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ICPP Calcined Solids Storage Facility Closure Study

Volume III

Engineering Design Files

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CALCINE SOLIDS STORAGE FACILITY CLOSURE STUDY

EDF STATUS AS OF 02/04/98

EDF Number	Title	Author	Status	Date Issued
EDF-BSC-001	Calcined Solids Storage Facilities – Volume Calculations	S. P. Swanson	Issued	1-26-98
EDF-BSC-002	Bin Set Closure Discussion with Maria Dumas, Jim Law, Mike Swenson, and Ambika Chakravartty	S. P. Swanson	Issued	1-21-98
EDF-BSC-003	Using CO2 For Removal of Radioactive Waste	K. D. McAllister	Issued	1-13-98
EDF-BSC-004	Commercially Available Robots and Associated Costs	K. D. McAllister	Issued	2-4-98
EDF-BSC-005	Bin Set Closure Starting Conditions	K. D. McAllister	Issued	2-2-98
EDF-BSC-006	Bin Set Closure Scoping Meeting Minutes (November 6, 1997)	M. M. Dahlmeir	Issued	11-20-97
EDF-BSC-007	Bin Set Description	K. D. McAllister	Issued	2-3-98
EDF-BSC-008	Estimates of Activity in Bin Sets Filled With Grout	C. Barnes	Issued	1-29-98
EDF-BSC-009	CSSF Bin, TFF Tank, NWCF Volume and Grout Production Accuracy	K. D. McAllister	Issued	1-29-98
EDF-BSC-010	Time to Remove Calcine from CSSF Bin Walls and Bin Bottom	K. D. McAllister	Issued	2-3-98
EDF-BSC-011	Bin Set Waste Classification Assumptions	K. C. DeCoria	Issued	1-29-98
EDF-BSC-012	Bin Set Waste Composition After Flushing With Nitric Acid	C. Barnes	Issued	1-29-98
EDF-BSC-013	Estimated Radionuclide Release Rates	I.E. Stepan	Issued	1-29-98

CALCINE SOLIDS STORAGE FACILITY CLOSURE STUDY
EDF STATUS AS OF 02/04/98

EDF Number	Title	Author	Status	Date Issued
EDF-BSC-014	Commercially Available Robots and Associated Costs	K. D. McAllister	Cancelled – information duplicate of EDF-BSC-004	2-3-98
EDF-BSC-015	Methodology for CSSF Radiation Calculations	S. P. Swanson	Issued	2-3-98
EDF-BSC-016	Cost Estimate for RBCC; NRC Class A Landfill	M.M. Dahlmeir	Issued	2-4-98
EDF-BSC-017	Nitric Acid Corrosion Assessment of ICPP Bin Set Vessels	B.C. Norby	Issued	2-3-98

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Project/Task Calcined Solids Storage Facility Closure Study

Sub task Groundwork for Design - CSSF Volume Calculations

TITLE: Calcined Solids Storage Facilities - Volume Calculations

SUMMARY

This Engineering Design File provides volumetric information that is necessary for cost estimating and radiation exposure estimates. For each of the seven Calcined Solids Storage Facilities (CSSFs), the following information was calculated: (1) bin capacity, (2) volume of calcine remaining following CRTP activities, (3) vault void volumes, and (4) equivalent number of filled 55-gallon drums.

The following table provides a summary of the remaining calcine volumes for Risk-Based Clean Closure and Closure to Landfill Standards after all removal activities have been completed.

CSSF	Total Calcine Volume Remaining in Bin Set Following Risk-Based Clean Closure		Total Calcine Volume Remaining in Bin Set Following Closure to Landfill Standards	
	(FT^3)	(M^3)	(FT^3)	(M^3)
1	31.2	(0.9)	70.0	(2.0)
2	88.1	(2.5)	120.8	(3.4)
3	149.4	(4.2)	303.9	(8.6)
4	49.7	(1.4)	67.1	(1.9)
5	106.5	(3.0)	158.2	(4.5)
6	162.9	(4.6)	233.9	(6.6)
7	178.4	(5.0)	233.9	(6.6)
Total	**766.2**	**(21.6)**	**1,187.8**	**(33.6)**

The following pages contain the methodology, assumptions, and results of the calculations. The supporting hand and software calculations are also included in the body of this EDF. See tables provided in the body of this EDF for details of the results.

Distribution: D. J. Harrell, MS 3211; B. R. Helm, MS 3765; B. C. Spaulding, MS 3765; M. M. Dahlmeir, MS 3765; S. P. Swanson, MS 3765; Project File (Original +1)

Authors	Department	Reviewed	Approved
Craig DeCoria Steven Swanson		T. L. Kinnaman	
Craig DeCoria	MC&IE 4130	Date 1/26/98	Date 1/26/98
Steven Swanson	MC&IE 4130		

Introduction

The following information was calculated to support cost estimates and radiation exposure calculations for closure activities at the Calcined Solids Storage Facility (CSSF). Within the estimate, volumes were calculated to determine the required amount of grout to be used during closure activities. The remaining calcine on the bin walls, supports, piping, and floor was also calculated to approximate the remaining residual calcine volumes at different stages of the removal process.

The estimates for remaining calcine and vault void volume are higher than what would actually be experienced in the field, but are necessary for bounding purposes. The residual calcine in the bins may be higher than what is experienced in the field as it was assumed that the entire bin volume is full of calcine before removal activities commence. The vault void volumes are higher as the vault roof beam volumes were neglected.

The estimations that follow should be considered rough order of magnitude, due to the time constraints as dictated by the project's scope of work. Should more accurate numbers be required, a new analysis would be necessary.

Methodology

The volumes of the bin heads (top and bottom domes) were estimated by assuming an ASME flanged and dished shape geometry for CSSFs 2-5, while an ellipsoidal geometry was assumed for the sixth and seventh bin sets. Volumes and surface areas for the heads were retrieved from pre-calculated volumes in reference 1. The cylindrical volume of the bin was then calculated and added to the head volumes. For CSSFs 5-7, an annular volume was subtracted. The total volume was then calculated for the entire bin set.

Based on a report concerning retrieval testing performed on CSSF 1 (Reference 3), it was assumed that 95% of the total bin volume would be removed during the Calcined Retrieval and Transport Project (CRTP) activities. Additional calcine was then added onto the walls, supports, internal piping, and external piping.

Calcine was assumed to remain on the internal bin supports and piping after the CRTP performed their removal activities. A 45° accumulation slope was assumed for these fixtures. The calcine film on the bin walls was assumed to be two particles thick with an average particle size of .4mm for CSSF 1 and .5mm for CSSFs 2 through 7 (See EDF-BSC-002 for particle size information).

99% of the calcine in the distributor and external piping was assumed to be removed during CRTP activities (1% remaining on the walls, expansion joints, etc.). Of the remaining calcine in the distributor and external piping, 95% was assumed to be removed by a pipe crawler robot during final removal activities – 90% of which falls to the bin floor, and 10% of which attaches to the bin walls.

80% of the calcine on the bin walls (calcine deposited during CRTP activities and during final removal activities), supports, and internal piping was assumed to be removed by carbon dioxide blasting and falls to the bin floor.

During the last step of the final removal activities, it was assumed that 95% of the calcine at the bottom of the bin could be removed by a robot and vacuum. See page 6 for a review of the assumptions.

Hand calculations were performed to gather initial data (See the attached sheets). Excel software was then used to manipulate the information done by hand. See the Excel printout for the results of all the calculations.

Results

Calculations indicate that out of the initial 255,984 cubic feet of calcine at the CSSF area, approximately 13,345 cubic feet of calcine will remain after the Calcine Retrieval and Transport Project (CRTP) performs its activities. At closure (after Bin Set Closure Project activities), approximately 766 cubic feet of calcine are estimated to remain for Risk-Based Clean Closure and 1,188 cubic feet for Closure to Landfill Standards. This is an additional reduction of over 12,579 cubic feet of calcine (1,711 55-gallon drums) for Risk-Based Clean Closure and 12,157 cubic feet (1,653 55-gallon drums) for Closure to Landfill Standards. Thus, approximately 94.7% of the initial calcine is estimated to be removed from the bins during CRTP activities, while an additional 5.0% is estimated to be removed by the BSCP removal activities during Risk-Based Clean Closure (4.7% is estimated for Closure to Landfill Standards).

The volume of grout necessary for grouting the piping entering the bins has also been calculated and is estimated at 686 cubic feet per bin set. The estimated height of the calcine in the bottom of a bin after initial removal is estimated at 2 feet.

The following tables summarize information that was estimated by hand and software calculations. See the attached copy of the Excel output for the results.

Risk-based Closure

Table 1. Remaining Calcine Volumes (Risk-based Clean Closure)

CSSF	Total Calcine Volume Remaining in Bin Set Following Risk-based Clean Closure FT^3	Total Calcine Volume Remaining in Bin Set Following Risk-Based Clean Closure (M^3)
1	31.2	0.9
2	88.1	2.5
3	149.4	4.2
4	49.7	1.4
5	106.5	3.0
6	162.9	4.6
7	178.4	5.0

Table 2. Summary of Calcine Volume at Various Stages in the Removal Process (Risk-based Clean Closure)

CSSF Bin Set #	Initial Calcine Volume[1][A] FT^3 (M^3)	Calcine Volume After CRTP Removal[B] FT^3 (M^3)	Calcine Volume After Bin Set Closure FT^3 (M^3)	Percent Calcine Removed - by CRTP %	Total Percent Calcine Removed (CRTP+BSCP) %
1	7,848 (222)	443 (13)	31 (1)	94.4	99.6
2	31,550 (893)	1,619 (46)	88 (3)	94.9	99.7
3	40,694 (1,152)	2,237 (63)	149 (4)	94.5	99.6
4	17,898 (506)	917 (26)	50 (1)	94.9	99.7
5	36,552 (1,035)	1,894 (54)	106 (3)	94.8	99.7
6	56,657 (1,604)	2,925 (83)	163 (5)	94.8	99.7
7	64,786 (1,835)	3,311 (94)	178 (5)	94.9	99.7

Table 3. Calcine Volumes Remaining on Bin Surfaces Following BSCP Closure Activities (Risk-based Closure)

CSSF	Calcine Left on Bin Walls FT^3 (M^3)	Calcine Left on Supports FT^3 (M^3)	Calcine Left on Piping FT^3 (M^3)	Calcine Left on External Piping FT^3 (M^3)	Calcine on Floor FT^3 (M^3)
1	.9 (.0)	8.5 (.2)	0 (0)	.2 (0)	21.6 (.6)
2	6.9 (.2)	0.2 (.0)	0 (0)	.3 (0)	80.6 (2.3)
3	8.9 (.3)	30.3 (.9)	0 (0)	.3 (0)	109.8 (3.1)
4	3.9 (.1)	0 (0)	0 (0)	.1 (0)	45.7 (1.3)
5	12.1 (.3)	0 (0)	0 (0)	.3 (0)	94.1 (2.7)
6	17.2 (.5)	0 (0)	0 (0)	.3 (0)	145.4 (4.1)
7	13.1 (.4)	0 (0)	0 (0)	.3 (0)	164.9 (4.7)

Table 4. Calcine Volumes Removed During CRTP and BSCP Activities (Risk-based Closure)

CSSF	Total Volume Removed by CRTP FT^3 (M^3)	Total Volume Removed During BSCP Activities FT^3 (M^3)	Total Volume Removed by CRTP+BSCP FT^3 (M^3)
1	7,406 (210)	411 (21)	7,817 (221)
2	29,931 (848)	1,531 (43)	31,462 (891)
3	38,457 (1089)	2 ,087 (59)	40,544 (1148)
4	16,981 (481)	868 (25)	17,849 (506)
5	34,658 (981)	1,787 (51)	36,445 (1032)
6	53,732 (1522)	2 ,762 (78)	56,494 (1600)
7	61,475 (1741)	3,312 (88)	64,607 (1829)

---

[1]

[A] Volume of calcine currently in each bin set. It is assumed for bounding purposes that the bins are filled to maximum capacity.

