Sta. 4 (21)

JAN 21 2005 **ENGINEERING DATA TRANSMITTAL**

1. EDT 821494

1A. Page 1 of

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) Closure Projects Engineering Support	4. Related EDT No.: N/A 7. Purchase Order No.: N/A
5. Proj./Prog./Dept./Div.: 244-CR Vault	6. Design Authority/Resp. Engr./Design Agent: L.S. Krogsrud	9. Equip./Component No.: N/A 10. System/Bldg./Facility: 244-CR
8. Originator Remarks: This calculation shows the tank and cell annulus volumes for 244-CR at various discrete depth intervals.		12. Major Assembly Dwg. No.: N/A 13. Permit/Permit Application No.: N/A
11. Receiver Remarks: None	11A. Design Basis Document? ☐ Yes ☒ No	14. Required Response Date: N/A

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	RPP-CALC-24219, Rev. 0	N/A	0	244-CR Vault Tank and Cell Volume Calculations	N/A	1	1	

16. IMPACTED DOCUMENTS – NON ENGINEERING		17. IMPACTED DOCUMENTS – ENGINEERING	
Type of Document	Document Number	Type of Document	Document Number
N/A	N/A		

18. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
See TFC-ESHQ-Q-INSP-C-05	1. Approval 3. Distribution 2. Review	1. Approved 3. Reviewed no comment 5. Disapproved 2. Approved w/comment 4. Reviewed w/comment

19. SIGNATURE/DISTRIBUTION

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
1	1	Originator A.B. Carlson	Alan B Carlson	1/10/05	23-86						
		Design Auth.									
1	1	Resp. Engr. L.S. Krogsrud	L S Krogsrud	1/12/05	S7-24						
1	1	Resp. Mgr. M.J. Sutey	[signature]	1/13/05							
		QA									
		IH&S Engr.									
		Env. Engr.									
1	1	Checker M.M. Durst	MM Durst	1/10/05	S7-70	20. DOE APPROVAL (if required) Ctrl. No. N/A					

244-CR Vault Tank and Cell Volume Calculations

Alan Carlson, Duratek Federal Services Northwest for
CH2M HILL Hanford Group, Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-99RL14047

EDT/ECN: 821494 UC: N/A
Cost Center: 7G330 Charge Code:
B&R Code: N/A Total Pages: 39

Key Words: CR, Volume, Calculation, Vault, 244-CR, Chart

Abstract: This calculation provides the volumes for the tanks and cells of 244-CR Vault at discrete depth intervals.

1/21/05

Release Approval Date

Release Stamp

Approved For Public Release

SPREADSHEET VERIFICATION FORM

1. SVF 194

2.	**Spreadsheet Owner, Organization, MSIN, & Phone No.:**	A.B. Carlson, Project Delivery, R3-86, 373-3786
3.	**Spreadsheet File Name, Rev. No./Version No.**	244-CR Tank and Cell Volumes With Respect to Level
4.	**Location of Spreadsheet:** (Identify where the spreadsheet file is located by checking the boxes to the right. If "Other," provide description of where it is located)	**Personal Computer** ☐ **CD** ☐ **Network Drive** ☒ **Path** \\AP014\244CR-W-535\Volume **Other** ☐ **Description**
5.	**Function and Purpose of Spreadsheet:** (Provide a brief description of the purpose of the spreadsheet)	Calculates volume at discrete depth intervals for 244-CR tanks and cells 001,002,003, and 011
6.	**Scope of Verification:** (Indicate scope of verification by checking box to right. If "Other" provide description of scope)	**All Formulas in Spreadsheet** ☐ **Input Data only** ☐ **Formulas and Input Data** ☒ **Formula Changes** ☐ **Other** ☐ **Description**

7. Method of Verification: (Provide brief description of the method used to verify the spreadsheet. Note multiple methods may be used to verify different parts of a spreadsheet)

Verified standard volume equations used are correct and correct input data was entered into those equations.

8.	**Verification Documentation:** (Provide description of where verification documentation may be located. The verification documentation should include a description of all unique intended formulae together with evidence that the interpretation of the formulae in the spreadsheet is correct and that the spreadsheet returns correct results)	**Attached:** ☐	**No. of Pages:**	
		Electronic Information File: ☐	**Ref:**	
		Engineering Document: ☒	**Ref:**	RPP-CALC-24219

9. Approvals	Name:	Signature:	Date:
Spreadsheet Owner:	AB Carlson	Alan B Carlson	1/10/05
Spreadsheet Verifier:	MM Durst	Matt Mott	1/10/05
Owner's Manager:	DS Rewinkel	[signature]	1/10/05

Calculation Review Checklist

Calculation Reviewed: 244-CR Vault Tank and Cell Volume Calculations

Scope of Review: Entire Document
(e.g., document section or portion of calculation)

Engineer/Analyst: A.B. Carlson *Alan B Carlson* Date: 1/10/05

Organizational Mgr: D.S. Rewinkel *D S Rewinkel* Date: 1/10/05

This document consists of 25 pages and the following attachments (if applicable):

N/A

Yes	No	NA*		
[X]	[ ]	[ ]	1.	Analytical and technical approaches and results are reasonable and appropriate.
[X]	[ ]	[ ]	2.	Necessary assumptions are reasonable, explicitly stated, and supported.
[X]	[ ]	[ ]	3.	Ensure calculations that use software include a paper printout, microfiche, CD ROM, or other electronic file of the input data and identification to the computer codes and versions used, or provide alternate documentation to uniquely and clearly identify the exact coding and execution process.
[X]	[ ]	[ ]	4.	Input data were checked for consistency with original source information.
[X]	[ ]	[ ]	5.	For both qualitative and quantitative data, uncertainties are recognized and discussed.
[X]	[ ]	[ ]	6.	Mathematical derivations were checked including dimensional consistency of results.
[X]	[ ]	[ ]	7.	Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information.
[X]	[ ]	[ ]	8.	Software verification and validation are addressed adequately.
[X]	[ ]	[ ]	9.	Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references.
[X]	[ ]	[ ]	10.	Conclusions are consistent with analytical results and applicable limits.
[X]	[ ]	[ ]	11.	Results and conclusions address all points in the purpose.
[X]	[ ]	[ ]	12.	Referenced documents are retrievable or otherwise available.
[X]	[ ]	[ ]	13.	The version or revision of each reference is cited.
[X]	[ ]	[ ]	14.	The document was prepared in accordance with Attachment A, "Calculation Format and Preparation Instructions."
[X]	[ ]	[ ]	15.	Impacts on requirements have been assessed and change documentation initiated to incorporate revisions to affected documents as appropriate.
[X]	[ ]	[ ]	16.	All checker comments have been dispositioned and the design media matches the calculations.

Matthew M. Durst *Matt Durst* *1/10/05*
Checker (Printed Name and Signature) Date

* If No or NA is chosen, an explanation must be provided on or attached to this form.

Subcontractor Calculation Review Checklist.

Page 1 of 1

Subject: 244-CR Vault Tank and Cell Volume Calculations

The subject document has been reviewed by the undersigned.
The checker reviewed and verified the following items as applicable.

Documents Reviewed: **244-CR Vault Tank and Cell Volume Calculations**

Analysis Performed By: A.B. Carlson *Alan B Carlson*

- Design Input
- Basic Assumptions
- Approach/Design Methodology
- Consistency with item or document supported by the calculation
- Conclusion/Results Interpretation
- Impact on existing requirements
- ______________________________

Checker (printed name, signature, and date) M.M. Durst *MMDurst* 1/10/05

Organizational Manager (printed name, signature and date) M.J. Sutey *MJ Sutey* 1/13/05

Title: 244-CR Vault Tank and Cell Volume Calculations **Identifier**: P-06-18 Rev: 0
Originator: AB Carlson *Alan B Carlson* **Date:** 1/10/05
Checker: MM Durst *MMD* **Date:** 1/10/05
Organizational Manager: MJ Sutey *MJ Sutey* **Date:** 1/13/05

1.0 OBJECTIVE/PURPOSE

Tank volume discrepancies exist among various documents for the 244-CR tanks and cells. Historical information showing the volume of the tanks and cells with respect to level of liquid present could not be found. It is necessary that volumes be provided for incremental levels for the CR Vault tanks and cells. This information will be used to determine the volume of waste left in the tanks once liquid level measurements are obtained.

2.0 INPUT DATA

Input data is provided in separate sections for calculating the tank volumes as a function of liquid level height and for calculating the cell volumes as a function of liquid level height.

2.1. Tank Volume Input Data

Tank dimensional information was gathered from the tank drawings listed in the references. Drawing H-2-41688, *Vessel Assembly & Details 20'-0" x 19'-2" Tank TK-CR-001 & TK-BXR-001 & TK-TXR-001*, provides the necessary dimensional information for tank TK-CR-001. Drawing H-2-41089, *Vessel Assembly & Details 14'-0" x 12'-2" Tank TK-CR-002 & TK-CR-003 & TK-BXR-002 & TK-BXR-003 & TK-TXR-002 & TK-TXR-003*, provides the necessary dimensional information for tanks TK-CR-002 and TK-CR-003. Drawing H-2-41108, *Vessel Assembly & Details 20'-0" x 19'-2" Tank TK-CR-011 & TK-BXR-011*, provides the necessary dimensional information for tank TK-CR-011. Drawing H-2-41090, "*Vessel Details – 14'-0" x 12' 0" Tank, TK-CR-002, TK-CR-003, TK-BXR-002, TK-BXR-003, TK-TXR-002, AND TK-TXR-003*, provides the necessary dimensional information for the coils within tanks TK-CR-002 and TK-CR-003.

From these sources the following information is used as input data:

1. Tanks TK-CR-001 and TK-CR-011 have 240 in. outside diameter flanged and dished heads with a 240 in. inside dish-radius and 14 ½ in. inside corner-radius (or knuckle-radius) at the top and bottom. The heads are a minimum 5/16 in. thick. (H-2-41688 & H-2-41108, respectively)
2. Tanks TK-CR-001 and TK-CR-011 have straight sections between upper and lower heads of 19 ft. 2 in. These straight sections are ¼ in. thick. (H-2-41688 & H-2-41108, respectively)
3. Tanks TK-CR-002 and TK-CR-003 have 168 in. outside diameter flanged and dished heads with a 168 in. inside dish-radius and 10-1/8 in. inside corner-radius (or knuckle-radius) at the top and bottom. The heads are a minimum 3/16 in. thick. (H-2-41089)
4. Tanks TK-CR-002 and TK-CR-003 have straight sections between upper and lower heads of 12 ft. (H-2-41089)

5. Tanks TK-CR-002 and TK-CR-003 each have three eccentric coils made of 1 ½ in. schedule 40 pipe. The radius of the innermost coil is 3 ft. 6 in. The radius of the middle coil is 4 ft. 7 ½ in. The radius of the outermost coil is 5 ft. 9 in. Each coil makes 12 ½ turns with an elevation change of 4 inches per turn. The centerline of the coils at its inlet header start 9 in. below the tangent line of the lower dished head. (H-2-41089 & H-2-41090)

2.2. Cell Volume Input Data

Cell dimensional information was gathered from the tank drawings listed in the references. Drawing H-2-41888, *Structural Concrete Plans & Details Process Tank Vault* provides the necessary dimensional information for all four cells including the sumps. Drawing H-2-41889, *Structural Concrete Sections & Details Process Tank Vault Sheet # 1* provides the necessary dimensional information for the concrete pad supporting tank TK-CR-011. The drawings identified in the section above provide the necessary dimensional information of the tanks.

From these sources the following information is used as input data:

1. For each of the four vaults, the sump dimensions are 2 feet wide by 3 feet long by 1 foot deep. (H-2-41888)
2. Cells CR-001 and CR-011 are each 26 feet long by 22 feet wide. The high point of the cell floor is 2 ½ inches above the low point of the cell floor. The low point of the floor is even with the top of the sump. (H-2-41888)
3. The grout pad that supports tank TK-CR-011 is 21 feet 0- ½ inch in diameter and extends three inches above the high point of the cell floor. (H-2-41888 & H-2-41889)
4. The tangent line of the bottom dished head for tank TK-CR-001 is 3 feet 9 inches above the bottom of the tank's column bases. (H-2-41688)
5. The tangent line of the bottom dished head for tank TK-CR-011 is 3 feet 9 inches above the bottom of the tank's skirt & base ring. (H-2-41108)
6. Cells CR-002 and CR-003 are each 20 feet long by 16 feet wide. The high point of the cell floor is 1 ¾ inches above the low point of the cell floor. The low point of the floor is even with the top of the sump. (H-2-41888)
7. The tangent line of the bottom dished head for tanks TK-CR-002 and TK-CR-003 is 2 feet 11 inches above the bottom of the tank's column bases. (H-2-41089)

3.0 ASSUMPTIONS

Assumptions for calculating the tank volumes as a function of liquid level height and for calculating the cell volumes as a function of liquid level height are provided in separate sections.

