th Edition, McGraw-Hill Book Company