[B] The Calcine Retrieval and Transportation Project will remove approximately 95% of the original calcine volume (EDF-BSC-005)

Table 5. Summary of Grout Estimates

CSSF	Volume of Clean Grout Necessary to Fill Vault FT^3 (M^3)	Volume of Grout Necessary to Fill Piping and Distributor[E] FT^3 (M^3)
1	17,025 (482)	686 (19)
2	75,513 (2138)	686 (19)
3	75,294 (2132)	686 (19)
4	49,617 (1405)	686 (19)
5	96,187 (2724)	686 (19)
6	134,824 (3818)	686 (19)
7	126,695 (3588)	686 (19)

Closure to Landfill Standards

Table 6. Remaining Calcine Volumes (Closure to Landfill Standards)

CSSF	Total Calcine Volume Remaining in Bin Set Following Closure to Landfill Standards (FT^3)	Total Calcine Volume Remaining in Bin Set Following Closure to Landfill Standards (M^3)
1	69.9	2.0
2	120.8	3.4
3	303.9	8.6
4	67.1	1.9
5	158.2	4.5
6	233.9	6.6
7	233.9	6.6

Table 7. Summary of Calcine Volume at Various Stages in the Removal Process (Closure to Landfill Standards)

CSSF Bin Set #	Initial Calcine Volume[C] FT^3 (M^3)	Calcine Volume After CRTP Removal[D] FT^3 (M^3)	Calcine Volume After Bin Set Closure FT^3 (M^3)	Percent Calcine Removed - by CRTP %	Total Percent Calcine Removed (CRTP+BSCP) %
1	7,848 (222)	443 (13)	70 (2)	94.4	99.1
2	31,550 (893)	1,619 (46)	121 (3.4)	94.9	99.6
3	40,694 (1,152)	2,237 (63)	304 (8.6)	94.5	99.3
4	17,898 (506)	917 (26)	67 (1.9)	94.9	99.6
5	36,552 (1,035)	1,894 (54)	158 (4.5)	94.8	99.6
6	56,657 (1,604)	2,925 (83)	234 (6.6)	94.8	99.6
7	64,786 (1,835)	3,311 (94)	234 (6.6)	94.9	99.6

[E] Average volume was applied for all seven storage facilities.

[C] Volume of calcine currently in each bin set. It is assumed for bounding purposes that the bins are filled to maximum capacity.

[D] The Calcine Retrieval and Transportation Project will remove approximately 95% of the original calcine volume (EDF-BSC-005)

Table 8. Calcine Volumes Remaining on Bin Surfaces Following BSCP Closure Activities (Closure to Landfill Standards)

CSSF	Calcine Left on Bin Walls FT^3 (M^3)	Calcine Left on Supports FT^3 (M^3)	Calcine Left on Piping FT^3 (M^3)	Calcine Left on External Piping FT^3 (M^3)	Calcine on Floor FT^3 (M^3)
1	4.0 (0.1)	42.4 (1.2)	0 (0)	3.9 (.1)	19.6 (.6)
2	33.9 (2.0)	1.0 (0.0)	.2 (0)	6.9 (.2)	78.9 (2.2)
3	43.9 (1.2)	151.5 (4.3)	0 (0)	6.9 (.2)	101.7 (2.9)
4	19.4 (0.5)	0 (0)	0 (0)	2.9 (.1)	44.7 (1.3)
5	60.0 (1.7)	0 (0)	0 (0)	6.9 (.2)	91.4 (2.6)
6	85.4 (2.4)	0 (0)	0 (0)	6.9 (.2)	141.6 (4.0)
7	65.1 (1.8)	0 (0)	0 (0)	6.9 (.2)	162.0 (4.6)

Table 9. Calcine Volumes Removed during CRTP and BSCP Activities (Closure to Landfill)

CSSF	Total Volume Removed by CRTP FT^3 (M^3)	Total Volume Removed During BSCP Activities FT^3 (M^3)	Total Volume Removed by CRTP+BSCP FT^3 (M^3)
1	7,406 (210)	372 (10)	7,778 (220)
2	29,931 (848)	1,498 (42)	31,429 (890)
3	38,457 (1089)	1,933 (55)	40,390 (1144)
4	16,981 (481)	850 (24)	17,831 (505)
5	34,658 (981)	1,736 (50)	36,393 (1031)
6	53,732 (1522)	2,691 (76)	56,423 (1598)
7	61,475 (1741)	3,077 (87)	64,552 (1828)

Table 10. Summary of Grout Estimates (Duplicate of Risk-based)

CSSF	Volume of Clean Grout Necessary to Fill Vault FT^3 (M^3)	Volume of Grout Necessary to Fill Piping and Distributor^E FT^3 (M^3)
1	17,025 (482)	686 (19)
2	75,513 (2138)	686 (19)
3	75,294 (2132)	686 (19)
4	49,617 (1405)	686 (19)
5	96,187 (2724)	686 (19)
6	134,824 (3818)	686 (19)
7	126,695 (3588)	686 (19)

Miscellaneous

Additional information has been provided at the end of this EDF. This information does not have a reference (gathered from Dan Staiger of LMITCO) and has not been reviewed for accuracy. The information in these pages does relate to the volume calculations for the bin sets and is included to provide a more detailed summary of the work performed. This information may be useful should additional volume calculations be required.

References

1 Megyesy, E. F. Pressure Vessel Handbook Tenth Edition. Pressure Vessel Publishing, Inc. July 1, 1995.
2 Information provided by Dan Staiger. See pages 35 through 56 of this EDF.
3 Griffith, D. L. "Status of Calcine Retrieval Development Work – DLG-06096" September 26, 1996.

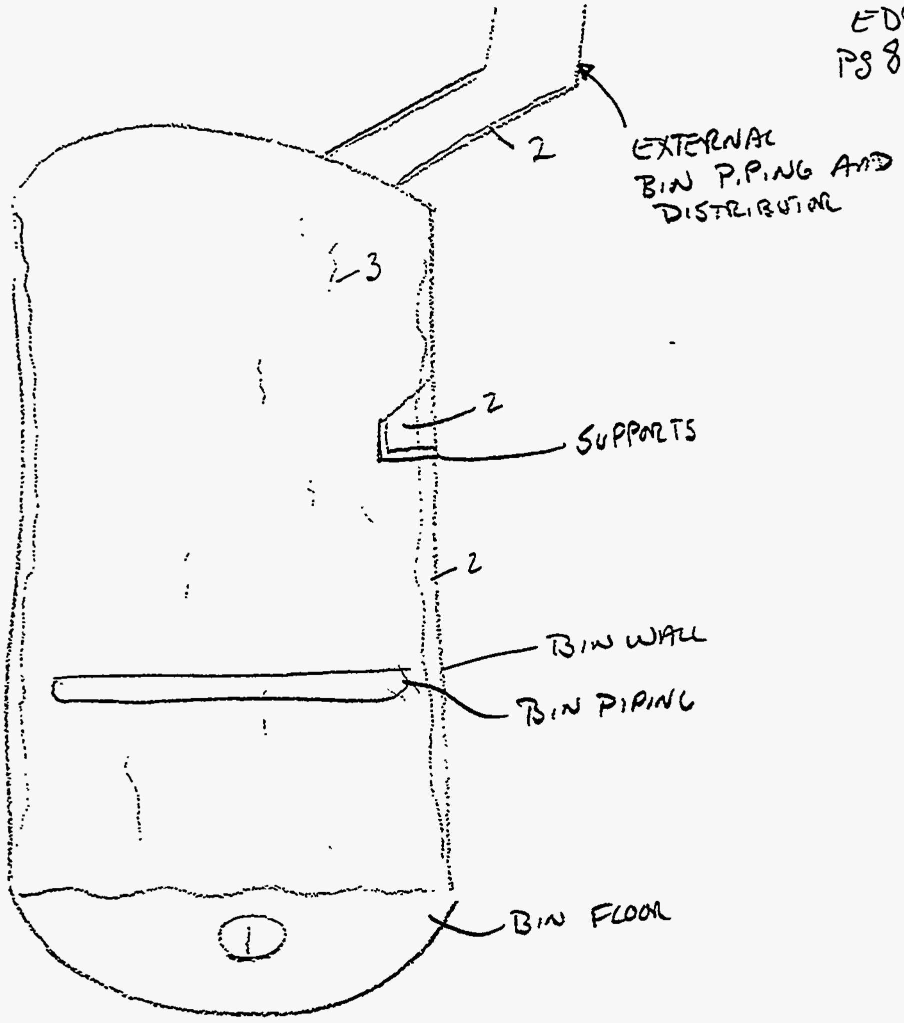
Attached Information

The following information is provided on the indicated pages.