3.1. Tank Volume Assumptions

For all four tanks, any installed equipment (e.g., agitator, pump, instruments,), with the exception of the steam coils in tanks TK-CR-002 and TK-CR-003, has a negligible effect on accurately specifying the volume of liquid present as a function of liquid level height. Therefore installed equipment, except as noted above, will not be accounted for in determining the calculation.

For tank TK-CR-001, the pump boot and its support structure, the four baffles and their support structures, and the 16" down pipe and its support structure all have a negligible effect on accurately specifying the volume of liquid present as a function of liquid level height, and, therefore, will not be accounted for in the calculation. A rough estimate of the volume of a single baffle is 7 gallons. A rough estimate of the volume of the wall of the 16" down pipe is 20 gallons.

For tanks TK-CR-002 and TK-CR-003, the supply and discharge lines and headers to and from the coil as well as the coil support structure have a negligible effect on accurately specifying the volume of liquid present as a function of liquid level height. Note that the volume of the coil is considered significant and will be accounted for in the calculation.

For tank TK-CR-011, the four baffles and their supports have a negligible effect on accurately specifying the volume of liquid present as a function of liquid level height, and, therefore, will not be accounted for in the calculation.

3.2. Cell Volume Assumptions

For all four cells, any installed equipment (e.g., steam jets, instruments, piping, etc.) has a negligible effect on accurately determining the volume of liquid present in the cell as a function of liquid level height. Therefore installed equipment will not be accounted for in the volume calculation.

For cells CR-001, CR-002, and CR-003 the concrete pads supporting the tank columns and the tank columns have a negligible effect on accurately specifying the volume of liquid present in the cell as a function of liquid level height, and, therefore, will not be accounted for in the calculation. For example in the case of either tank TK-CR-002 or TK-CR-003, the four columns supporting each tank together occupy approximately 0.6 gallons of volume per 1 inch of column height. Note that the volume of the pad supporting tank TK-CR-011 is considered significant (on the order of 1,000 gallons) and will be accounted for in the calculation.

For all four cells, making simplifying assumptions regarding the geometry of the sloped floors will have a negligible effect on accurately determining the volume of liquid present in the cell as a function of liquid level height.

4.0 METHOD OF ANALYSIS

The method of analysis for calculating the tank volumes as a function of liquid level height and for calculating the cell volumes as a function of liquid level height are provided in separate sections below.

4.1. Tank Volume Method of Analysis

The equation for computing the volume as a function of height for a vertical tank with an ASME flanged and dished head (i.e., torispherical head) has been documented by Jones 2002. The equation consists of three regions: the spherical portion of the dish; the knuckle portion of the dish; and, the straight cylindrical portion of the tank. The equation for calculating the volume in the tank, where the fluid height, h, is measured from the bottom center of the tank to the surface of the fluid in the tank is:

$$V_f = \begin{cases} \dfrac{\pi h^2}{4}\left(2a_1 + \dfrac{D_1^2}{2a_1} - \dfrac{4h}{3}\right) & 0 \le h \le a_1 \\[2ex] \dfrac{\pi}{4}\left(\dfrac{2a_1^3}{3} + \dfrac{a_1 D_1^2}{2}\right) + \pi u\left[\left(\dfrac{D}{2} - kD\right)^2 + s\right] + \dfrac{\pi t u^2}{2} - \dfrac{\pi u^3}{3} \\ \quad + \pi D(1-2k)\left[\dfrac{2u-t}{4}\sqrt{s+tu-u^2} + \dfrac{t\sqrt{s}}{4} + \dfrac{k^2D^2}{2}\left(\cos^{-1}\dfrac{t-2u}{2kD} - \alpha\right)\right] & a_1 < h \le a_1 + a_2 \\[2ex] \dfrac{\pi}{4}\left(\dfrac{2a_1^3}{3} + \dfrac{a_1 D_1^2}{2}\right) + \dfrac{\pi t}{2}\left[\left(\dfrac{D}{2} - kD\right)^2 + s\right] \\ \quad + \dfrac{\pi t^3}{12} + \pi D(1-2k)\left(\dfrac{t\sqrt{s}}{4} + \dfrac{k^2D^2}{2}\sin^{-1}(\cos\alpha)\right) + \dfrac{\pi D^2}{4}\left[h - (a_1 + a_2)\right] & a_1 + a_2 < h \end{cases}$$

$$\alpha \equiv \sin^{-1}\frac{1-2k}{2(f-k)} = \cos^{-1}\frac{\sqrt{4f^2 - 8fk + 4k - 1}}{2(f-k)}$$

$$a_1 \equiv fD(1-\cos\alpha)$$
$$a_2 \equiv kD\cos\alpha$$
$$D_1 \equiv 2fD\sin\alpha$$
$$s \equiv (kD\sin\alpha)^2$$
$$t \equiv 2kD\cos\alpha = 2a_2$$
$$u \equiv h - fD(1-\cos\alpha)$$

where,

a_1	is the distance from the lowest part of the tank to the point where the dish-radius and knuckle-radius intersect
a_2	is the distance from where the dish-radius and knuckle-radius intersect to where the knuckle-radius and the cylindrical section of the tank intersect
D	is the diameter of the cylindrical section of the tank
D_1	is the diameter of the torispherical bottom of the tank where the dish-radius and knuckle-radius intersect
f	is the dish-radius parameter for the tank torispherical heads or bottoms; fD is the dish radius
h	is the height of fluid in the tank measured from the lowest part of the tank to the fluid surface
k	is the knuckle-radius parameter for the tank torispherical heads or bottoms; kD is the knuckle radius
R	is the radius of the cylindrical section of the tank
V_f	is the fluid volume, for fluid depth h, in the tank, not accounting for any internals (e.g., coils, pumps, agitators, baffles, instruments, etc.)

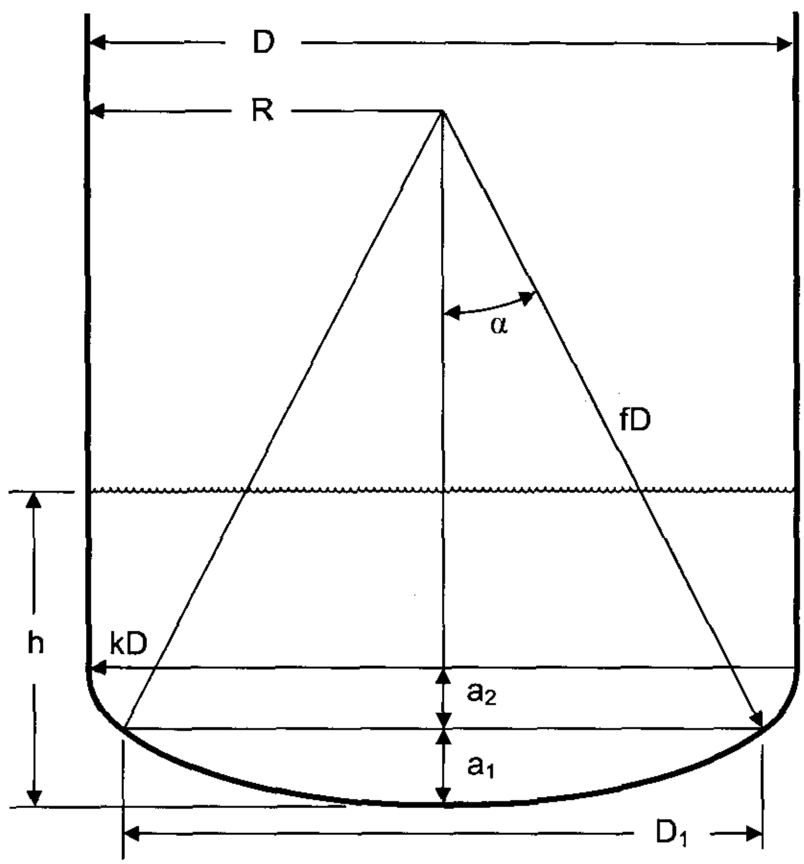
See Figure 1 for tank configuration and dimension parameters. For tanks TK-CR-002 and TK-CR-003, the required parameters to solve the equation are D = 168 inches, fD = 168 inches, and kD = 10.125 inches. For tanks TK-CR-001 and TK-CR-011, the required parameters to solve the equation are D = 240 inches, fD = 240 inches, and kD = 14.5 inches.

For tanks TK-CR-001 and TK-CR-011, the fluid volume, not accounting for any internals, V_f, is equal to the calculated fluid volume, V_{fluid}. However, for tanks TK-CR-002 and TK-CR-003, the calculated fluid volume must account for the presence of the coil and therefore,

$$V_{fluid} = V_f - V_{coil}$$

The calculated volume of the coil, V_{coil}, is determined by the material of construction and geometry of the coil. The coil consists of three separate coils of 1 ½ inch schedule 40 pipe, which has an outside diameter of 1.9 inches. Each of these coils consists of 12 ½ turns at a 4 inch rise per turn for an overall height of 4 feet 2 inches from the centerline of the bottom turn starting at the coil inlet header to the centerline of the top turn ending at the coil outlet header. The inner coil has a radius of 3 feet 6 inches. The middle coil has a radius of 4 feet 7-½ inches. The outer coil has a radius of 5 feet 9 inches. The external volume of these three coils can be calculated by multiplying the circumference of each coil by the number of turns and by the cross-sectional area of the 1 ½ inch schedule 40 pipe. The calculated volume of the coil is 37,080 cubic inches or 160.5 gallons. The centerline of the bottom turn of the coil at the inlet header is 9 inches below the tangent line of the bottom head of the tank. For convenience, the calculated volume of the coil can be smeared from the bottom of the coil, starting 9.95 inches below the tangent line of the bottom head of the tank and ending 41.95 above the tangent line of the tank's bottom head. The coil volume can be approximated as 3.1 gallons per inch of height of coil.