Pg. 8	Summary of Assumptions
Pg.9	Intentionally left blank
Pg. 10a-10h	Excel Printout of Results
Pg. 11-16	First CSSF Bin Calculations
Pg. 17	Second CSSF Bin Calculations
Pg. 18	Third CSSF Bin Calculations
Pg. 19	Fourth CSSF Bin Calculations
Pg. 20	Fifth CSSF Bin Calculations
Pg. 21	Sixth CSSF Bin Calculations
Pg. 22	Seventh CSSF Bin Calculations
Pg. 23	Methodology for Estimating Calcine on Pipes (2 inch pipes)
Pg. 24	Methodology for Estimating Calcine on Pipes (.5 inch pipes)

VAULTS

Pg. 25	First CSSF Vault Void Calculations
Pg. 26	Second CSSF Vault Void Calculations
Pg. 27	Third CSSF Vault Void Calculations
Pg. 28	Fourth CSSF Vault Void Calculations
Pg. 29	Fifth CSSF Vault Void Calculations
Pg. 30	Sixth CSSF Vault Void Calculations
Pg. 31	Seventh CSSF Vault Void Calculations
Pg. 32	Grout and Calcine in the External Bin Piping
Pg. 33-34	Methodology for Estimating the Height of Calcine at the Bottom of the Bin
Pg. 35-56	Information from Dan Staiger



STEP 1 - CRTP REMOVAL

· 95% of Bin Volume Removed -> leaves 5% on floor

STEP 2 - Add calcine on walls, supports, internal piping, & external piping
Bin Wall thickness (.8mm CSSF1
1 mm CSSF 2-7)
SUPPORTS + PIPING - ASSUMED 45° slope accumulation
EXTERNAL PIPING - ASSUMED 1% of volume is remaining calcine

STEP 3 - FINAL REMOVAL

-> CLEAN OUT EXTERNAL PIPING
Assumed 95% of remaining calcine removed
-> 90% of which falls to the bin floor
10% of which sticks to the bin walls

STEP 4 - FINAL REMOVAL

-> CLEAN OFF BIN WALLS, SUPPORTS, & INTERNAL PIPING
Assumed 80% falls to floor and 20% is fixed contamination

STEP 5 - FINAL REMOVAL

-> CLEAN FLOOR
Assumed 95% of calcine on floor is removed by robot.

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This is an Excel printout of data manipulation that was accomplished using the information provided by hand calculations.
The first columns of information are in cubic feet, while the second column is in cubic meters.

Risk Based Closure - Includes the cleaning of the bin walls, supports, internal and external piping, and floor.

INITIAL CONDITIONS FOR THE BIN SETS

CSSF	NUMBER OF BINS PER BIN SET	TOTAL BIN SET VOLUME (CU.FT)	TOTAL BIN SET VOLUME (CU.M.)	TOTAL STARTING CALCINE VOLUME (CU.FT)
1	4	7844	222.1169792	7848.355551
2	7	31,542	893.1685056	31549.62221
3	7	40,686	1152.097325	40693.62221
4	3	17,895	506.729136	17898.26666
5	7	36,544	1034.809139	36551.62221
6	7	56649	1604.118403	56656.62221
7	7	64778	1834.30567	64785.62221
		SUM OF TOTAL BIN VOLUME	SUM OF TOTAL BIN VOLUME	SUM OF TOTAL BIN VOLUME
		255938	7247.345158	255983.7333

CONDITIONS AFTER CALCINED RETRIEVAL AND TRANSPORTATION PROJECT ACTIVITIES
(INITIAL CSSF CLOSURE PROJECT CONDITIONS)

CSSF	CALCINE LEFT ON FLOOR (CU.FT)	CALCINE LEFT ON FLOOR (CU.M)	CALCINE LEFT ON WALLS (CU.FT)	CALCINE LEFT ON WALLS (CU.M)
1	392.2	11.10584896	4.01	0.113550368
2	1577.1	44.65842528	33.88	0.959373184
3	2034.3	57.60486624	43.88	1.242541184
4	894.75	25.3364568	19.4	0.54934592
5	1827.2	51.74045696	59.96	1.698441664
6	2832.45	80.20592016	85.4	2.41825472
7	3238.9	91.71528352	65.1	1.84342368
	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
	12796.9	362.3672579	311.65	8.82493072

CONDITIONS AT CLOSURE (AFTER CSSF CLOSURE ACTIVITIES)

CSSF	CALCINE LEFT ON FLOOR (CU.FT)	CALCINE LEFT ON FLOOR (CU.M)	CALCINE LEFT ON WALLS (CU.FT)	CALCINE LEFT ON WALLS (CU.M)
1	21.648876	0.613026892	0.87648	0.024819109
2	80.578533	2.281726203	6.90634	0.195565449
3	109.848653	3.110562337	8.90634	0.252199049
4	45.650357	1.292672029	3.93586	0.11145096
5	94.078533	2.664003003	12.12634	0.343379145
6	145.357833	4.116068685	17.21034	0.487341756
7	164.868333	4.668543612	13.15034	0.372375548
	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
	662.031118	18.74660276	63.11204	1.787131014

EDF-BSC-001
Pg 10a

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TOTAL STARTING CALCINE VOLUME (CU.M)
222.2403145
893.3843423
1152.313162
506.8216375
1035.024976
1604.33424
1834.521507
SUM OF TOTAL BIN VOLUME
7246.640179

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CALCINE LEFT ON SUPPORTS (CU.FT)	CALCINE LEFT ON SUPPORTS (CU.M)	CALCINE LEFT ON PIPES (CU.FT)	CALCINE LEFT ON PIPES (CU.M)
42.4	1.20063232	0	0
1.05	0.02973264	0.175	0.00495544
151.45	4.28857936	0.028	0.00079287
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
194.9	5.51894432	0.203	0.00574831

……

CALCINE LEFT ON SUPPORTS (CU.FT)	CALCINE LEFT ON SUPPORTS (CU.M)	CALCINE LEFT ON PIPES (CU.FT)	CALCINE LEFT ON PIPES (CU.M)
8.48	0.240128464	0	0
0.21	0.005946528	0.035	0.000991088
30.29	0.857715872	0.0056	0.000158574
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
38.98	1.103788864	0.0406	0.001149862

……

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CALCINE LEFT IN EXTERNAL PIPING (CU.FT)	CALCINE LEFT IN EXTERNAL PIPING (CU.M)	TOTAL CALCINE LEFT IN THE BIN SET (CU.FT)	TOTAL CALCINE LEFT IN THE BIN SET (CU.M)
3.92	0.111001858	442.53	12.5310335
6.86	0.194253248	1619.065	45.84673979
6.86	0.194253248	2236.518	63.3310329
2.94	0.083251392	917.09	25.96905411
6.86	0.194253248	1894.04	53.63315187
6.86	0.194253248	2924.71	82.81842813
6.86	0.194253248	3310.86	93.75296045
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
41.16	1.165519488	13344.813	377.8824008

……

CALCINE LEFT IN EXTERNAL PIPING (CU.FT)	CALCINE LEFT IN EXTERNAL PIPING (CU.M)	TOTAL CALCINE LEFT IN THE BIN SET (CU.FT)	TOTAL CALCINE LEFT IN THE BIN SET (CU.M)
0.196	0.005550093	31.201356	0.883522558
0.343	0.009712662	88.072873	2.49394193
0.343	0.009712662	149.393593	4.230348494
0.147	0.00416257	49.733217	1.408285559
0.343	0.009712662	106.547873	3.01709481
0.343	0.009712662	162.911173	4.613123104
0.343	0.009712662	178.361673	5.050631822
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
2.058	0.058275974	766.221758	21.69694828

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EQUIVALENT NUMBER OF 55-GALLON DRUMS	TOTAL PERCENTAGE REMOVED %	TOTAL CALCINE REMOVED (CU.FT)	TOTAL CALCINE REMOVED (CU.M)
60.18408	94.36149398	7405.825551	209.709281
220.19284	94.86819529	29930.55721	847.5376025
304.166448	94.50400854	38457.10421	1088.982129
124.72424	94.87609601	16981.17666	480.8525833
257.58944	94.818178	34657.58221	981.3918241
397.76056	94.83783204	53731.91221	1521.515812
450.27696	94.88951424	61474.76221	1740.768547
SUM OF CALCINE IN ALL CSSF	AVERAGE REMOVAL	AVERAGE REMOVAL	AVERAGE REMOVAL
1814.894568	94.73647401	34662.7029	981.5368254

……

EQUIVALENT NUMBER OF 55-GALLON DRUMS	TOTAL PERCENTAGE REMOVED %	TOTAL CALCINE REMOVED (CU.FT)	TOTAL CALCINE REMOVED (CU.M)
4.243384416	99.60244722	7817.154195	221.3567919
11.97791073	99.72084334	31461.54934	890.8904004
20.31752865	99.63288205	40544.22862	1148.082813
6.763717512	99.72213389	17848.53345	505.4133519
14.49051073	99.70850029	36445.07434	1032.007881
22.15591953	99.71245873	56493.71104	1599.721117
24.25718753	99.72468942	64607.26054	1829.470875
SUM OF CALCINE IN ALL CSSF	AVERAGE REMOVAL	AVERAGE REMOVAL	AVERAGE REMOVAL
104.2061591	99.68913642	36459.6445	1032.420461

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Landfill Calculations - Assumes only floor is cleaned (95% removal).
Does not include cleaning the bin walls, supports, or internal and external piping.

INITIAL CONDITIONS FOR THE BIN SETS

CSSF	NUMBER OF BINS PER BIN SET	TOTAL BIN SET VOLUME (CU.FT)	TOTAL BIN SET VOLUME (CU.M.)	TOTAL STARTING CALCINE VOLUME (CU.FT)
1	4	7844	222.1169792	7848.355551
2	7	31,542	893.1685056	31549.62221
3	7	40,686	1152.097325	40693.62221
4	3	17,695	506.729136	17698.26666
5	7	36,544	1034.809139	36551.62221
6	7	56649	1604.118403	56656.62221
7	7	64778	1834.30567	64785.62221
		SUM OF TOTAL BIN VOLUME	SUM OF TOTAL BIN VOLUME	SUM OF TOTAL BIN VOLUME
		255938	7247.345158	255983.7333

CONDITIONS AFTER CALCINED RETRIEVAL AND TRANSPORTATION PROJECT ACTIVITIES
(INITIAL CONDITIONS FOR CSSF CLOSURE PROJECT)

CSSF	CALCINE LEFT ON FLOOR (CU.FT)	CALCINE LEFT ON FLOOR (CU.M)	CALCINE LEFT ON WALLS (CU.FT)	CALCINE LEFT ON WALLS (CU.M)
1	392.2	11.10584896	4.01	0.113550368
2	1577.1	44.65842528	33.88	0.959373184
3	2034.3	57.60486624	43.88	1.242541184
4	894.75	25.3364568	19.4	0.54934592
5	1827.2	51.74045696	59.98	1.698441664
6	2832.45	80.20592016	85.4	2.41825472
7	3238.9	91.71528352	65.1	1.84342368
	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
	12796.9	362.3672579	311.65	8.82493072

CONDITIONS AT CLOSURE (AFTER CSSF CLOSURE ACTIVITIES)

CSSF	CALCINE LEFT ON FLOOR (CU.FT)	CALCINE LEFT ON FLOOR (CU.M)	CALCINE LEFT ON WALLS (CU.FT)	CALCINE LEFT ON WALLS (CU.M)
1	19.61	0.555292448	4.01	0.113550368
2	78.855	2.232921264	33.88	0.959373184
3	101.715	2.880243312	43.88	1.242541184
4	44.7375	1.26682284	19.4	0.54934592
5	91.36	2.587022848	59.98	1.698441664
6	141.6225	4.010296008	85.4	2.41825472
7	161.945	4.585764176	65.1	1.84342368
	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
	639.845	18.1183629	311.65	8.82493072

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TOTAL STARTING CALCINE VOLUME (CU.M)
222.2403145
893.3843423
1152.313162
506.8216375
1035.024976
1604.33424
1834.521507
SUM OF TOTAL BIN VOLUME
7248.640179

……

CALCINE LEFT ON SUPPORTS (CU.FT)	CALCINE LEFT ON SUPPORTS (CU.M)	CALCINE LEFT ON PIPES (CU.FT)	CALCINE LEFT ON PIPES (CU.M)
42.4	1.20063232	0	0
1.05	0.02973264	0.175	0.00495544
151.45	4.28857936	0.028	0.00079287
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
194.9	5.51894432	0.203	0.00574831

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CALCINE LEFT ON SUPPORTS (CU.FT)	CALCINE LEFT ON SUPPORTS (CU.M)	CALCINE LEFT ON PIPES (CU.FT)	CALCINE LEFT ON PIPES (CU.M)
42.4	1.20063232	0	0
1.05	0.02973264	0.175	0.00495544
151.45	4.28857936	0.028	0.00079287
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
194.9	5.51894432	0.203	0.00574831

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CALCINE LEFT IN EXTERNAL PIPING (CU.FT)	CALCINE LEFT IN EXTERNAL PIPING (CU.M)	TOTAL CALCINE LEFT IN THE BIN SET (CU.FT)	TOTAL CALCINE LEFT IN THE BIN SET (CU.M)
3.92	0.111001856	442.53	12.5310335
6.86	0.194253248	1619.065	45.84673979
6.86	0.194253248	2236.518	63.3310329
2.94	0.083251392	917.09	25.96905411
6.86	0.194253248	1894.04	53.63315187
6.86	0.194253248	2924.71	82.81842813
6.86	0.194253248	3310.86	93.75296045
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
41.16	1.165519488	13344.813	377.8824008

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CALCINE LEFT IN EXTERNAL PIPING (CU.FT)	CALCINE LEFT IN EXTERNAL PIPING (CU.M)	TOTAL CALCINE LEFT IN THE BIN SET (CU.FT)	TOTAL CALCINE LEFT IN THE BIN SET (CU.M)
3.92	0.111001856	69.94	1.980476992
6.86	0.194253248	120.82	3.421235776
6.86	0.194253248	303.933	8.606409974
2.94	0.083251392	67.0775	1.899420152
6.86	0.194253248	158.2	4.47971776
6.86	0.194253248	233.8825	6.622803976
6.86	0.194253248	233.905	6.623441104
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
41.16	1.165519488	1187.758	33.63350573

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EQUIVALENT NUMBER OF 55-GALLON DRUMS	TOTAL PERCENTAGE REMOVED %	TOTAL CALCINE REMOVED (CU.FT)	TOTAL CALCINE REMOVED (CU.M)
60.18408	94.36149398	7405.825551	209.709281
220.19284	94.86819529	29930.55721	847.5376025
304.166448	94.50400854	38457.10421	1088.982129
124.72424	94.87609601	16981.17666	480.8525833
257.58944	94.818178	34657.58221	981.3918241
397.76056	94.83783204	53731.91221	1521.515812
450.27696	94.88951424	61474.76221	1740.768547
SUM OF CALCINE IN ALL CSSF	AVERAGE REMOVAL	AVERAGE REMOVAL	AVERAGE REMOVAL
1814.894568	94.73647401	34662.7029	981.5368254

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EQUIVALENT NUMBER OF 55-GALLON DRUMS	TOTAL PERCENTAGE REMOVED %	TOTAL CALCINE REMOVED (CU.FT)	TOTAL CALCINE REMOVED (CU.M)
9.51184	99.10885791	7778.415551	220.2598375
16.43152	99.61704771	31428.80221	889.9631066
41.334688	99.25311883	40389.68921	1143.706752
9.12254	99.62522907	17831.18916	504.9222173
21.5152	99.56718747	36393.42221	1030.545258
31.80802	99.587193	56422.73971	1597.711436
31.81108	99.63895539	64551.71721	1827.898066
SUM OF CALCINE IN ALL CSSF	AVERAGE REMOVAL	AVERAGE REMOVAL	AVERAGE REMOVAL
161.535088	99.48536991	36399.42504	1030.715239

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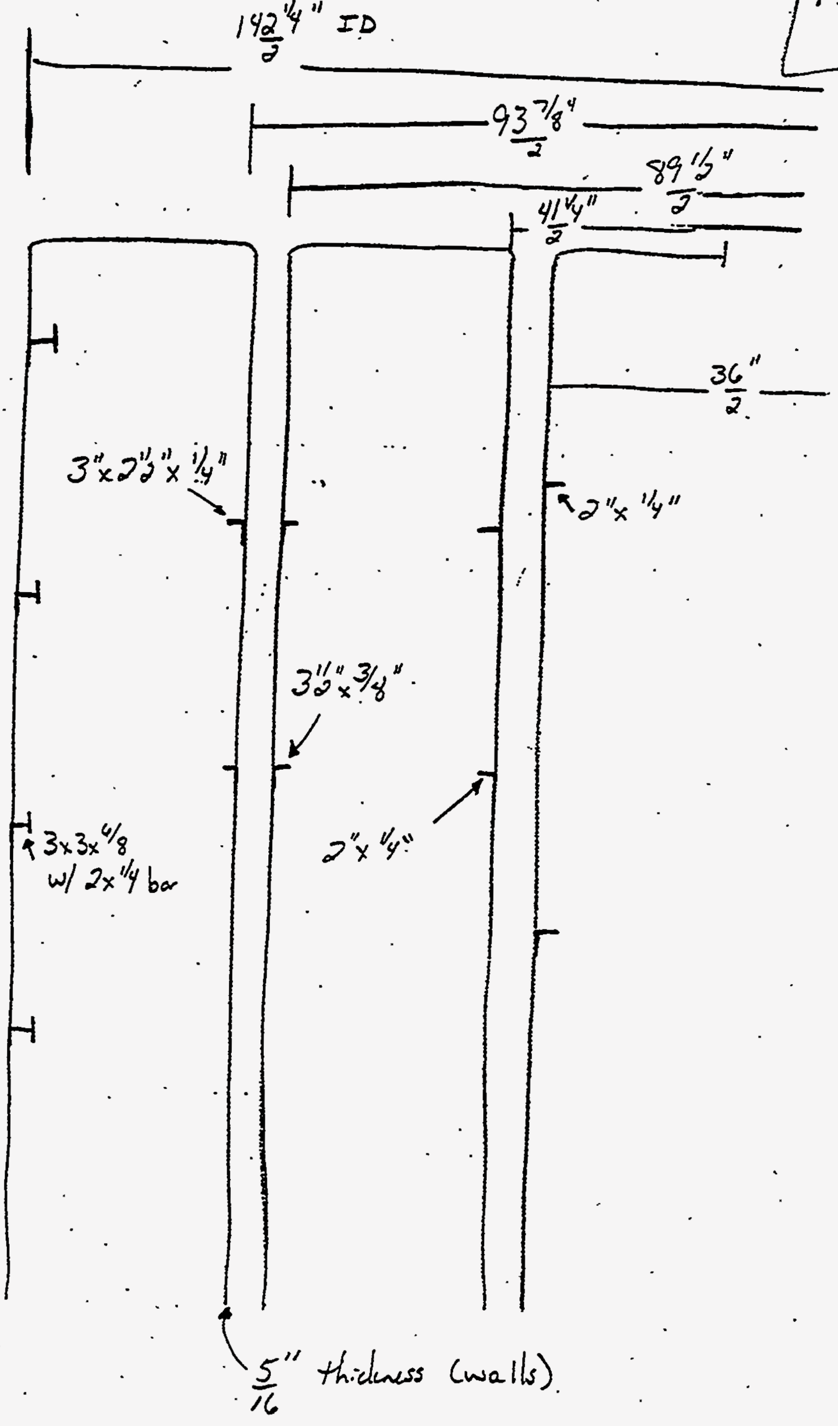
Amount of Remaining Calcine Due to Stiffners

ALL Dimensions
From DWG # 106577



This sketch shows the vessel radii and angle (stiffner) dimensions.

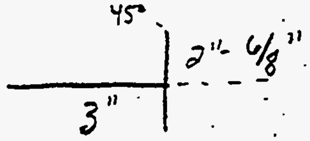
Reference 1

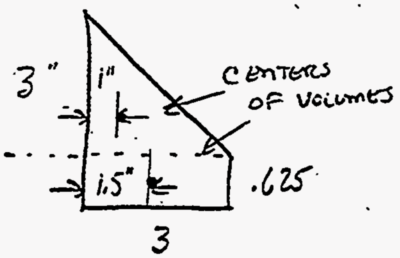
Stewart, James, Calculus. Second Edition. James Stewart. 1991
Brooks/Cole Publishing Company Pg. 505

Reference 2

Meriam, J.L. Engineering Mechanics - Statics and Dynamics.
John Wiley & Sons. 1978 Pg. 526

ASSUMING THE FOLLOWING DIMENSIONS (45° slope of calcine on top of stiffners)





USING THEORUM OF Poppus (8.38) pg 505 [Reference #1]

ESTIMATING VOLUME OF CALCINE ON THE STIFFNERS

$V = 2\pi r^{*}A$ where r^{*} is radius to center of volume (mass) [revolving an area around an axis]

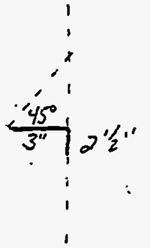
CENTER OF VOLUME FOR A TRIANGLE => $\frac{1}{3}b$

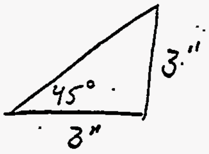
$V_1 = 2\pi[\frac{142.25}{2} - 1.5][(3)(.625)] = 819.834$ in^3 [Volume of square]

$V_2 = 2\pi[\frac{142.25}{2} - 1][\frac{1}{2}(3)(3)] = 1981.733$ in^3 [Volume of triangle]

V_{TOTAL} for each channel = 2801.6 in^3 = 1.621 ft^3 [Total volume on each channel -(square + triangle)]