Figure 1. Parameters for Vertical Cylindrical Tanks with Torispherical Bottoms



4.2. Cell Volume Method of Analysis

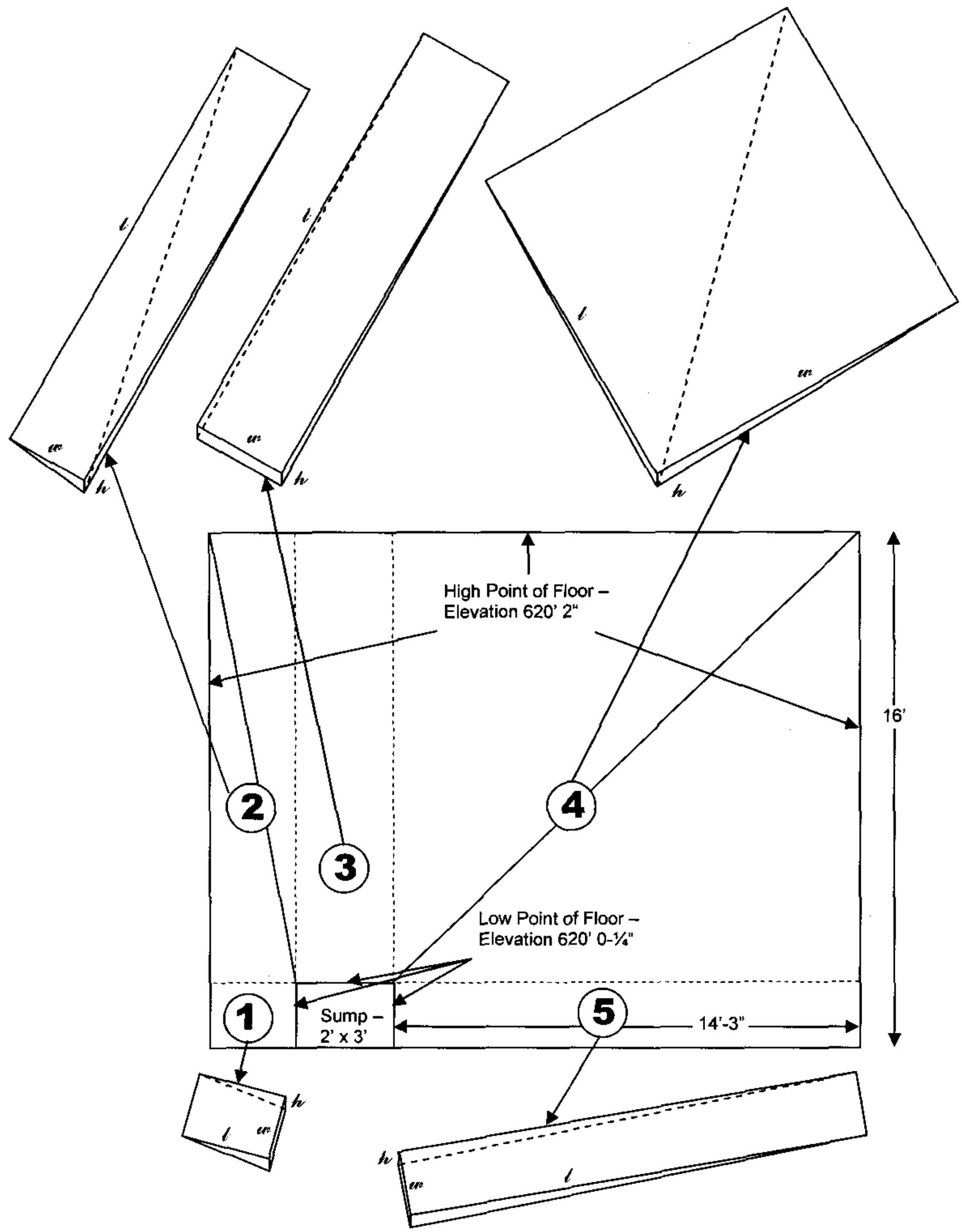
The 244-CR vault cells can be considered, by making simplifying assumptions, to be made up of regions that are standard geometric volumes. For example each sump is a cube, the liquid on the sloped floor can be represented by wedges and pyramids. The volume above the high point of the floor is a cube minus the volume occupied by the tank and its supports.

The slope and shape of the sloped floor for each cell is shown on H-2-41888, Sheet 1 of 1. Figure 2 graphically depicts the general shape and contours of the floor of cells CR-002 and CR-003. The grout pads for the tank supports and a slight jog in the floor slope around one of these grout pads is not shown in Figure 2. These features (i.e., grout pads, jog in the floor slope) have a minimal impact and are not accounted for in determining the volume of waste on the sloped floor. Figure 2 shows that liquid present on the sloped floor can be split into five regions, three of which can be depicted as wedges and two which can be depicted as pyramids. The general equation for the volume of a wedge is ½ the area of the base of the wedge times the height of the wedge. The general equation for the volume of a pyramid is $^1/_3$ the area of the base of the pyramid times the height of the pyramid. The areas of the floor identified on Figure 2 by the circled numbers 1, 3, and 5 are wedges and the circled numbers 2 and 4 are pyramids. The relationship of the sides of the wedges and pyramids to their height can be determined by examining the ratio of the sides to height at the point where liquid would be at the level equal to the high point of the floor. For cells CR-002 and CR-003, the low point of the floor is 1 ¾ inches lower than the high point of the floor. So, when the liquid level is even with the high point of the floor, then the height of the 3 wedge-shaped and 2 pyramid-shaped volumes of liquid depicted in Figure 2 is 1 ¾ inches. Using the dimensions provided from H-2-41888, the volume equations for the 5 areas of the floor in Figure 2, when the liquid level is at the high point of the floor are:

Area 1 $(\text{Wedge})_{CR\text{-}002/003}$	Volume = ½ x (24 in.) x (33 in.) x (1 ¾ in.)
Area 2 $(\text{Pyramid})_{CR\text{-}002/003}$	Volume = $^1/_3$ x (33 in.) x (168 in.) x (1 ¾ in.)
Area 3 $(\text{Wedge})_{CR\text{-}002/003}$	Volume = ½ x (36 in.) x (168 in.) x (1 ¾ in.)
Area 4 $(\text{Pyramid})_{CR\text{-}002/003}$	Volume = $^1/_3$ x (168 in.) x (171 in.) x (1 ¾ in.)
Area 5 $(\text{Wedge})_{CR\text{-}002/003}$	Volume = ½ x (24 in.) x (171 in.) x (1 ¾ in.)

Based on the law of similar triangles, the ratio of the lengths of the sides of the wedges and pyramids can be determined for any height between the minimum height of 0 inches and maximum height of 1 ¾ inches. Each of the three wedges has one side of its base that is the edge of the 2' x 3' sump. This side depicted as w on the exploded volumetric shapes for areas 1, 3, and 5 remains constant as the height of the fluid rises on the sloped floor. However the length of the wedge, depicted as l for areas 1, 3, and 5 is proportional to the height of the fluid, depicted as h. From the equation above for Area 1 we see that the length of the wedge is 33 in. when the height of the wedge is 1 ¾ in. Therefore, the ratio between the length of the wedge and height of the wedge for area 1 is $l/33 = h/(1\ ¾)$. Rearranging, this proportion can be written as $l = 132/7\ h$.

Figure 2. Graphical Depiction of Geometric Shapes Representing Liquid on the Sloped Floor of Cells CR-002 and CR-003



The volume equations for the liquid on the sloped floor represented by wedges can then be generically written in terms of *h*, the level of the liquid above the low point of the floor (or top of the sump) as follows:

Area 1 $(\text{Wedge})_{CR\text{-}002/003}$	Volume = ½ x (24 in.) x (132/7 *h* in.) x (*h* in.)
Area 3 $(\text{Wedge})_{CR\text{-}002/003}$	Volume = ½ x (36 in.) x (96 *h* in.) x (*h* in.)
Area 5 $(\text{Wedge})_{CR\text{-}002/003}$	Volume = ½ x (24 in.) x (684/7 *h* in.) x (*h* in.)

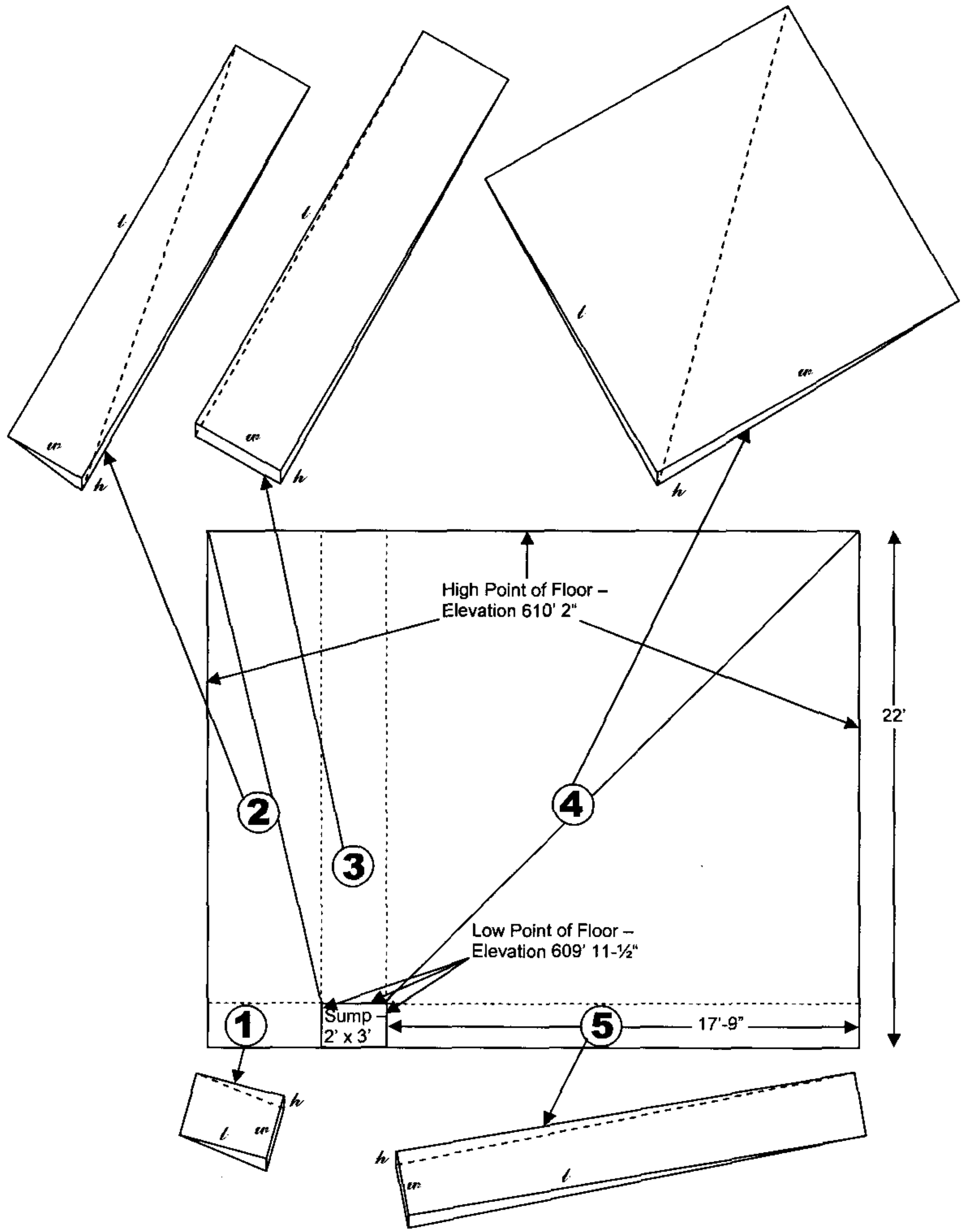
Unlike the wedges, both sides of the bases for the pyramids, depicted as *w* and *l* on the exploded volumetric shapes for areas 2, and 4 is proportional to the height of the fluid, depicted as *h*. These proportionalities are the same as those found for the common side for the adjacent wedge (e.g., the sides of Area 1 and Area 3 that are proportional to *h* make up the sides of the base for the pyramid in Area 2. The volume equations for the liquid on the sloped floor represented by pyramids can then be generically written in terms of *h*, the level of the liquid above the low point of the floor (or top of the sump) as follows:

Area 2 $(\text{Pyramid})_{CR\text{-}002/003}$	Volume = ⅓ x (132/7 *h* in.) x (96 *h* in.) x (*h* in.)
Area 4 $(\text{Pyramid})_{CR\text{-}002/003}$	Volume = ⅓ x (96 *h* in.) x (684/7 *h* in.) x (*h* in.)

Figure 3 graphically depicts the general shape and contours of the floor of cell CR-001. The grout pads for the tank supports and a slight jog in the floor slope around one of these grout pads is not shown in Figure 3. These features (i.e., grout pads, jog in the floor slope) have a minimal impact and are not accounted for in determining the volume of waste on the sloped floor. In the same manner as described for the sloped floor of cells CR-002 and CR-003, Figure 3 shows that liquid present on the sloped floor can be split into five regions, three of which can be depicted as wedges and two which can be depicted as pyramids. For cell CR-001, the low point of the floor is 2 ½ inches lower than the high point of the floor. So, when the liquid level is even with the high point of the floor, then the height of the 3 wedge-shaped and 2 pyramid-shaped volumes of liquid depicted in Figure 3 is 2 ½ inches. Using the dimensions provided from H-2-41888, the volume equations for the 5 areas of the floor in Figure 3, when the liquid level is at the high point of the floor are:

Area 1 $(\text{Wedge})_{CR\text{-}001}$	Volume = ½ x (24 in.) x (63 in.) x (2 ½ in.)
Area 2 $(\text{Pyramid})_{CR\text{-}001}$	Volume = ⅓ x (63 in.) x (240 in.) x (2 ½ in.)
Area 3 $(\text{Wedge})_{CR\text{-}001}$	Volume = ½ x (36 in.) x (240 in.) x (2 ½ in.)
Area 4 $(\text{Pyramid})_{CR\text{-}001}$	Volume = ⅓ x (240 in.) x (213 in.) x (2 ½ in.)
Area 5 $(\text{Wedge})_{CR\text{-}001}$	Volume = ½ x (24 in.) x (213 in.) x (2 ½ in.)