There are 4 in the outer vessel". Thus $4(1.621\ ft^3) = \boxed{6.484\ ft^3}$





$A = \frac{1}{2}bh = \frac{1}{2}(3")(3")$

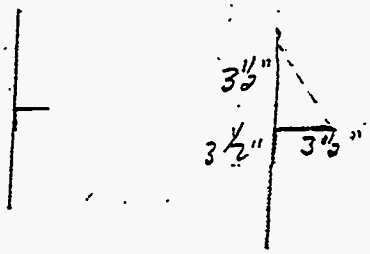
$A = 4.5$ in^2

Assuming 5/16" vessel thickness

$V = 2\pi r^{*}A$ Radius of bin bin thickness to center of mass

$V = 2\pi(\frac{93\,7/8"}{2} + 5/16" + 1")[4.5\ in^2] = 1,363.54\ in^3 = .789\ ft^3$

There are 2 vacuum stiffners => $(2)(.789\ ft^3) = \boxed{1.578\ ft^3}$

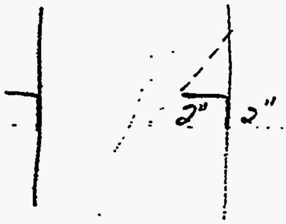


$$A = \frac{1}{2}bh = \frac{1}{2}(3\tfrac{1}{2}")^2 = 6.125\text{ in}^2$$

$$V = 2\pi r^{*}A$$

$$V = 2\pi\left[\frac{89\tfrac{1}{2}"}{2} - \frac{1}{3}(3\tfrac{1}{2}")\right]\left[6.125\text{ in}^2\right] = 1{,}676.43\text{ in}^3 = .970\text{ ft}^3$$

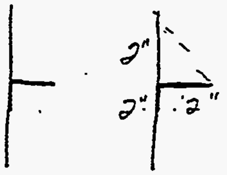
there are 2 stiffners in the middle "vessel" ⇒ $2(.97\text{ ft}^3) = \boxed{1.94\text{ ft}^3}$



$$A = \frac{1}{2}bh = \frac{1}{2}(2")(2") = 2\text{ in}^2$$

$$V = 2\pi r^{*}A = 2\pi\left[\frac{41\tfrac{1}{4}"}{2} + \tfrac{5}{16}" + \frac{1}{3}(2")\right]\left[2\text{ in}^2\right] = 271.348\text{ in}^3 \; .157\text{ ft}^3$$

There are 2 stiffners in the middle bin ⇒ $2(.157\text{ ft}^3) = \boxed{.314\text{ ft}^3}$



$$A = \frac{1}{2}bh = \frac{1}{2}(2")(2") = 2\text{ in}^2$$

$$V = 2\pi r^{*}A$$

$$V = 2\pi\left(\frac{36"}{2} - \frac{1}{3}(2")\right)\left[2\text{ in}^2\right] = 217.706\text{ in}^3 = .126\text{ ft}^3$$

Then are 2 stiffners in the center "vessel" ⇒ $2(.126) = \boxed{.25\text{ ft}^3}$

Total volume due to stiffners in Bin Set #1 [per bin] is equal to
$(6.484\text{ ft}^3) + (1.578\text{ ft}^3) + (1.94\text{ ft}^3) + (.314\text{ ft}^3) + (.25\text{ ft}^3) = \boxed{10.566\text{ ft}^3}$

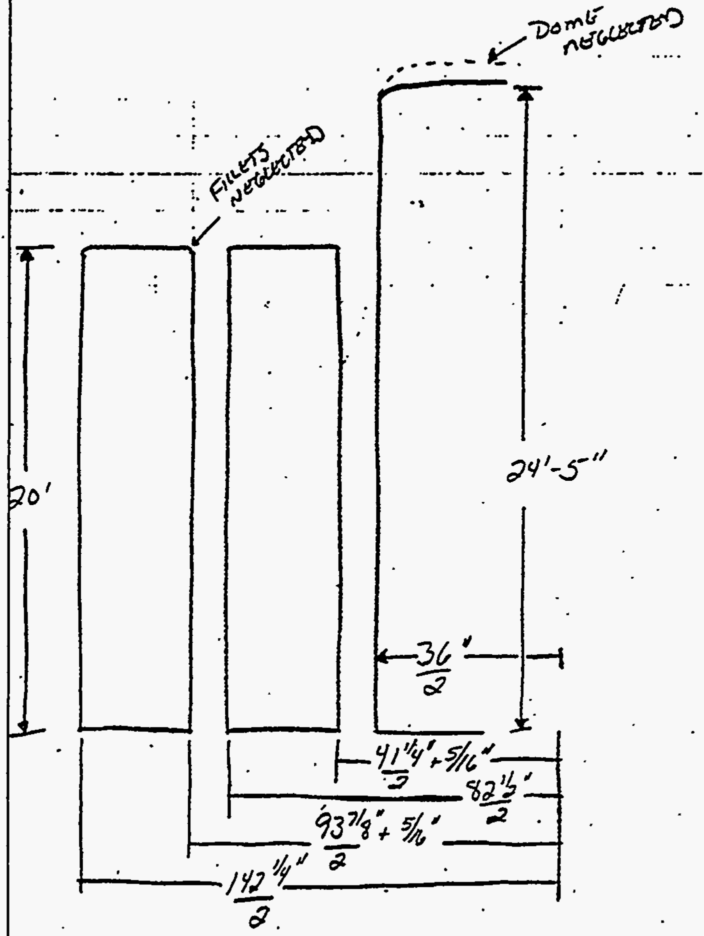
Total volume for all four bins ⇒ $4(10.566\text{ ft}^3] = \boxed{42.264\text{ ft}^3}$

Amount of Remaining Calcine Due to Wall Film and Residuals on Floor.

Volume of Bins: Assuming the following "usable" volume - the bins will not be completely full.

This sketch shows 50% of the side view for Bin Set #1.

Assuming 5/16" wall thickness



Surface Area of 1 Bin in Bin Set #1 (walls)

where $h = 26'$ [for outer + middle bin]
$h = 24'\text{-}5''$ [for center bin]

$A_w = 2\pi(r_o + r_i)h$

$A_{w_1} = 2\pi\left[\left(\frac{142\frac{1}{4}''}{2}\right) + \left(\frac{93\frac{7}{8}''}{2} + \frac{5}{16}''\right)\right]\left[20' \cdot 12''\right] = 178{,}414.8 \text{ in}^2 = 103.25 \text{ ft}^2$ [outer bin]

$A_{w_2} = 2\pi\left[\left(\frac{82\frac{1}{2}''}{2}\right) + \left(\frac{41\frac{1}{4}''}{2} + \frac{5}{16}''\right)\right]\left[20' \cdot 12''\right] = 93{,}729 \text{ in}^2 = 54.24 \text{ ft}^2$ [middle bin]

$A_{w_3} = 2\pi\left[36''\right]\left[24'\text{-}5'' \cdot 12''\right] = 66{,}241.44 \text{ in}^2 = 38.33 \text{ ft}^2$ [center bin]

Surface Area of the ceilings

$A_c = \pi(r_o^2 - r_i^2)$

$A_{c_1} = \pi\left[\left(\frac{142\frac{1}{4}''}{2}\right)^2 - \left(\frac{93\frac{7}{8}''}{2} + \frac{5}{16}''\right)^2\right] = 8{,}874.277 \text{ in}^2 = 61.63 \text{ ft}^2$ [outer bin]

$A_{c_2} = \pi\left[\left(\frac{82\frac{1}{2}''}{2}\right)^2 - \left(\frac{41\frac{1}{4}''}{2} + \frac{5}{16}''\right)^2\right] = 3966.396 \text{ in}^2 = 27.54 \text{ ft}^2$ [middle bin]

$A_{c_3} = \pi\left[\frac{36''}{2}\right]^2 = 1017.36 \text{ in}^2 = 7.1 \text{ ft}^2$ [center bin]

Volume of the "Vessels" and Volume w/ 5% Calcine Remaining

$V_{BINS} = \pi(r_o^2 - r_i^2)h$

where $h_1 = 20'$ [two outer vessels]
$h_2 = 24'\text{-}5''$ [center bin]

Using calculations from previous section

$V_{BINS_1} = A_{c_1} h_1 = (61.63 \text{ ft}^2)(20 \text{ ft}) = 1232.6 \text{ ft}^3$

$V_{BINS_2} = A_{c_2} h_1 = (27.54 \text{ ft}^2)(20 \text{ ft}) = 550.8 \text{ ft}^3$

$V_{BINS_3} = A_{c_3} h_2 = (7.1 \text{ ft}^2)(24 \text{ ft } 5 \text{ in}) = 173.4 \text{ ft}^3$

$$\boxed{\text{Total Volume} = 1956.8 \text{ ft}^3}$$

Remaining Calcine [5%]

[Calcine after 95% is removed]

$\Rightarrow$ Total Volume [.05] = $1956.8 \text{ ft}^3(.05) = \boxed{97.84 \text{ ft}^3}$

Remaining Calcine on Walls = Surface Area (thickness)

$= (103.25 \text{ ft}^2 + 54.24 \text{ ft}^2 + 38.33 \text{ ft}^2 + 61.63 \text{ ft}^2 + 27.54 \text{ ft}^2 + 7.1 \text{ ft}^2)(\overset{.8 \text{ mm}}{.0026 \text{ ft}})$

$= \boxed{.76 \text{ ft}^3}$

DRAWING 106577

$h_{\text{smaller bins}} = 20'$
$h_{\text{center bin}} = 26'9''$

Using calculations and numbers from page 7

Surface Area (walls)

$A_{w_1} = 103.25\ ft^2$
$A_{w_2} = 54.24\ ft^2$
$A_{w_3} = 2\pi[36''][26'9''\cdot 12''] = 72{,}572\ in^2 = 504\ ft^2$

$\text{Total} = (103.25 + 54.24 + 504)\ ft^2 = 662\ ft^2$

Remaining Calcine on walls = Surface Area (thickness)
$= (662\ ft^2)(.8mm) =$
$(662\ ft^2)(.00262ft) = \boxed{1.73\ ft^3}$

Total Volume $\Rightarrow A_{c_1}h_1 + A_{c_2}h_2 + A_{c_3}h_3$
$= (61.63ft^2)(20ft) + (27.54ft^2)(20ft) + (7.1ft^2)(26'9'')$
$= \boxed{1{,}973\ ft^3}$

Remaining Calcine [5%] = Total Volume (.05)
$= (1973ft^3)(.05) = \boxed{99\ ft^3}$

Calcine on bin supports is the same as the other bins.

Using Drawing 118871 for dimensions.

Volume of Top + Bottom:
Using Pressure Vessel Handbook - 10th Edition
by Eugene F. Megyesy Pg 417 (Reference 1)

Using ASME Flanged and Dished Head for a 144 OD vessel
(neglecting wall thickness)

$$\text{Volume} = 147.9\,ft^3$$

$$\text{Volume}_{HEADS} = \text{Volume}(2) = 147.9\,ft^3(2) = 295.8\,ft^3$$

Volume of Cylinder:

$$\text{Volume}_{cylinder} = \pi r^2 h = \pi(72''-.25'')^2(37\cdot12''+6'') = 7{,}274{,}212\,in^3$$
$$= 4210\,ft^3$$

Total Bin Volume:

$$\text{Volume}_{BIN} = \text{Volume}_{HEADS} + \text{Volume}_{CYLINDER} = (295.8+4210)\,ft^3 = \boxed{4506\,ft^3}$$

$$\text{Total Bin Set Volume} = 4506\,ft^3(7) = \boxed{31{,}542\,ft^3}$$

→ Comparing the volume when the wall thickness is taken into account for head volumes.

$$\text{Volume}' = \text{Volume}_{Heads} + \text{Volume}_{cylinder} = (137.21\,ft^3)(2) + 4210\,ft^3 = \boxed{4484\,ft^3}$$

an additional .47% is added → this justifies neglecting wall thicknesses

Calcine on Walls:

$$\text{Volume}_{WALLS} = \text{Surface Area}(\text{thickness})$$ [assume thickness = 1mm]

$$\text{Volume}_{WALLS} = 2\pi r L(\text{thickness}) = \left[2\pi(72''-.25'')(37'+6'')i + \left(\frac{132.2\,ft^2}{2}\right)\right](.03937\,in)$$

↑ see Reference 2 pg 425 - Head Surface Area

$$\boxed{=4.84\,ft^3}$$

Whole Bin Set $= 4.84(7) = \boxed{33.88\,ft^3}$

Calcine on Supports:

Assume slope of 45° on piping + supports
- See Methodology on page 23 for Area calculations

$$\text{Volume}_{piping} = \text{Area}(\text{length}) = .3\,in^2(72'')[2\,lines] = 43.2\,in^3$$
$$\boxed{=.025\,ft^3}$$

scaled off drawings

$$\text{Volume}_{supports} = \text{Area}(\text{length}) = .3\,in^2(72'')(12) \boxed{= .15\,ft^3}$$

Whole Bin Set $= .025(7) = \boxed{.175\,ft^3}$

Calcine on Floor:

Assume 5% of Total Volume

Whole Bin Set $= .15(7) = \boxed{1.05\,ft^3}$

Drawing 153510 for dimensions

Volume of Heads:

$D = 144'' - 2(.25'') = 143.5''$

Neglecting wall thickness → page 417 of Reference 1

$\text{Volume}_{HEAD} = 147.9\ ft^3 (2) = 295.8\ ft^3$

Volume of Cylinder:

outer bins $\text{Volume}_{cylinder} = \pi r^2 h = \pi(72''-.25'')(48.12'') = 9,310,992\ in^3$
$= 5388.3\ ft^3$

centerbin $\text{Volume}_{cylinder} = \pi r^2 h = \pi(72''-.25'')(56.12'') = 10,862,824\ in^3$
$= 6286.4\ ft^3$

Total Volume of a Bin:

$\text{Volume}_{OUTER\ BINS} = \text{Volume}_{HEADS} + \text{Volume}_{cylinder} = (295.8 + 5388.3)\ ft^3 = 5,684\ ft^3$

$\text{Volume}_{center\ BIN} = \text{Volume}_{HEADS} + \text{Volume}_{cylinder} = (295.8 + 6286.4)\ ft^3 = 6,582\ ft^3$

Total Bin Set Volume:

$\text{Volume}_{BIN\ SET} = \text{Volume}_{OUTER\ BINS}(6\ \text{bins}) + \text{Volume}_{center\ Bin}(1\ \text{bin})$
$= 5684\ ft^3(6) + 6582\ ft^3 = \boxed{40,686\ ft^3}$

Calcine on Walls:

$\text{Volume}_{WALLS} = (\text{Surface Area}_{CYLINDER} + \text{Surface Area}_{HEAD} \times 1mm)$

$= (2\pi r l + \underset{\uparrow}{\frac{132.2}{2}}\ ft^2)(\underset{\uparrow\ 1mm}{.00328\ ft})$

from page 425 of Reference 1

outer bins $= (2\pi(72''-.25'')(48.12'') + \frac{132.2}{2}\ ft^2)(.00328) = 6.1285\ ft^3$

centerbin $= (2\pi(72''-.25'')(56.12'') + \frac{132.2}{2}\ ft^2)(.00328\ ft) = 7.1138\ ft^3$

Total Calcine on Walls for the bin Set $= \text{Volume}_{WALLS-OUTER}(6) + \text{Volume}_{WALLS-Center}(1)$

$= (6.1285\ ft^3)(6) + 7.1138\ ft^3 = \boxed{43.88\ ft^3}$

Calcine on Supports: [Assuming ½ pipe - see Methodology page 24 for area calculations]

$\text{Volume}_{piping} = \text{Area}(\text{length})$

$= (.0134\ in^2)(72'')(7\ \text{lines}) = 6.754\ in^3 = .004\ ft^3$

↓ 6 rods + 1 thermocouple

$.004\ ft^3(7\ \text{bins}) = \boxed{.028\ ft^3}$ for the bin Set

$\text{Volume}_{supports} = \text{Area}(\text{length})$

$= \frac{1}{2} bhL = \frac{1}{2}(5.25'')^2(2\pi r)(\#\ \text{of rings})$

$= \frac{1}{2}(5.25'')^2(2\pi\ 72'')(6) = 21.64\ ft^3$ or $21.64(7) = \boxed{151.45\ ft^3}$ whole Bin Set

$D = 144'' - 2(.25'') = 143.5''$

Drawing 155750 for dimensions

Volume of HEADS:

$V = 147.9\ ft^3$ -> page 417 of Reference 1 (neglecting wall thickness)

$Volume_{HEADS} = (147.9\ ft^3)(2) = 295.8\ ft^3$

Volume of Cylinder:

$Volume_{cylinder} = \pi r^2 L = \pi(72''-.25'')^2(55' - 2(27''))$

-> scaled off drawing (height of head)

$Volume_{cylinder} = 5,669\ ft^3$

Volume of Vessel:

$Volume_{BIN} = Volume_{HEADS} + Volume_{cylinder} = (295.8 + 5669)ft^3 = 5965\ ft^3$

$Volume_{BIN\ SET} = Volume_{BIN}(3) = 5965\ ft^3(3) = \boxed{17,895\ ft^3}$

Volume on Walls:

$Volume_{WALLS} = Surface\ Area\ (thickness) = (2\pi r L + head\ volume)(1\ mm)$

page 425 of Ref 1

$Volume_{WALLS} = \left(2\pi(72'')(55' - 2(27'')) + \frac{132.2\ ft^2}{2}\right)(.03927\ in) = 6.46\ ft^3$

$Volume_{WALLS\ (BIN\ SET)} = Volume_{WALLS}(3\ bins) = 6.46\ ft^3(3) = \boxed{19.4\ ft^3}$

Volume on Supports + Piping:

None calculated -> none in bins

Bin Set #5

OD = 144" − 2(.25") = 143.5"   ID = 4'

$\boxed{\text{Drawing 158510 for dimensions}}$

Volume of Heads:

$Volume_{Head}$ = 147.9 ft³ -> page 417 of Reference 1 (neglecting wall thickness)

$Volume_{HEAD_{TOTAL}} = Volume_{HEAD} - Volume_{Annulus}$

$= 147.9\ ft^3 - \pi r^2 L = 147.9 ft^3 - \pi(2')^2(2'+4")$

$= 118.6\ ft^3$

$Volume_{HEADS} = (118.6\ ft^3 X\ 2\ heads) = 237.2\ ft^3$

Volume of Cylinder:

$Volume_{cylinder} = \pi r^2 L_{outer} - \pi r^2 L_{annulus}$

$= \pi(\frac{143.5"}{2})^2(50 \cdot 12") - \pi(2')^2(50 \cdot 12")$

$= 4984.8\ ft^3$

Volume of Bin + Bin Set:

$Volume_{BIN} = Volume_{HEADS} + Volume_{cylinder} = (237.2 + 49848)\ ft^3$

$= 5222\ ft^3$

$Volume_{BINSET} = Volume_{BIN}(7\ bins) = \boxed{36{,}554\ ft^3}$

Calcine on Walls:

$Volume_{WALLS}$ = Surface $Area_{outerwall}$ (thickness) + Surface $Area_{inner wall}$ (thickness) + head (thickness)

$Volume_{WALLS} = 2\pi r_o L(thickness) + 2\pi r_i L(thickness)$

$= 2\pi(\frac{143.5"}{2})(50')(.03937 in) + 2\pi(2')(55')(.03937 in)$

$+ .66(\frac{132.2}{2} ft^2)(.03937 in)$

$= 8.6\ ft^3$

Assumed 66% of surface area from page 425 of reference 1 -> to account for annulus

$Volume_{WALLS_{BIN SET}} = Volume_{WALLS}(7\ bins) = \boxed{59.98\ ft^3}$

Calcine on Supports + Piping:

None present.

$D = 13'+6''$

Drawing. 160283 for dimensions

Volume of Heads:

Assuming Ellipsoidal Shape

See Ref 2 for equation → $\text{Volume}_{\text{head}} = \pi \frac{D_i^2 h}{6} = \pi \frac{(13.5')^2 (2'+5\tfrac{1}{2}'')}{6} = 234.5\ ft^3$

PS 35 of this EDF

$\text{Volume}_{\text{HEADS}} = (\text{Volume}_{\text{head}} - \text{Volume}_{\text{annulus}})2 = [(234.5 ft^3) - \pi (\frac{5}{2}')^2 (2'+5\tfrac{1}{2}'')]2$

$= 372.5\ ft^3$

Volume of Cylinder:

$\text{Volume}_{\text{cylinder}} = \text{Volume}_{\text{outer}} - \text{Volume}_{\text{annulus}}$

$= \pi (\frac{13 \cdot 12'' + 6''}{2})^2 (68 \cdot 12'' - 6\tfrac{1}{2}'' - 2(2'+5\tfrac{1}{2}'')) - \pi (\frac{5'}{2})^2 (68 \cdot 12'' - 6\tfrac{1}{2}'' - 2(2'+5\tfrac{1}{2}''))$

$\text{Volume}_{\text{cylinder}} = 7{,}720\ ft^3$

Volume of Bin and Bin Set

$\text{Volume}_{\text{BIN}} = \text{Volume}_{\text{HEADS}} + \text{Volume}_{\text{cylinders}} = (372.5 + 7720) ft^3 = 8093 ft^3$

$\text{Volume}_{\text{BIN SET}} = \text{Volume}_{\text{Bins}} (7) = \boxed{56{,}649\ ft^3}$

Calcine on Walls: [neglecting calcine on dome]

$\text{Volume}_{\text{WALLS}} = [\text{Surface Area}_{\text{outer wall}} + \text{Surface Area}_{\text{inner wall}}](1\ mm)$

$\text{Volume}_{\text{WALLS}} = [2\pi (\frac{13.5'}{2})(68' - 6\tfrac{1}{2}'' - 2(2'+5\tfrac{1}{2}'')) + 2\pi (\frac{5}{2}')(68')](.00328\ ft)$

$= [2\pi (6.75')(68' - .5416' - 4.916') + 2\pi (2.5')(68')](.00328')$

$\boxed{= 12.2\ ft^3}$

for whole Bin set

$= (12.2\ ft^3)(7) = \boxed{85.4\ ft^3}$

Calcine on Supports + Piping:

None in bins.