Figure 3. Graphical Depiction of Geometric Shapes Representing Liquid on the Sloped Floor of Cell CR-001



Again, as was done for cells CR-002 and CR-003, based on the law of similar triangles, the ratio of the lengths of the sides of the wedges and pyramids can be determined for any height between the minimum height of 0 inches and maximum height of 2 ½ inches. Each of the three wedges has one side of its base that is the edge of the 2 ft. x 3 ft. sump. This side depicted as *w* on the exploded volumetric shapes for areas 1, 3, and 5 remains constant as the height of the fluid rises on the sloped floor. However the length of the wedge, depicted as *l* for areas 1, 3, and 5 is proportional to the height of the fluid, depicted as *h*. From the equation above for Area 1 we see that the length of the wedge is 63 in. when the height of the wedge is 2 ½ in. Therefore, the ratio between the length of the wedge and height of the wedge for area 1 is $l/63 = h/(2\ ½)$. Rearranging, this proportion can be written as $l = 126/5\ h$. The volume equations for the liquid on the sloped floor represented by wedges can then be generically written in terms of *h*, the level of the liquid above the low point of the floor (or top of the sump) as follows:

Area 1 $(\text{Wedge})_{CR\text{-}001}$	Volume = ½ x (24 in.) x (126/5 *h* in.) x (*h* in.)
Area 3 $(\text{Wedge})_{CR\text{-}001}$	Volume = ½ x (36 in.) x (96 *h* in.) x (*h* in.)
Area 5 $(\text{Wedge})_{CR\text{-}001}$	Volume = ½ x (24 in.) x (426/5 *h* in.) x (*h* in.)

Following the discussion of the pyramid-shaped liquid volumes for cells CR-002 and CR-003, both sides of the bases for the pyramids, depicted as *w* and *l* on the exploded volumetric shapes for areas 2, and 4 is proportional to the height of the fluid, depicted as *h*. These proportionalities are the same as those found for the common side for the adjacent wedge (e.g., the sides of Area 1 and Area 3 that are proportional to *h* make up the sides of the base for the pyramid in Area 2. The volume equations for the liquid on the sloped floor represented by pyramids for cell CR-002 can then be generically written in terms of *h*, the level of the liquid above the low point of the floor (or top of the sump) as follows:

Area 2 $(\text{Pyramid})_{CR\text{-}001}$	Volume = $^1/_3$ x (126/5 *h* in.) x (96 *h* in.) x (*h* in.)
Area 4 $(\text{Pyramid})_{CR\text{-}001}$	Volume = $^1/_3$ x (96 *h* in.) x (426/5 *h* in.) x (*h* in.)

Although the external dimensions and high- and low-point elevations of the floor for cells CR-001 and CR-011 are the same, the sloping and footprint of the sloped floor for cell CR-011 is different from cell CR-001. As shown in Figure 4, in cell CR-011 there is a 21 ft 0 ½ in. diameter grout pad that supports tank TK-CR-011. The floor is sloped around this pad rather than directly to the sump. The pad for tank TK-CR-011 takes up roughly 60% of the footprint of the cell floor. This pad extends 3 inches above the high point of the floor. Because of its size this pad must be taken into consideration when determining the volume of liquid present. The volume taken up by this grout pad at the elevations between the low-point and high-point of the sloped floor can be considered a pyramid. However the pyramid is assumed to have a circular base rather than rectangular. Using the dimensions listed above, the volume equations for the grout pad supporting tank TK-CR-011, when the liquid level is at the high point of the floor are:

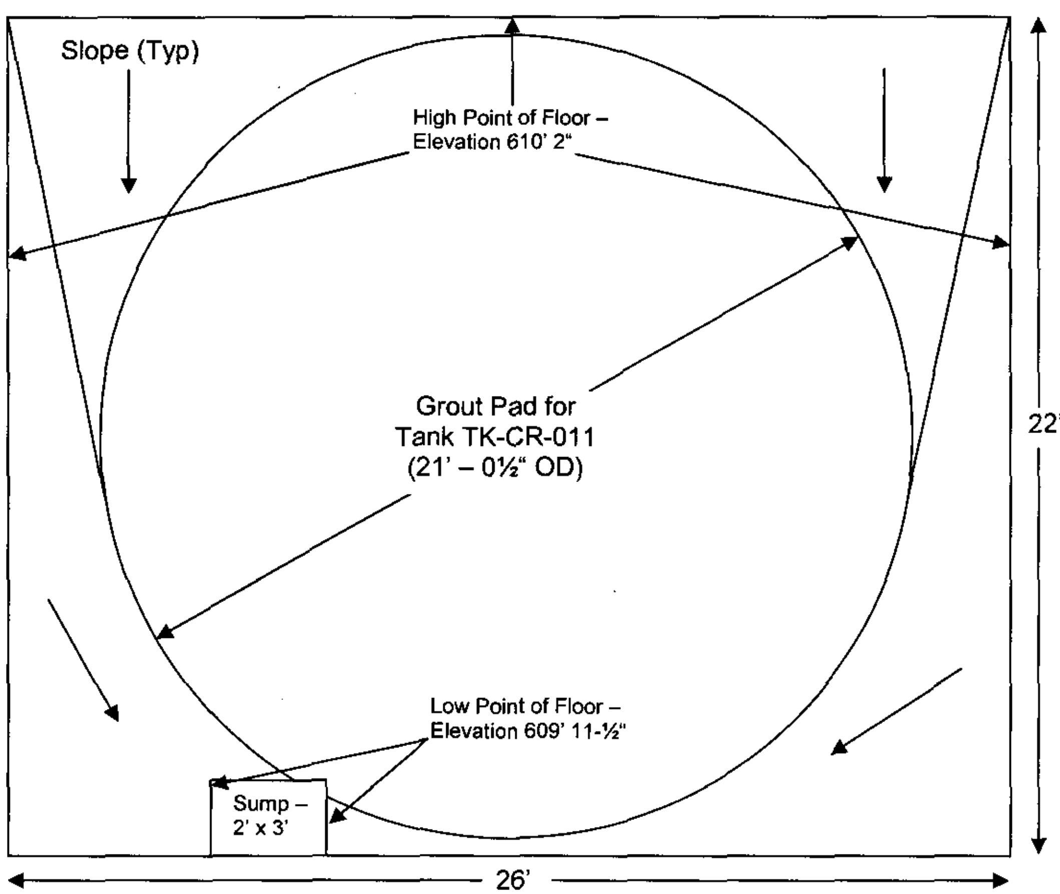
$(\text{Circular Pyramid})_{CR\text{-}011}$ Volume = $^1/_3$ x $\pi/4$ x $(252.5\text{ in.})^2$ x (2 ½ in.)

It can be assumed that the diameter of the grout pad, D, that displaces liquid on the sloped floor of the cell is proportional to the height of the fluid, depicted as h. From the equation above it is shown that the diameter of the grout pad is 252.5 in. when the height of liquid surrounding the grout pad is 2 ½ in. Therefore, the ratio between the diameter of the grout pad and height of liquid surrounding the grout pad is $D/252.5 = h/(2\ ½)$. Rearranging, this proportion can be written as $D = 101\ h$. The volume equation for displaced liquid on the sloped floor due to the grout pad for cell CR-011 can then be generically written in terms of h, the level of the liquid above the low point of the floor (or top of the sump) as follows:

$$(\text{Circular Pyramid})_{CR\text{-}011} \qquad \text{Volume} = {}^1/_3 \times \pi/4 \times (101\ h \text{ in.})^2 \times (h \text{ in.})$$

Above the high-point of the floor in cell CR-011 to the top of the grout pad (3 inches above the high-point of the floor), the volume of the grout pad is a simple right-circular cylinder.

Figure 4. Graphical Depiction of Configuration of Sloped Floor of Cell CR-001 with Grout Pad for Tank TK-CR-011



The equation for calculating the volume in cell CR-001, $V_{cell001}$, where the fluid height, h_c, is measured from the bottom of the sump to the surface of the fluid in the cell is:

$$V_{cell001} = \begin{cases} 36\text{in.} \times 24\text{in. } x\ h_c & 0 \le h \le 12 \text{ in.} \\ (36\text{in.} \times 24\text{in. } x\ h_c \text{ in.}) + \left(\frac{1}{2} \times 24\text{in.} \times \frac{126}{5}(h_c - 12)\text{in.} \times (h_c - 12)\text{in.}\right) + \\ \left(\frac{1}{3} \times 96(h_c - 12)\text{in.} \times \frac{126}{5}(h_c - 12)\text{in.} \times (h_c - 12)\text{in.}\right) + \left(\frac{1}{2} \times 36\text{in.} \times 96(h_c - 12)\text{in.} \times (h_c - 12)\text{in.}\right) + \\ \left(\frac{1}{3} \times 96(h_c - 12)\text{in.} \times \frac{426}{5}(h_c - 12)\text{in.} \times (h_c - 12)\text{in.}\right) + \\ \left(\frac{1}{2} \times 24\text{in.} \times \frac{426}{5}(h_c - 12)\text{in.} \times (h_c - 12)\text{in.}\right) & 12 < h \le 14\text{-}1/2 \text{ in.} \\ 86808\text{in.}^3 + (264\text{in.} \times 312\text{in.} \times (h_c - 14.5)\text{in.}) & 14\text{-}1/2 < h \le 21.57 \text{ in.} \\ 86808\text{in.}^3 + (264\text{in.} \times 312\text{in.} \times (h_c - 14.5)\text{in.}) - V_t & 21.57 \text{ in.} < h \end{cases}$$

where,

h_c is the height of fluid in the cell measured from the bottom of the cell sump to the fluid surface

V_t is the volume of the tank based on its external dimensions, at fluid depth h in the cell.

The equation to use above 12 inches accounts for the slope of the floor. The equations to use above 14.5 inches replace the value of liquid calculated for the sump and the sloped floor, namely 86,808 cubic inches. The equation to use above 21.57 inches also accounts for the volume displaced by the tank. The volume of the tank based on its external dimensions can be calculated using the formula presented in Section 4.1. For the external volume of tank TK-CR-001, the required parameters to solve the equation are D = 240-5/16 inches, fD = 240-5/16 inches, and kD = 14-13/16 inches (taken from H-2-41688). The height of the tank TK-CR-001 bottom dished head (from its exterior) to the tangent line between the head and the straight wall of the tank is calculated to be 40.93 in. using the equation in Section 4.1. Drawing H-2-41688 shows the height from the bottom of the tank's column bases to the tangent line of the bottom head to be 3 ft. 9 in. or 45 in. The grout pads supporting the tank's column bases extend 3 in. above the high point of the floor as shown in H-2-41888. Therefore, the exterior bottom of tank TK-CR-001 is 7.07 in. (45 in + 3 in. – 40.93 in.) above the high-point of the cell floor or 21.57 in. (45 in. + 3 in. – 40.93 in. + 14.5 in.) above the bottom of the sump.