$D_i = 13'+5\frac{1}{4}''$

Drawing 160283 for dimensions

Volume of Heads:

Assuming ellipsoidal shape (See Ref 2 for equation) Pg 35 of this EDF

$$\text{Volume}_{\text{HEAD}} = \frac{\pi D_i^2 h}{6} = \frac{\pi (13.4375')^2 (2'+8\frac{1}{4}'')}{6} = 253.96\ ft^3$$

$$\text{Volume}_{\text{HEADS}} = (\text{Volume}_{\text{head}} - \text{Volume Annulus})(2)$$
$$= \left[253.96\ ft^3 - \pi(.5')^2(2'+8\tfrac{1}{4}'')\right](2)$$
$$= 503.7\ ft^3$$

Volume Cylinder:

$$\text{Volume}_{\text{cylinder}_{\text{TOTAL}}} = \text{Volume}_{\text{cylinder}} - \text{Volume}_{\text{annulus}}$$
$$= \pi\left(\frac{13'+5\frac{1}{4}''}{2}\right)^2\left(68'-5\tfrac{7}{8}'' - 2(2'+8\tfrac{1}{2}'')\right) - \pi\left(\frac{1'}{2}\right)^2\left(68'-5\tfrac{7}{8}''\right)$$
$$= 141.75(62.1) - 53 = 8{,}750\ ft^3$$

Volume Bin + Bin Set:

$$\text{Volume}_{\text{BIN}} = \text{Volume}_{\text{HEADS}} + \text{Volume}_{\text{cylinder}} = (504 + 8750)ft^3 = 9254\ ft^3$$

$$\text{Volume}_{\text{BIN SET}} = \text{Volume}_{\text{BIN}}(7\text{ bins}) = 9254\ ft^3(7) = \boxed{64{,}778\ ft^3}$$

Calcine on Walls:

$$= (2\pi r L_{\text{OUTER WALL}} + 2\pi r L_{\text{inner wall}})(1mm)\ [\text{neglecting calcine on dome}]$$
$$= \left[2\pi\left(\frac{13'+5\frac{1}{4}''}{2}\right)\left(68'-(5''+\tfrac{7}{8}'')-2(2'+8\tfrac{1}{2}'')\right) + 2\pi(.5')(68')\right](.00328\ ft)$$
$$= ((42.2 \cdot 62.1)+(213.52))(.00328) = 9.3\ ft^3$$

$$\text{for whole Bin set} = (9.3)(7\text{ bins}) = \boxed{65.1\ ft^3}$$

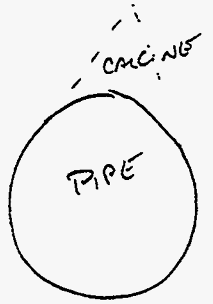
Calcine on Supports + Piping:

None in bins.

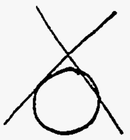
Methodology for Estimating Calcine on Pipes (2")

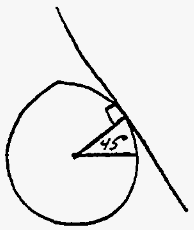
Assume maximum slope of 45°

2" pipe has an OD of $2\frac{3}{8}$"
thus a radius of 1.1875"



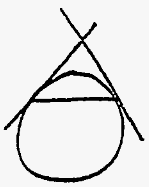
2" Pipe



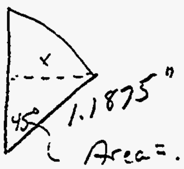


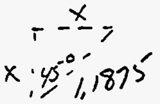
Area = $\pi r^2 = \pi(1.1875)^2 = 4.43 in^2$
45° = $\frac{1}{8}$ of a circle
thus $\frac{1}{8}$ of the area = $\frac{1}{8}(4.43 in^2)$
= .5534 in^2

To find area of calcine:

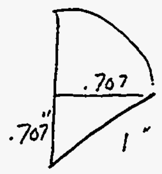


subtract out area of Pipe

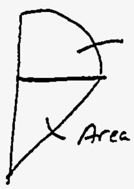




$\cos 45° = \frac{x}{1.1875} \Rightarrow x = .8397$

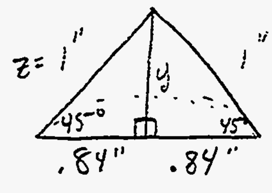


Area of triangle = $\frac{1}{2} bh = \frac{1}{2}(.84")^2 = .35 in^2$



Area .5534 in^2 − .35 in^2 = .2034 in^2

Area = .5534 in^2
(whole 1/8 circle)



$\cos 45 = \frac{.84}{z} \Rightarrow z = 1.1875"$

$y = .84"$

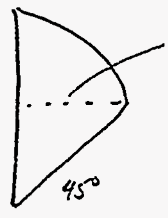
thus Calcine Area = $[\frac{1}{2} bh - \text{pipe area}]\,2$
$= [\frac{1}{2}(.84)^2 - (.2034)]\,2 = \boxed{.3\ in^2}$

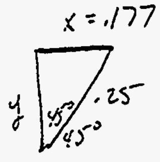
1/2" Pipe

Assuming OD for a 1/2" pipe is = 1/2"

Area = $\pi r^2 = \pi(\frac{.5}{4}")^2 = .19625 \text{ in}^2$

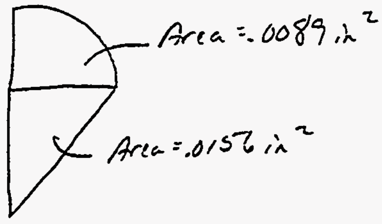
$1/8$ Area = $.0245 \text{ in}^2$





$\cos 45 = \frac{y}{.25} \Rightarrow y = .177 \text{ in}$

Area = $\frac{1}{2} bh = \frac{1}{2}(.177)^2 = .0156 \text{ in}^2$



Area of calcine = $2(.0156) - 2(.0089) = .0134 \text{ in}^2 =$

Vault Volume | Bin Set 1

Dwg No.

(4) vessels 115-1 Height 24' 5" Dia 3.0ft 106577

} 20'0" Dia 146 1/8"

115-4 Height From Baseline = 28' 5"

106583

Vault height = 39'4" 25.5ft Square vault. 106585

$$\text{Vault Volume} = \text{Length} \times \text{Width} \times \text{heigth}$$
$$= 25.5ft \times 25.5ft \times 39.3ft$$
$$= 25,554.8ft^3$$

Vessel Volume = $7844\ ft^3$

[This information was calculated in the vessel section for CSSF 1]

Distributor + Piping Volume = $686\ ft^3$

$$\text{Vault Void Volume} = \text{Vault Volume} - \text{Vessel Volume} - \text{Piping Volume}$$
$$= (25,555 - 7844 - 686)\ ft^3$$
$$\boxed{= 17025\ ft^3} = 482.1m^3$$

Vault Volume | Bin Set 2 742 | EDF-BSC-001 K. C. De Coria | PS2

Dwg No

(7) Vessels Height 42.5 ft O.D. 12.0 ft 118871

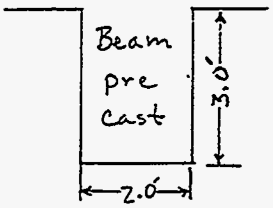
vault height 61.10" ft + 3 ft for Roof Beam 118877

Vault I.D. 46.0 ft 118879

roof beam spacing 3.5 ft x 3 ft

beam size =

(8)beams



$$\frac{\pi(46ft)}{4}$$

$$\text{Vault Total Volume} = \frac{\pi D_i^2}{4} \times \text{height}$$

$$= \frac{\pi (46.ft)^2}{4} \times 64.83 ft$$

$$= 107,741\ ft^3$$

Vessel Volumes = 31,542 ft^3

[This information was calculated in the vessel portion of the calculations]

Piping + Distributor Volume = 686 ft^3

Net Volume = Vault Volume - Vessel Volumes - Piping Volume

$$= (107,741 - 31,542 - 686) ft^3 = \boxed{75,513 ft^3} = 2138.3\ m^3$$

Vault ID. = 46.0 ft

Vault Height = 67' 2 ½"

Roof Beam = 3.0 ft

DWG No.
154148
153242
153510

Vessel height 53.0 ft O.D. dia 12.0 ft
140-1 thur 140-6

Vessel 139 height 61.0 ft dia O.D. 12.0 ft

Vault Total height = 67.2 ft + 3 ft = 70.2 ft

$$\text{Vault Total Volume} = \frac{\pi (D_i)^2}{4} \times h$$

$$= \frac{\pi (46.ft)^2}{4} \times 70.2\ ft$$

$$= 116{,}665.5\ ft^3$$

Vessel Volume = 40,686 ft³

Piping and Distributor Volume = 686 ft³

Vault net Volume = Vault Volume − Vessel Volume − Pip + Dist Volume

$$= (116{,}666 - 40{,}686 - 686)\ ft^3$$

$$\boxed{= 75{,}294\ ft^3} = 2132.1\ m^3$$

(3) Vessels vessel O.D. 12'.0 Vessel Height = 55.0 ft

6" Retrieval lines (2) per vessel Sch 40

Vault I.D. = 36 ft Height = 64'8.5" + 2'6" = 67.2 ft

Manway 18" STD. W.T. Ventilation 27" O.D 10 G.A. S.S.T.

DWG No.
157778
or 155750
maybe 156750

Ref No. 1375-CPP-760-M-1

Roof beam 157801

$$\text{Vault Volume} = \frac{\pi d^2}{4} \times \text{height}$$

$$= \frac{\pi (36 ft)^2}{4} \times 67. ft$$

$$= 68,197.7 ft^3$$

Vessel Volume = 17,895 ft^3

Piping + Distributor Volume = 686 ft^3

Vault net Volume = Vault Volume - Vessel Volume - Pip + Dist Volume

$$= 68,197.7 ft^3 - 17,895 ft^3 - 686 ft^3$$

$$\boxed{= 49,617 ft^3} = 1405 m^3$$

(7) Vessels Height 55.0 ft Dia 12.0 ft

open center dia 4.0 ft

Dwg No.