The equation for calculating the volume in cell CR-002 and cell CR-003, $V_{cell2/3}$, where the fluid height, h_c, is measured from the bottom of the sump to the surface of the fluid in the cell is:

$$V_{cell2/3} = \begin{cases} 36\,\text{in.} \times 24\,\text{in.} \times h_c & 0 \le h \le 12\text{ in.} \\ (24\,\text{in.} \times 36\,\text{in.} \times h_c\,\text{in.}) + \left(\frac{1}{2} \times 24\,\text{in.} \times \frac{132}{7}(h_c - 12)\,\text{in.} \times (h_c - 12)\,\text{in.}\right) + & \\ \left(\frac{1}{3} \times 96(h_c - 12)\,\text{in.} \times \frac{132}{7}(h_c - 12)\,\text{in.} \times (h_c - 12)\,\text{in.}\right) + \left(\frac{1}{2} \times 36\,\text{in.} \times 96(h_c - 12)\,\text{in.} \times (h_c - 12)\,\text{in.}\right) + & \\ \left(\frac{1}{3} \times 96(h_c - 12)\,\text{in.} \times \frac{684}{7}(h_c - 12)\,\text{in.} \times (h_c - 12)\,\text{in.}\right) + & \\ \left(\frac{1}{2} \times 24\,\text{in.} \times \frac{684}{7}(h_c - 12)\,\text{in.} \times (h_c - 12)\,\text{in.}\right) & 12 < h \le 13\text{-}3/4\text{ in.} \\ 41448\,\text{in.}^3 + (192\,\text{in.} \times 240\,\text{in.} \times (h_c - 13.75)\,\text{in.}) & 13\text{-}3/4 < h \le 23.14\text{ in.} \\ 41448\,\text{in.}^3 + (192\,\text{in.} \times 240\,\text{in.} \times (h_c - 13.75)\,\text{in.}) - V_t & 23.14\text{ in.} < h \end{cases}$$

The equation to use above 12 inches accounts for the slope of the floor. The equations to use above 13 ¾ inches replace the value of liquid calculated for the sump and the sloped floor, namely 41,448 cubic inches. The equation to use above 23.14 inches also accounts for the volume displaced by the tank. The volume of the tank based on its external dimensions can be calculated using the formula presented in Section 4.1. For the external volume of tank TK-CR-002 or TK-CR-003, the required parameters to solve the equation are D = 168-3/16 inches, fD = 168-3/16 inches, and kD = 10-5/16 inches (taken from H-2-41089). The height of the tank TK-CR-002 or TK-CR-003 bottom dished head (from its exterior) to the tangent line between the head and the straight wall of the tank is calculated to be 28.61 in. using the equation in Section 4.1. Drawing H-2-41089 shows the height from the bottom of the tank's column bases to the tangent line of the bottom head to be 2 ft. 11 in. or 35 in. The grout pads supporting the tank's column bases extend 3 in. above the high point of the floor as shown in H-2-41888. Therefore, the exterior bottom of tank TK-CR-002 or TK-CR-003 is 9.39 in. (35 in + 3 in. – 28.61 in.) above the high-point of the cell floor or 23.14 in. (35 in. + 3 in. – 28.61 in. + 13.75 in.) above the bottom of the sump.

The equation for calculating the volume in cell CR-011, where the fluid height, h_c, is measured from the bottom of the sump to the surface of the fluid in the cell is:

$$V_{cell011} = \begin{cases} 36\text{in.} \times 24\text{in.} \times h_c & 0 \le h \le 12 \text{ in.} \\ (24\text{in.} \times 36\text{in.} \times h_c \text{ in.}) + \left(\frac{1}{2} \times 24\text{in.} \times \frac{126}{5}(h_c - 12)\text{in.} \times (h_c - 12)\text{in.}\right) + & \\ \left(\frac{1}{3} \times 96(h_c - 12)\text{in.} \times \frac{126}{5}(h_c - 12)\text{in.} \times (h_c - 12)\text{in.}\right) + \left(\frac{1}{2} \times 36\text{in.} \times 96(h_c - 12)\text{in.} \times (h_c - 12)\text{in.}\right) + & \\ \left(\frac{1}{3} \times 96(h_c - 12)\text{in.} \times \frac{426}{5}(h_c - 12)\text{in.} \times (h_c - 12)\text{in.}\right) + \left(\frac{1}{2} \times 24\text{in.} \times \frac{426}{5}(h_c - 12)\text{in.} \times (h_c - 12)\text{in.}\right) - & \\ \left(\frac{1}{3} \times \frac{\pi}{4}(101(h_c - 12)\text{in.})^2 \times (h_c - 12)\text{in.}\right) & 12 < h \le 14\text{-}1/2 \text{ in.} \\ 45080\text{in.}^3 + (264\text{in.} \times 312\text{in.} \times (h_c - 14.5)\text{in.}) - & \\ \left(\frac{\pi}{4}(252.5\text{in.})^2 \times (h_c - 14.5)\text{in.}\right) & 14\text{-}1/2 < h \le 17\text{-}1/2 \text{ in.} \\ 141962\text{in.}^3 + (264\text{in.} \times 312\text{in.} \times (h_c - 17.5)\text{in.}) & 17\text{-}1/2 < h \le 21.57 \text{ in.} \\ 141962\text{in.}^3 + (264\text{in.} \times 312\text{in.} \times (h_c - 17.5)\text{in.}) - V_t & 21.57 \text{ in.} < h \end{cases}$$

The equations to use above 12 inches account for the slope of the floor, but assume the shape of the floor is the same as for cell CR-001. The equations to use above 12 inches also account for the portion of the circular grout pad supporting tank TK-CR-011 that is below the liquid level. The equation for liquid level greater than 14 ½ inches but less than or equal to 17 ½ inches replace the terms for calculating the liquid in the sump and up to the top of the sloped floor with the calculated volume, namely 45,080 cubic inches. The equations for liquid level greater than 17 ½ inches replace the terms for calculating the liquid in the sump and on the floor up to the top of the grout pad that supports the tank with the calculated volume, namely 141,962 cubic inches. The equation to use above 21.57 inches also accounts for the volume displaced by the tank. The volume of the tank based on its external dimensions can be calculated using the formula presented in Section 4.1. For the external volume of tank TK-CR-011, the required parameters to solve the equation are D = 240-5/16 inches, fD = 240-5/16 inches, and kD = 14-13/16 inches (taken from H-2-41108). The height of the tank TK-CR-011 bottom dished head (from its exterior) to the tangent line between the head and the straight wall of the tank is calculated to be 40.93 in. using the equation in Section 4.1. Drawing H-2-41108 shows the height from the bottom of the tank's skirt to the tangent line of the bottom head to be 3 ft. 9 in. or 45 in. The grout pad supporting the tank's skirt extends 3 in. above the high point of the floor as shown in H-2-41888. Therefore, the exterior bottom of tank TK-CR-011 is 7.07 in. (45 in + 3 in. – 40.93 in.) above the high-point of the cell floor or 21.57 in. (45 in. + 3 in. – 40.93 in. + 14.5 in.) above the bottom of the sump.

5.0 USE OF COMPUTER SOFTWARE

The volume calculations as a function of liquid level are performed by a spreadsheet (Microsoft Excel®) application. The following information is provided for the spreadsheet used in support of this calculation:

- Spreadsheet name: 244-CR Tank & Cell Volumes With Respect to Level
- Spreadsheet Owner: Alan Carlson
- Location of spreadsheet: 244-CR project share drive \\AP014\244CR-W-535\Volume
- Spreadsheet Verification File Number: 194

6.0 RESULTS

The volume of tanks TK-CR-001 and TK-CR-011 as a function of liquid level are presented in table 1. The volume of tanks TK-CR-001 and TK-CR-011 as a function of liquid level are considered the same. Both tanks have the same shell dimensions and internal configuration differences result in negligible differences in calculated volume. Liquid level height is measured from the center bottom of the tank.

The volume of tanks TK-CR-002 and TK-CR-003 as a function of liquid level are presented in table 2. The volume of tanks TK-CR-002 and TK-CR-003 as a function of liquid level are considered the same. Both tanks have the same shell dimensions and internal configuration differences result in negligible differences in calculated volume. Liquid level height is measured from the center bottom of the tank.

The volume of cell CR-001 as a function of liquid level is presented in table 3. The volume calculation accounts for the sloped floor of the cell as well as volume that would be displaced by the tank shell at levels above the bottom of the tank. Liquid level height is measured from the bottom of the sump.

The volume of cells CR-002 and CR-003 as a function of liquid level are presented in table 4. The volume of cells CR-002 and CR-003 as a function of liquid level are the same. Both cells have the same dimensions and the configuration of the tank within each cell are also the same. The volume calculation accounts for the sloped floor in each cell as well as volume that would be displaced by the tank shell at levels above the bottom of the tank. Liquid level height is measured from the bottom of the sump.

The volume of cell CR-011 as a function of liquid level is presented in table 5. The volume calculation accounts for the sloped floor of the cell , volume that would be displaced by the grout pad supporting the tank, and volume that would be displaced by the tank shell at levels above the bottom of the tank. Liquid level height is measured from the bottom of the sump.

7.0 CONCLUSIONS

Tank volumes were calculated for the 244-CR tanks up to the maximum operating height of each tank. With the exception of the coils present in tanks TK-CR-002 and TK-CR-003, miscellaneous objects that may exist in the tanks (pumps, pipes, structural supporting members, etc.) are of relatively small volume and therefore not included in the volume calculation. Accounting for these items would have a negligible effect on accurately calculating the liquid volume present in the tank. Not accounting for these items will result in a marginal increase to the calculated volume of liquid present for a given liquid height. The information presented in this calculation can be used to determine 244-CR vault tank waste volumes for obtained level measurements.

Cell volumes were calculated for the 244-CR cells up to a point above the right cylindrical portion of the tank present in the cell. With the exception of the grout pad that supports tank TK-CR-011, miscellaneous objects that may exist in the cells (pumps, pipes, smaller support pads, tank column bases or skirts, etc.) are of relatively small volume and therefore not included in the volume calculation. Accounting for these items would have a negligible effect on accurately calculating the liquid volume present in the tank. Not accounting for these items will result in a marginal increase to the calculated volume of liquid present for a given liquid height. The information presented in this calculation can be used to determine 244-CR vault cell waste volumes for obtained level measurements.

Title: 244-CR Vault Tank and Cell Volume Calculations **Identifier**: P-06-18 Rev: 0

Originator: AB Carlson **Date:** 1/10/05

Checker: MM Durst **Date:** 1/10/05

Organizational Manager: MJ Sutey **Date:** 1/13/05

Table 1. Volume as a Function of Liquid Level for Tanks TK-CR-001 and TK-CR-011 (2 pages)

Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)
0	0	14.5	672	28.75	2590	43	5309	57.5	8148	72	10988	86.5	13828	101	16667
0.25	0.2	14.75	696	29	2634	43.25	5358	57.75	8197	72.25	11037	86.75	13877	101.25	16716
0.5	0.8	15	719	29.25	2678	43.5	5407	58	8246	72.5	11086	87	13926	101.5	16765
0.75	1.8	15.25	743	29.5	2723	43.75	5456	58.25	8295	72.75	11135	87.25	13975	101.75	16814
1	3.3	15.5	767	29.75	2768	44	5505	58.5	8344	73	11184	87.5	14024	102	16863
1.25	5.1	15.75	792	30	2813	44.25	5554	58.75	8393	73.25	11233	87.75	14073	102.25	16912
1.5	7.3	16	817	30.25	2858	44.5	5603	59	8442	73.5	11282	88	14122	102.5	16961
1.75	10	16.25	842	30.5	2904	44.75	5651	59.25	8491	73.75	11331	88.25	14170	102.75	17010
2	13	16.5	868	30.75	2949	45	5700	59.5	8540	74	11380	88.5	14219	103	17059
2.25	16	16.75	894	31	2995	45.25	5749	59.75	8589	74.25	11429	88.75	14268	103.25	17108
2.5	20	17	921	31.25	3041	45.5	5798	60	8638	74.5	11478	89	14317	103.5	17157
2.75	25	17.25	948	31.5	3088	45.75	5847	60.25	8687	74.75	11527	89.25	14366	103.75	17206
3	29	17.5	975	31.75	3134	46	5896	60.5	8736	75	11576	89.5	14415	104	17255
3.25	34	17.75	1003	32	3181	46.25	5945	60.75	8785	75.25	11625	89.75	14464	104.25	17304
3.5	40	18	1031	32.25	3227	46.5	5994	61	8834	75.5	11674	90	14513	104.5	17353
3.75	46	18.25	1060	32.5	3274	46.75	6043	61.25	8883	75.75	11722	90.25	14562	104.75	17402
4	52	18.5	1088	32.75	3321	47	6092	61.5	8932	76	11771	90.5	14611	105	17451
4.25	59	18.75	1118	33	3368	47.25	6141	61.75	8981	76.25	11820	90.75	14660	105.25	17500
4.5	66	19	1147	33.25	3415	47.5	6190	62	9030	76.5	11869	91	14709	105.5	17549
4.75	73	19.25	1177	33.5	3463	47.75	6239	62.25	9079	76.75	11918	91.25	14758	105.75	17598
5	81	19.5	1208	33.75	3510	48	6288	62.5	9128	77	11967	91.5	14807	106	17647
5.25	89	19.75	1238	34	3558	48.25	6337	62.75	9177	77.25	12016	91.75	14856	106.25	17696
5.5	98	20	1269	34.25	3606	48.5	6386	63	9226	77.5	12065	92	14905	106.5	17745
5.75	107	20.25	1301	34.5	3653	48.75	6435	63.25	9274	77.75	12114	92.25	14954	106.75	17794
6	117	20.5	1333	34.75	3701	49	6484	63.5	9323	78	12163	92.5	15003	107	17842
6.25	126	20.75	1365	35	3749	49.25	6533	63.75	9372	78.25	12212	92.75	15052	107.25	17891
6.5	137	21	1397	35.25	3797	49.5	6582	64	9421	78.5	12261	93	15101	107.5	17940
6.75	147	21.25	1430	35.5	3845	49.75	6631	64.25	9470	78.75	12310	93.25	15150	107.75	17989
7	158	21.5	1464	35.75	3894	50	6680	64.5	9519	79	12359	93.5	15199	108	18038
7.25	170	21.75	1497	36	3942	50.25	6729	64.75	9568	79.25	12408	93.75	15248	108.25	18087
7.5	182	22	1532	36.25	3990	50.5	6778	65	9617	79.5	12457	94	15297	108.5	18136
7.75	194	22.25	1566	36.5	4039	50.75	6826	65.25	9666	79.75	12506	94.25	15346	108.75	18185
8	207	22.5	1601	36.75	4087	51	6875	65.5	9715	80	12555	94.5	15394	109	18234
8.25	220	22.75	1636	37	4136	51.25	6924	65.75	9764	80.25	12604	94.75	15443	109.25	18283
8.5	233	23	1671	37.25	4184	51.5	6973	66	9813	80.5	12653	95	15492	109.5	18332
8.75	247	23.25	1707	37.5	4233	51.75	7022	66.25	9862	80.75	12702	95.25	15541	109.75	18381
9	261	23.5	1744	37.75	4282	52	7071	66.5	9911	81	12751	95.5	15590	110	18430
9.25	276	23.75	1780	38	4330	52.25	7120	66.75	9960	81.25	12800	95.75	15639	110.25	18479
9.5	291	24	1817	38.25	4379	52.5	7169	67	10009	81.5	12849	96	15688	110.5	18528
9.75	306	24.25	1855	38.5	4428	52.75	7218	67.25	10058	81.75	12898	96.25	15737	110.75	18577
10	322	24.5	1893	38.75	4477	53	7267	67.5	10107	82	12946	96.5	15786	111	18626
10.25	338	24.75	1931	39	4526	53.25	7316	67.75	10156	82.25	12995	96.75	15835	111.25	18675
10.5	355	25	1969	39.25	4574	53.5	7365	68	10205	82.5	13044	97	15884	111.5	18724
10.75	372	25.25	2008	39.5	4623	53.75	7414	68.25	10254	82.75	13093	97.25	15933	111.75	18773
11	389	25.5	2047	39.75	4672	54	7463	68.5	10303	83	13142	97.5	15982	112	18822
11.25	407	25.75	2087	40	4721	54.25	7512	68.75	10352	83.25	13191	97.75	16031	112.25	18871
11.5	425	26	2127	40.25	4770	54.5	7561	69	10401	83.5	13240	98	16080	112.5	18920
11.75	443	26.25	2167	40.5	4819	54.75	7610	69.25	10450	83.75	13289	98.25	16129	112.75	18969
12	462	26.5	2208	**40.70**[#]	4859	55	7659	69.5	10498	84	13338	98.5	16178	113	19018
12.25	481	26.75	2249	40.75	4868	55.25	7708	69.75	10547	84.25	13387	98.75	16227	113.25	19066
12.5	501	27	2290	41	4917	55.5	7757	70	10596	84.5	13436	99	16276	113.5	19115
12.75	521	27.25	2332	41.25	4966	55.75	7806	70.25	10645	84.75	13485	99.25	16325	113.75	19164
13	542	27.5	2374	41.5	5015	56	7855	70.5	10694	85	13534	99.5	16374	114	19213
13.25	562	27.75	2417	41.75	5064	56.25	7904	70.75	10743	85.25	13583	99.75	16423	114.25	19262
13.5	584	**27.89***	2440	42	5113	56.5	7953	71	10792	85.5	13632	100	16472	114.5	19311
13.75	605	28	2459	42.25	5162	56.75	8002	71.25	10841	85.75	13681	100.25	16521	114.75	19360
14	627	28.25	2503	42.5	5211	57	8050	71.5	10890	86	13730	100.5	16570	115	19409
14.25	650	28.5	2546	42.75	5260	57.25	8099	71.75	10939	86.25	13779	100.75	16618	115.25	19458

Title: 244-CR Vault Tank and Cell Volume Calculations **Identifier**: P-06-18 Rev: 0
Originator: AB Carlson **Date:** 1/10/05
Checker: MM Durst **Date:** 1/10/05
Organizational Manager: MJ Sutey **Date:** 1/13/05

Table 1. Volume as a Function of Liquid Level for Tanks TK-CR-001 and TK-CR-011 (2 pages)

Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)
115.5	19507	128.75	22102	142	24697	155.25	27292	168.5	29887	181.75	32481	195	35076	208.25	37671
115.75	19556	129	22151	142.25	24746	155.5	27341	168.75	29936	182	32530	195.25	35125	208.5	37720
116	19605	129.25	22200	142.5	24795	155.75	27390	169	29985	182.25	32579	195.5	35174	208.75	37769
116.25	19654	129.5	22249	142.75	24844	156	27439	169.25	30033	182.5	32628	195.75	35223	209	37818
116.5	19703	129.75	22298	143	24893	156.25	27488	169.5	30082	182.75	32677	196	35272	209.25	37867
116.75	19752	130	22347	143.25	24942	156.5	27537	169.75	30131	183	32726	196.25	35321	209.5	37916
117	19801	130.25	22396	143.5	24991	156.75	27585	170	30180	183.25	32775	196.5	35370	209.75	37965
117.25	19850	130.5	22445	143.75	25040	157	27634	170.25	30229	183.5	32824	196.75	35419	210	38014
117.5	19899	130.75	22494	144	25089	157.25	27683	170.5	30278	183.75	32873	197	35468	210.25	38063
117.75	19948	131	22543	144.25	25137	157.5	27732	170.75	30327	184	32922	197.25	35517	210.5	38112
118	19997	131.25	22592	144.5	25186	157.75	27781	171	30376	184.25	32971	197.5	35566	210.75	38161
118.25	20046	131.5	22641	144.75	25235	158	27830	171.25	30425	184.5	33020	197.75	35615	211	38210
118.5	20095	131.75	22689	145	25284	158.25	27879	171.5	30474	184.75	33069	198	35664	211.25	38259
118.75	20144	132	22738	145.25	25333	158.5	27928	171.75	30523	185	33118	198.25	35713	211.5	38308
119	20193	132.25	22787	145.5	25382	158.75	27977	172	30572	185.25	33167	198.5	35762	211.75	38357
119.25	20242	132.5	22836	145.75	25431	159	28026	172.25	30621	185.5	33216	198.75	35811	212	38406
119.5	20290	132.75	22885	146	25480	159.25	28075	172.5	30670	185.75	33265	199	35860	212.25	38455
119.75	20339	133	22934	146.25	25529	159.5	28124	172.75	30719	186	33314	199.25	35909	212.5	38504
120	20388	133.25	22983	146.5	25578	159.75	28173	173	30768	186.25	33363	199.5	35958	212.75	38553
120.25	20437	133.5	23032	146.75	25627	160	28222	173.25	30817	186.5	33412	199.75	36007	213	38601
120.5	20486	133.75	23081	147	25676	160.25	28271	173.5	30866	186.75	33461	200	36056	213.25	38650
120.75	20535	134	23130	147.25	25725	160.5	28320	173.75	30915	187	33510	200.25	36105	213.5	38699
121	20584	134.25	23179	147.5	25774	160.75	28369	174	30964	187.25	33559	200.5	36153	213.75	38748
121.25	20633	134.5	23228	147.75	25823	161	28418	174.25	31013	187.5	33608	200.75	36202	214	38797
121.5	20682	134.75	23277	148	25872	161.25	28467	174.5	31062	187.75	33657	201	36251	214.25	38846
121.75	20731	135	23326	148.25	25921	161.5	28516	174.75	31111	188	33705	201.25	36300	214.5	38895
122	20780	135.25	23375	148.5	25970	161.75	28565	175	31160	188.25	33754	201.5	36349	214.75	38944
122.25	20829	135.5	23424	148.75	26019	162	28614	175.25	31209	188.5	33803	201.75	36398	215	38993
122.5	20878	135.75	23473	149	26068	162.25	28663	175.5	31257	188.75	33852	202	36447	215.25	39042
122.75	20927	136	23522	149.25	26117	162.5	28712	175.75	31306	189	33901	202.25	36496	215.5	39091
123	20976	136.25	23571	149.5	26166	162.75	28761	176	31355	189.25	33950	202.5	36545	215.75	39140
123.25	21025	136.5	23620	149.75	26215	163	28809	176.25	31404	189.5	33999	202.75	36594	216	39189
123.5	21074	136.75	23669	150	26264	163.25	28858	176.5	31453	189.75	34048	203	36643	216.25	39238
123.75	21123	137	23718	150.25	26313	163.5	28907	176.75	31502	190	34097	203.25	36692	216.5	39287
124	21172	137.25	23767	150.5	26361	163.75	28956	177	31551	190.25	34146	203.5	36741	216.75	39336
124.25	21221	137.5	23816	150.75	26410	164	29005	177.25	31600	190.5	34195	203.75	36790	217	39385
124.5	21270	137.75	23865	151	26459	164.25	29054	177.5	31649	190.75	34244	204	36839	217.25	39434
124.75	21319	138	23913	151.25	26508	164.5	29103	177.75	31698	191	34293	204.25	36888	217.5	39483
125	21368	138.25	23962	151.5	26557	164.75	29152	178	31747	191.25	34342	204.5	36937	217.75	39532
125.25	21417	138.5	24011	151.75	26606	165	29201	178.25	31796	191.5	34391	204.75	36986	218	39581
125.5	21466	138.75	24060	152	26655	165.25	29250	178.5	31845	191.75	34440	205	37035	218.25	39630
125.75	21514	139	24109	152.25	26704	165.5	29299	178.75	31894	192	34489	205.25	37084	218.5	39679
126	21563	139.25	24158	152.5	26753	165.75	29348	179	31943	192.25	34538	205.5	37133	218.75	39728
126.25	21612	139.5	24207	152.75	26802	166	29397	179.25	31992	192.5	34587	205.75	37182	219	39776
126.5	21661	139.75	24256	153	26851	166.25	29446	179.5	32041	192.75	34636	206	37231	219.25	39825
126.75	21710	140	24305	153.25	26900	166.5	29495	179.75	32090	193	34685	206.25	37280	219.5	39874
127	21759	140.25	24354	153.5	26949	166.75	29544	180	32139	193.25	34734	206.5	37329	219.75	39923
127.25	21808	140.5	24403	153.75	26998	167	29593	180.25	32188	193.5	34783	206.75	37377	220	39972
127.5	21857	140.75	24452	154	27047	167.25	29642	180.5	32237	193.75	34832	207	37426	220.25	40021
127.75	21906	141	24501	154.25	27096	167.5	29691	180.75	32286	194	34881	207.25	37475	220.5	40070
128	21955	141.25	24550	154.5	27145	167.75	29740	181	32335	194.25	34929	207.5	37524	**220.70^**	40110
128.25	22004	141.5	24599	154.75	27194	168	29789	181.25	32384	194.5	34978	207.75	37573		
128.5	22053	141.75	24648	155	27243	168.25	29838	181.5	32433	194.75	35027	208	37622		

Footnotes:

* Transition from flange dish to knuckle dish

\# Transition from knuckle dish to straight section of tank

^ Maximum fill height of tank

Title: 244-CR Vault Tank and Cell Volume Calculations **Identifier:** P-06-18 Rev: 0
Originator: AB Carlson **Date:** 1/10/05
Checker: MM Durst **Date:** 1/10/05
Organizational Manager: MJ Sutey **Date:** 1/13/05

Table 2. Volume as a Function of Liquid Level for Tanks TK-CR-002 and TK-CR-003 (2 pages)

Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)
0	0	10.5	247	20.5	915	30.75	1845	41.25	2819	51.75	3794
0.25	0.1	10.75	258	20.75	936	31	1868	41.5	2843	52	3817
0.5	0.6	11	270	21	957	31.25	1891	41.75	2866	52.25	3840
0.75	1.3	11.25	283	21.25	979	31.5	1914	42	2889	52.5	3863
1	2.3	11.5	295	21.5	1000	31.75	1938	42.25	2912	52.75	3887
1.25	3.6	11.75	308	21.75	1022	32	1961	42.5	2935	53	3910
1.5	5.1	12	321	22	1044	32.25	1984	42.75	2959	53.25	3933
1.75	7.0	12.25	335	22.25	1066	32.5	2007	43	2982	53.5	3956
2	9.1	12.5	348	22.5	1088	32.75	2030	43.25	3005	53.75	3979
2.25	12	12.75	362	22.75	1110	33	2054	43.5	3028	54	4003
2.5	14	13	376	23	1132	33.25	2077	43.75	3051	54.25	4026
2.75	17	13.25	391	23.25	1154	33.5	2100	44	3075	54.5	4049
3	20	13.5	405	23.5	1177	33.75	2123	44.25	3098	54.75	4072
3.25	24	13.75	420	23.75	1199	34	2146	44.5	3121	55	4096
3.5	28	14	435	24	1222	34.25	2170	44.75	3144	55.25	4119
3.75	32	14.25	451	24.25	1244	34.5	2193	45	3167	55.5	4142
4	36	14.5	467	24.5	1267	34.75	2216	45.25	3191	55.75	4165
4.25	41	14.75	483	24.75	1290	35	2239	45.5	3214	56	4188
4.5	46	15	499	25	1313	35.25	2262	45.75	3237	56.25	4212
4.75	51	15.25	515	25.25	1336	35.5	2286	46	3260	56.5	4235
5	57	15.5	532	25.5	1359	35.75	2309	46.25	3283	56.75	4258
5.25	62	15.75	549	25.75	1382	36	2332	46.5	3307	57	4281
5.5	68	16	566	26	1405	36.25	2355	46.75	3330	57.25	4304
5.75	75	16.25	584	26.25	1428	36.5	2378	47	3353	57.5	4328
6	81	16.5	602	26.5	1451	36.75	2402	47.25	3376	57.75	4351
6.25	88	16.75	620	26.75	1474	37	2425	47.5	3399	58	4374
6.5	95	17	638	27	1497	37.25	2448	47.75	3423	58.25	4397
6.75	103	17.25	657	27.25	1520	37.5	2471	48	3446	58.5	4420
7	110	17.5	675	27.5	1543	37.75	2495	48.25	3469	58.75	4444
7.25	118	17.75	695	27.75	1566	38	2518	48.5	3492	59	4467
7.5	127	18	714	28	1590	38.25	2541	48.75	3515	59.25	4490
7.75	135	18.25	733	28.25	1613	38.5	2564	49	3539	59.5	4513
8	144	18.5	753	**28.48^**	1634	38.75	2587	49.25	3562	59.75	4536
8.25	153	**18.53***	755	28.5	1636	39	2611	49.5	3585	60	4560
8.5	162	18.75	773	28.75	1659	39.25	2634	49.75	3608	60.25	4583
8.75	172	19	792	29	1682	39.5	2657	50	3631	60.5	4606
9	182	19.25	812	29.25	1706	39.75	2680	50.25	3655	60.75	4629
9.25	192	19.5	832	29.5	1729	40	2703	50.5	3678	61	4652
9.5	202	**19.53#**	834	29.75	1752	40.25	2727	50.75	3701	61.25	4676
9.75	213	19.75	852	30	1775	40.5	2750	51	3724	61.5	4699
10	224	20	873	30.25	1798	40.75	2773	51.25	3747	61.75	4722
10.25	235	20.25	894	30.5	1822	41	2796	51.5	3771	62	4745

Title: 244-CR Vault Tank and Cell Volume Calculations **Identifier**: P-06-18 Rev: 0
Originator: AB Carlson **Date:** 1/10/05
Checker: MM Durst **Date:** 1/10/05
Organizational Manager: MJ Sutey **Date:** 1/13/05

Table 2. Volume as a Function of Liquid Level for Tanks TK-CR-002 and TK-CR-003 (2 pages)

Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)
62.25	4768	71.5	5633	81	6545	90.5	7457	100	8368	109.5	9280
62.5	4792	71.75	5657	81.25	6569	90.75	7481	100.25	8392	109.75	9304
62.75	4815	72	5681	81.5	6593	91	7505	100.5	8416	110	9328
63	4838	72.25	5705	81.75	6617	91.25	7528	100.75	8440	110.25	9352
63.25	4861	72.5	5729	82	6641	91.5	7552	101	8464	110.5	9376
63.5	4884	72.75	5753	82.25	6665	91.75	7576	101.25	8488	110.75	9400
63.75	4908	73	5777	82.5	6689	92	7600	101.5	8512	111	9424
64	4931	73.25	5801	82.75	6713	92.25	7624	101.75	8536	111.25	9448
64.25	4954	73.5	5825	83	6737	92.5	7648	102	8560	111.5	9472
64.5	4977	73.75	5849	83.25	6761	92.75	7672	102.25	8584	111.75	9496
64.75	5000	74	5873	83.5	6785	93	7696	102.5	8608	112	9520
65	5024	74.25	5897	83.75	6809	93.25	7720	102.75	8632	112.25	9544
65.25	5047	74.5	5921	84	6833	93.5	7744	103	8656	112.5	9568
65.5	5070	74.75	5945	84.25	6857	93.75	7768	103.25	8680	112.75	9592
65.75	5093	75	5969	84.5	6881	94	7792	103.5	8704	113	9616
66	5116	75.25	5993	84.75	6905	94.25	7816	103.75	8728	113.25	9640
66.25	5140	75.5	6017	85	6929	94.5	7840	104	8752	113.5	9664
66.5	5163	75.75	6041	85.25	6953	94.75	7864	104.25	8776	113.75	9688
66.75	5186	76	6065	85.5	6977	95	7888	104.5	8800	114	9712
67	5209	76.25	6089	85.75	7001	95.25	7912	104.75	8824	114.25	9736
67.25	5232	76.5	6113	86	7025	95.5	7936	105	8848	114.5	9760
67.5	5256	76.75	6137	86.25	7049	95.75	7960	105.25	8872	114.75	9784
67.75	5279	77	6161	86.5	7073	96	7984	105.5	8896	115	9808
68	5302	77.25	6185	86.75	7097	96.25	8008	105.75	8920	115.25	9832
68.25	5325	77.5	6209	87	7121	96.5	8032	106	8944	115.5	9856
68.5	5348	77.75	6233	87.25	7145	96.75	8056	106.25	8968	115.75	9880
68.75	5372	78	6257	87.5	7169	97	8080	106.5	8992	116	9904
69	5395	78.25	6281	87.75	7193	97.25	8104	106.75	9016	116.25	9928
69.25	5418	78.5	6305	88	7217	97.5	8128	107	9040	116.5	9952
69.48**	5439	78.75	6329	88.25	7241	97.75	8152	107.25	9064	116.75	9976
69.5	5441	79	6353	88.5	7265	98	8176	107.5	9088	117	10000
69.75	5465	79.25	6377	88.75	7289	98.25	8200	107.75	9112	117.25	10023
70	5489	79.5	6401	89	7313	98.5	8224	108	9136	117.5	10047
70.25	5513	79.75	6425	89.25	7337	98.75	8248	108.25	9160	117.75	10071
70.5	5537	80	6449	89.5	7361	99	8272	108.5	9184	118	10095
70.75	5561	80.25	6473	89.75	7385	99.25	8296	108.75	9208	118.25	10119
71	5585	80.5	6497	90	7409	99.5	8320	109	9232	118.48@	10141
71.25	5609	80.75	6521	90.25	7433	99.75	8344	109.25	9256		

Footnotes:
* Bottom of coil
# Transition from flange dish to knuckle dish
^ Transition from knuckle dish to straight section of tank
** Top of coil
@ Maximum fill height of tank

Table 3. Volume as a Function of Liquid Level for Cell CR-001
(As Measured from the Bottom of the Sump)

Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)
0	0	11.25	42	22.25	3138	33.5	6693	44.75	9462	56	11529
0.25	0.9	11.5	43	22.5	3226	33.75	6763	45	9515	56.25	11570
0.5	1.9	11.75	44	22.75	3313	34	6833	45.25	9568	56.5	11611
0.75	2.8	12*	45	23	3400	34.25	6902	45.5	9620	56.75	11652
1	3.7	12.25	47	23.25	3487	34.5	6971	45.75	9672	57	11693
1.25	4.7	12.5	52	23.5	3573	34.75	7039	46	9723	57.25	11734
1.5	5.6	12.75	62	23.75	3659	35	7107	46.25	9774	57.5	11775
1.75	6.5	13	77	24	3744	35.25	7175	46.5	9825	57.75	11816
2	7.5	13.25	100	24.25	3829	35.5	7242	46.75	9875	58	11856
2.25	8.4	13.5	132	24.5	3914	35.75	7309	47	9925	58.25	11897
2.5	9.4	13.75	174	24.75	3998	36	7375	47.25	9975	58.5	11937
2.75	10	14	228	25	4081	36.25	7441	47.5	10024	58.75	11978
3	11	14.25	294	25.25	4165	36.5	7507	47.75	10073	59	12018
3.25	12	14.5#	376	25.5	4248	36.75	7572	48	10121	59.25	12059
3.5	13	14.75	465	25.75	4330	37	7637	48.25	10170	59.5	12099
3.75	14	15	554	26	4413	37.25	7702	48.5	10217	59.75	12139
4	15	15.25	643	26.25	4494	37.5	7766	48.75	10265	60	12179
4.25	16	15.5	732	26.5	4576	37.75	7830	49	10312	60.25	12220
4.5	17	15.75	822	26.75	4657	38	7893	49.25	10359	60.5	12260
4.75	18	16	911	27	4737	38.25	7956	49.5	10405	60.75	12300
5	19	16.25	1000	27.25	4817	38.5	8019	49.75	10451	61	12340
5.25	20	16.5	1089	27.5	4897	38.75	8081	50	10497	61.25	12380
5.5	21	16.75	1178	27.75	4977	39	8143	50.25	10542	61.5	12420
5.75	22	17	1267	28	5056	39.25	8204	50.5	10587	61.75	12460
6	22	17.25	1356	28.25	5134	39.5	8265	50.75	10632	62	12500
6.25	23	17.5	1446	28.5	5212	39.75	8326	51	10676	62.25	12541
6.5	24	17.75	1535	28.75	5290	40	8387	51.25	10721	62.5**	12581
6.75	25	18	1624	29	5367	40.25	8446	51.5	10765	62.75	12621
7	26	18.25	1713	29.25	5444	40.5	8506	51.75	10809	63	12661
7.25	27	18.5	1802	29.5	5521	40.75	8565	52	10852	63.25	12701
7.5	28	18.75	1891	29.75	5597	41	8624	52.25	10896	63.5	12741
7.75	29	19	1980	30	5673	41.25	8683	52.5	10939	63.75	12781
8	30	19.25	2070	30.25	5748	41.5	8741	52.75	10982	64	12821
8.25	31	19.5	2159	30.5	5823	41.75	8799	53	11025	64.25	12861
8.5	32	19.75	2248	30.75	5898	42	8856	53.25	11068	64.5	12901
8.75	33	20	2337	31	5972	42.25	8913	53.5	11110	64.75	12941
9	34	20.25	2426	31.25	6046	42.5	8970	53.75	11153	65	12981
9.25	35	20.5	2515	31.5	6120	42.75	9026	54	11195	65.25	13021
9.5	36	20.75	2604	31.75	6193	43	9082	54.25	11237	65.5	13061
9.75	36	21	2694	32	6265	43.25	9137	54.5	11279	65.75	13101
10	37	21.25	2783	32.25	6338	43.5	9192	54.75	11321	66	13141
10.25	38	21.5	2872	32.5	6409	43.75	9247	55	11363		
10.5	39	21.57^	2896	32.75	6481	44	9301	55.25	11404		
10.75	40	21.75	2961	33	6552	44.25	9355	55.5	11446		
11	41	22	3049	33.25	6623	44.5	9409	55.75	11487		

Footnotes:

- * Top of Sump/Low Point of Floor
- \# High Point of Floor
- ^ Bottom of tank TK-CR-001
- ** Transition between tank dished head and straight side of tank

Title: 244-CR Vault Tank and Cell Volume Calculations **Identifier**: P-06-18 Rev: 0
Originator: AB Carlson **Date:** 1/10/05
Checker: MM Durst **Date:** 1/10/05
Organizational Manager: MJ Sutey **Date:** 1/13/05

Table 4. Volume as a Function of Liquid Level for Cells CR-002 and CR-003
(As Measured from the Bottom of the Sump)

Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)
0	0	11.25	42	22.5	1925	33.5	3879	44.75	5343	56	6518
0.25	0.9	11.5	43	22.75	1975	33.75	3917	45	5370	56.25	6544
0.5	1.9	11.75	44	23	2025	34	3955	45.25	5397	56.5	6570
0.75	2.8	**12***	45	**23.14^**	2052	34.25	3992	45.5	5424	56.75	6596
1	3.7	12.25	47	23.25	2074	34.5	4030	45.75	5451	57	6622
1.25	4.7	12.5	52	23.5	2124	34.75	4067	46	5478	57.25	6647
1.5	5.6	12.75	62	23.75	2173	35	4104	46.25	5505	57.5	6673
1.75	6.5	13	78	24	2222	35.25	4141	46.5	5531	57.75	6699
2	7.5	13.25	102	24.25	2271	35.5	4177	46.75	5558	58	6725
2.25	8.4	13.5	135	24.5	2320	35.75	4213	47	5584	58.25	6751
2.5	9.4	**13.75#**	179	24.75	2368	36	4249	47.25	5611	58.5	6777
2.75	10	14	229	25	2416	36.25	4285	47.5	5637	58.75	6802
3	11	14.25	279	25.25	2463	36.5	4320	47.75	5664	59	6828
3.25	12	14.5	329	25.5	2511	36.75	4355	48	5690	59.25	6854
3.5	13	14.75	379	25.75	2558	37	4390	48.25	5716	59.5	6880
3.75	14	15	429	26	2604	37.25	4424	48.5	5742	59.75	6906
4	15	15.25	479	26.25	2651	37.5	4459	48.75	5768	60	6932
4.25	16	15.5	529	26.5	2697	37.75	4493	49	5794	60.25	6957
4.5	17	15.75	578	26.75	2743	38	4526	49.25	5820	60.5	6983
4.75	18	16	628	27	2789	38.25	4560	49.5	5846	60.75	7009
5	19	16.25	678	27.25	2834	38.5	4593	49.75	5872	61	7035
5.25	20	16.5	728	27.5	2879	38.75	4626	50	5898	61.25	7061
5.5	21	16.75	778	27.75	2924	39	4659	50.25	5924	61.5	7087
5.75	22	17	828	28	2968	39.25	4691	50.5	5950	61.75	7112
6	22	17.25	878	28.25	3013	39.5	4723	50.75	5976	62	7138
6.25	23	17.5	927	28.5	3057	39.75	4755	51	6002	62.25	7164
6.5	24	17.75	977	28.75	3100	40	4787	51.25	6028	62.5	7190
6.75	25	18	1027	29	3144	40.25	4818	51.5	6053	62.75	7216
7	26	18.25	1077	29.25	3187	40.5	4850	**51.75****	6079	63	7241
7.25	27	18.5	1127	29.5	3230	40.75	4881	52	6105	63.25	7267
7.5	28	18.75	1177	29.75	3272	41	4911	52.25	6131	63.5	7293
7.75	29	19	1227	30	3315	41.25	4942	52.5	6157	63.75	7319
8	30	19.25	1277	30.25	3357	41.5	4972	52.75	6183	64	7345
8.25	31	19.5	1326	30.5	3399	41.75	5002	53	6208	64.25	7371
8.5	32	19.75	1376	30.75	3440	42	5031	53.25	6234	64.5	7396
8.75	33	20	1426	31	3481	42.25	5061	53.5	6260	64.75	7422
9	34	20.25	1476	31.25	3522	42.5	5090	53.75	6286	65	7448
9.25	35	20.5	1526	31.5	3563	42.75	5119	54	6312	65.25	7474
9.5	36	20.75	1576	31.75	3603	43	5147	54.25	6338	65.5	7500
9.75	36	21	1626	32	3643	43.25	5176	54.5	6363	65.75	7526
10	37	21.25	1676	32.25	3683	43.5	5204	54.75	6389	66	7551
10.25	38	21.5	1725	32.5	3723	43.75	5232	55	6415		
10.5	39	21.75	1775	32.75	3762	44	5260	55.25	6441		
10.75	40	22	1825	33	3801	44.25	5288	55.5	6467		
11	41	22.25	1875	33.25	3840	44.5	5315	55.75	6492		

Footnotes:

* Top of Sump/Low Point of Floor
\# High Point of Floor
^ Bottom of tank TK-CR-002 or TK-CR-003
** Transition between tank dished head and straight side of tank

Title: 244-CR Vault Tank and Cell Volume Calculations **Identifier**: P-06-18 Rev: 0
Originator: AB Carlson **Date:** 1/10/05
Checker: MM Durst **Date:** 1/10/05
Organizational Manager: MJ Sutey **Date:** 1/13/05

Table 5. Volume as a Function of Liquid Level for Cell CR-011
(As Measured from the Bottom of the Sump)

Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)	Ht. (in.)	Vol. (gal)
0	0	11.25	42	22.25	2307	33.5	5862	44.75	8631	56	10698
0.25	0.9	11.5	43	22.5	2395	33.75	5932	45	8684	56.25	10739
0.5	1.9	11.75	44	22.75	2482	34	6002	45.25	8737	56.5	10780
0.75	2.8	**12***	45	23	2569	34.25	6071	45.5	8789	56.75	10821
1	3.7	12.25	47	23.25	2656	34.5	6140	45.75	8841	57	10862
1.25	4.7	12.5	51	23.5	2742	34.75	6208	46	8892	57.25	10903
1.5	5.6	12.75	57	23.75	2828	35	6276	46.25	8943	57.5	10944
1.75	6.5	13	66	24	2913	35.25	6344	46.5	8994	57.75	10985
2	7.5	13.25	77	24.25	2998	35.5	6411	46.75	9044	58	11025
2.25	8.4	13.5	93	24.5	3083	35.75	6478	47	9094	58.25	11066
2.5	9.4	13.75	112	24.75	3167	36	6544	47.25	9144	58.5	11106
2.75	10	14	135	25	3251	36.25	6610	47.5	9193	58.75	11147
3	11	14.25	163	25.25	3334	36.5	6676	47.75	9242	59	11187
3.25	12	**14.5#**	195	25.5	3417	36.75	6741	48	9290	59.25	11228
3.5	13	14.75	230	25.75	3499	37	6806	48.25	9339	59.5	11268
3.75	14	15	265	26	3582	37.25	6871	48.5	9386	59.75	11308
4	15	15.25	300	26.25	3663	37.5	6935	48.75	9434	60	11349
4.25	16	15.5	335	26.5	3745	37.75	6999	49	9481	60.25	11389
4.5	17	15.75	370	26.75	3826	38	7062	49.25	9528	60.5	11429
4.75	18	16	405	27	3906	38.25	7125	49.5	9574	60.75	11469
5	19	16.25	440	27.25	3986	38.5	7188	49.75	9620	61	11509
5.25	20	16.5	475	27.5	4066	38.75	7250	50	9666	61.25	11549
5.5	21	16.75	510	27.75	4146	39	7312	50.25	9711	61.5	11589
5.75	22	17	545	28	4225	39.25	7373	50.5	9756	61.75	11629
6	22	17.25	580	28.25	4303	39.5	7434	50.75	9801	62	11670
6.25	23	17.5	615	28.5	4381	39.75	7495	51	9845	62.25	11710
6.5	24	17.75	704	28.75	4459	40	7556	51.25	9890	**62.5****	11750
6.75	25	18	793	29	4537	40.25	7616	51.5	9934	62.75	11790
7	26	18.25	882	29.25	4613	40.5	7675	51.75	9978	63	11830
7.25	27	18.5	971	29.5	4690	40.75	7734	52	10021	63.25	11870
7.5	28	18.75	1060	29.75	4766	41	7793	52.25	10065	63.5	11910
7.75	29	19	1149	30	4842	41.25	7852	52.5	10108	63.75	11950
8	30	19.25	1239	30.25	4918	41.5	7910	52.75	10151	64	11990
8.25	31	19.5	1328	30.5	4993	41.75	7968	53	10194	64.25	12030
8.5	32	19.75	1417	30.75	5067	42	8025	53.25	10237	64.5	12070
8.75	33	20	1506	31	5141	42.25	8082	53.5	10279	64.75	12110
9	34	20.25	1595	31.25	5215	42.5	8139	53.75	10322	65	12150
9.25	35	20.5	1684	31.5	5289	42.75	8195	54	10364	65.25	12190
9.5	36	20.75	1773	31.75	5362	43	8251	54.25	10406	65.5	12230
9.75	36	21	1863	32	5434	43.25	8306	54.5	10448	65.75	12270
10	37	21.25	1952	32.25	5507	43.5	8361	54.75	10490	66	12310
10.25	38	21.5	2041	32.5	5579	43.75	8416	55	10532		
10.5	39	**21.57^**	2065	32.75	5650	44	8470	55.25	10574		
10.75	40	21.75	2130	33	5721	44.25	8524	55.5	10615		
11	41	22	2219	33.25	5792	44.5	8578	55.75	10657		

Footnotes:

* Top of Sump/Low Point of Floor
\# High Point of Floor
^ Bottom of tank TK-CR-011
** Transition between tank dished head and straight side of tank

8.0 REFERENCES

H-2-41089 Sheet. 1, "Vessel Assembly & Details 14 Feet 0 Inches x 12 Feet 2 Inches Tank TK-CR-002 & TK-CR-003 & TK-BXR-002 & TK-BXR-003 & TK-TXR-002 & TK-TXR-003"

H-2-41090 Sheet 1, "Vessel Details – 14 Feet 0 Inches x 12 Feet 0 Inches Tank, TK-CR-002, TK-CR-003, TK-BXR-002, TK-BXR-003, TK-TXR-002, And TK-TXR-003"

H-2-41108 Sheet 1, "Vessel Assembly & Details 20 Feet 0 Inches x 19 Feet 2 Inches Tank TK-CR-011 & TK-BXR-011"

H-2-41688 Sheet 1, "Vessel Assembly & Details 20 Feet 0 Inches x 19 Feet 2 Inches Tank TK-CR-001 & TK-BXR-001 & TK-TXR-001"

H-2-41888 Sheet 1, "Structural Concrete Plans & Details Process Tank Vault"

H-2-41889 Sheet 1, "Structural Concrete Sections & Details Process Tank Vault Sheet Number 1"

Jones 2002, Dan Jones, "Computing Fluid Tank Volumes", *Chemical Processing*, Volume 65, pp. 46-50, November 2002.

INFORMATION CLEARANCE REVIEW AND RELEASE APPROVAL

Part I: Background Information

Title: 244-CR Vault Tank and Cell Volume Calculations	Information Category: ☐ Abstract ☐ Journal Article ☐ Summary ☐ Internet ☐ Visual Aid ☐ Software ☐ Full Paper ☐ Report ☑ Other WMA C Closure WIR Evaluation Reference
Publish to OSTI? ☐ Yes ☑ No	
Trademark/Copyright "Right to Use" Information or Permission Documentation	Yes ☐ NA ☑
Document Number: RPP-CALC-24219 Revision 0	Date: January 2005
Author: Darling, David (Dave) B	

Part II: External/Public Presentation Information

Conference Name: N/A	
Sponsoring Organization(s): Rebecca Blackwell	
Date of Conference: N/A	Conference Location: N/A
Will Material be Handed Out? ☐ Yes ☑ No	Will Information be Published? ☐ Yes ☑ No *(If Yes, attach copy of Conference format instructions/guidance.)*

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If product contains pictures, safety review completed?	☐	☑	

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Responsible Manager	WRPS		Levitt, Marc T Approved via att. IDMS data file.
Other:			

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INFORMATION CLEARANCE REVIEW AND RELEASE APPROVAL

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Description	*Approved for Release*		*Print Name/Signature*
	Yes	*N/A*	
WRPS External Affairs	☑	☐	Kraemer, Kristin M. - Approved via att. IDMS data file.
WRPS Office of Chief Counsel	☑	☐	Kneese, Kyle C - Approved via att. IDMS data file.
DOE – ORP Public Affairs/Communications	☑	☐	Dawson, Edward M - Approved via att. IDMS data file.
Other: DOE SME	☑	☐	Millikin, Emily J - Approved via att. IDMS data file.
Other:	☐	☐	

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Reference for WMA C Closure WIR Evaluation that will be put into Hanford Administrative Record.

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By Julia Killinger at 11:06 am, Nov 19, 2024

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