Man Way to vessel 18" OD STD W.T 158469

158462

Retrieval lines 8" O.D Sch 40 (2) per vessel 158510

Vault. Height 73.25 ft + 3.67 ft = 76.9 ft

Vault wall thickness = 4.0 ft

Vault I.D. = 47.0 ft

Vault O.D. = 55.0 ft

Vault Volume with out Vessels $= \frac{\pi d^2}{4} \times \text{height}$

$= \frac{\pi (47.0\ \text{ft})^2}{4} \times 76.9\ \text{ft}$

$= 133417\ \text{ft}^3$

Vessel Volume $= 36,544\ \text{ft}^3$

Piping + Distributor Volume $= 686\ \text{ft}^3$

Volume = Vault Volume - vessel volume - Piping + Dist Volume

$133,417\ \text{ft}^3 - 36,544\ \text{ft}^3 - 686\ \text{ft}^3 = \boxed{96,187\ \text{ft}^3} = 2723.7\ \text{m}^3$

Vault Volume | Bin Set 6 | EDF-BSC-001 | Pg 30

Vault I.D. = 52' 4" = 52.33 ft

Vault height = 88.5 ft

Bottom of Double Tee Panel add 10"

88' 6" + 10" = 89' 4"

DWG No.
161360
161373
161379

Total Vault inside height = 89.33 ft

$$\text{Total Vault Volume} = \frac{\pi (Di)^2}{4} \times \text{height}$$

$$= \frac{\pi (52.33\ ft)^2}{4} \times 89.33\ ft$$

$$= 192,158.8\ ft^3$$

$$= \underline{192,159\ ft^3}$$

Vessel Volume = 56,649 ft^3

Piping and Distributor Volume = 686 ft^3

Net Volume = Vault Volume - Vessel Volume - Pip + Dist Volume

$$= (192159 - 56,649 - 686)\ ft^3$$

$$= \boxed{134,824\ ft^3} = 3817.8\ m^3$$

Vault Volume | Bin Set 7 | EDF-BSC-001

DWG No.
168137
168120
168123
168116
168110

Vault I.D. = 52' 4" = 52.33ft

Vault Height = 88.5'

Bottom of Double Tee Panel add 10"

88' 6" + 10" = 89' 4"

Total vault inside Height = 89.33 ft

$$\text{Total Vault Volume} = \frac{\pi (D_i)^2}{4} \times \text{height}$$

$$= \frac{\pi (52.33ft)^2}{4} \times 89.33ft$$

$$= 192{,}158.8\ ft^3$$

$$= \underline{192{,}159\ ft^3}$$

Vessel Volume = 64,778 ft^3

Piping + Distributor Volume = 686 ft^3

Net Volume = Vault - Vessel - Pip + Dist

$$= (192{,}159 - 64{,}778 - 686)\ ft^3 = \boxed{126{,}695\ ft^3} = 3587.6m^3$$

Assuming : Bin Set #7 as standard
Additional lines to be added → 7 - 18" Risers

Piping:
There are currently 4 - 8" Lines (Riser + fill Lines) and 1 - 3" offgas line per tank

According to drawing 168190, the vertical risers are approximately
17'-7 7/16" + 6" + 1' + 5'-3" heigh =

$$\Rightarrow 17.62' + .5' + 1' + 5.25' = \boxed{24.37'\text{ heigh}}$$

Fill line lengths are not given, but were approximated by scaling off drawing 168190 (eventhough the drawing may not be accurate)

Scaling estimates each fill line to be approximately 30 ft

$$\frac{17'7\,7/16''}{24.5} = \frac{x}{42} \qquad (x)(24.5) = (42)(17'7\,7/16'')$$

$$\Rightarrow x = \boxed{30.2\text{ ft} \rightarrow \text{fill line length}}$$

Using "60" scale on Engineers ruler

Total Volume [per vessel (Bin)]

$$\text{Total Volume} = \sum \pi r^2 L_{8''\text{retrieval}} + \sum \pi r^2 L_{18''\text{retrieval}} + \sum \pi r^2 L_{8''\text{fill}}$$

$$\Rightarrow \pi(4'')^2(24.37')[4] + \pi(9'')^2(24.37')[1] + \pi(4'')^2(30.2')[2]$$

$$= 34\text{ ft}^3 + 43\text{ ft}^3 + 21.1\text{ ft}^3 = \boxed{98\text{ ft}^3}$$

Assuming 18" Retrieval line length = 17.62'

* Neglecting distributor
- assuming other dimensions are overestimated and compensate for this.

Assuming an additional 10% for the vessel offgas system.

Total for the whole Bin Set [7 bins] =

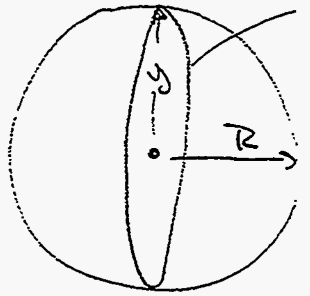
$$\text{Bin Total} = \text{Total Volume}[7] = [98\text{ ft}^3][7] = \boxed{686\text{ ft}^3}$$

amount of Grout needed per bin

Assuming 1% of volume is calcine [trapped on line, in expansion joints and distributor]

$$\text{Calcine Volume} = \text{Bin Total}[.01] = (686\text{ ft}^3)(.01) = \boxed{6.86\text{ ft}^3}$$

$$\text{per bin} = \frac{6.86\text{ ft}^3}{7} = .98\text{ ft}^3$$



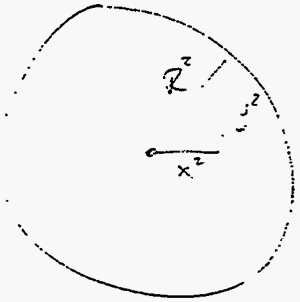
circle → circumference = $2\pi r_x$

r_x is a function of the circle's curvature

$$x^2+y^2+z^2=R^2$$

along the plane $z=0$, $x^2+y^2=R^2$

Using a circular area within the sphere, and integrating along the plane $z=0$



Area = πr_x^2 where r_x changes and is equal to y

$$\text{Volume} = \int_0^x (\text{Area})\,dx = \int_0^x \pi r_x^2\,dx = \int_0^x \pi y^2\,dx$$

but, $x^2+y^2=R^2$ and R^2 is known.

thus $y^2=R^2-x^2$

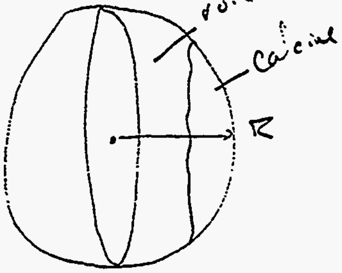
so

$$\text{Volume} = \int_0^x \pi(R^2-x^2)\,dx = \pi\int_0^x R^2\,dx - \pi\int_0^x x^2\,dx$$

$$\Rightarrow \pi R^2 x - \frac{\pi x^3}{3} = \pi R^3 - \frac{\pi R^3}{3} = \frac{2}{3}\pi r^3$$ ⇒ half the volume of a sphere

- method good.

Volume Calcine is known and is equal to area shown below.



$$\underset{\text{known}}{\text{Volume Dome}} - \underset{\text{known}}{\text{Volume Calcine}} = \text{Volume Void}$$ ← can get height from this

$$\text{Void Volume} = \int_0^x \pi(R^2-x^2)\,dx$$ where x is to be solved for

$$\text{Void Volume} = \pi R^2 x - \frac{\pi x^3}{3}$$ solve for x

$$\boxed{\text{Height} = R - x}$$

Bin Set #2

Calcine Volume = 260 ft^3 (average calcine in a bin)
Dome Volume = 448 ft^3

Void Volume = Dome Volume - Calcine Volume = (448-260) ft^3 = 188 ft^3

Void Volume = $\pi R^2 x - \frac{\pi x^3}{3}$ where R = (72" - .25") = 5.98 ft $\Rightarrow$ ~6 ft

So: $188 \text{ ft}^3 = \pi(6\text{ft})^2 x - \frac{\pi x^3}{3}$

$188 \text{ft}^3 = \pi\left[(36\text{ft}^2)x - \frac{x^3}{3}\right]$

Using calculator to solve → $\boxed{x \sim 1.71 \text{ ft}}$

Bin Set #6

Calcine Volume = 3,388/7 ft^3 = 484 ft^3 (average calcine in a bin)
Dome Volume = 644 ft^3

Void Volume = Dome Volume - Calcine Volume = (644-484) ft^3 = 160 ft^3

Void Volume = $\pi R^2 x - \frac{\pi x^3}{3}$ where R = $\frac{13'6"}{2}$ = 6.75 ft

So: $160 \text{ft}^3 = \pi(6.75\text{ft})^2 x - \frac{\pi x^3}{3}$

$160 \text{ft}^3 = \pi\left[(45.6\text{ft}^2)x - \frac{x^3}{3}\right]$

Using calculator to solve → $\boxed{x = 1.13 \text{ ft}}$

Double to account for annulus missing $\boxed{= 2.26 \text{ ft}}$

Using these two bin sets as indicators, a robot should be capable of handling a max of 2 feet of calcine at the bottom of the bins.

Reference #2
EDF-BSC-001 PS35

Table 6-51B. Volume of Cylinders, 10 to 98 Ft. Diameter*

Diam., ft.	Diam., in.	Gal./ft.	Diam., ft.	Diam., in.	Gal./ft.	Diam., ft.	Gal./ft.	Diam., ft.	Gal./ft.
10	0	588	17	6	1,799	30	5,288	55	17,770
10	3	617	18	0	1,904	31	5,650	56	18,420
10	6	648	18	6	2,011	32	6,020	57	19,090
10	9	679	19	0	2,121	33	6,400	58	19,760
11	0	711	19	6	2,234	34	6,790	59	20,450
11	3	744	20	0	2,350	35	7,200	60	21,150
11	6	777	20	6	2,469	36	7,810	62	22,580
11	9	811	21	0	2,591	37	8,040	64	24,060
12	0	846	21	6	2,716	38	8,480	66	25,590
12	3	882	22	0	2,844	39	8,940	68	27,170
12	6	918	22	6	2,974	40	9,400	70	28,790
12	9	955	23	0	3,108	41	9,880	72	30,460
13	0	993	23	6	3,244	42	10,360	74	32,170
13	3	1,031	24	0	3,384	43	10,860	76	33,930
13	6	1,071	24	6	3,528	44	11,370	78	35,740
13	9	1,111	25	0	3,672	45	11,900	80	37,600
14	0	1,152	25	6	3,820	46	12,430	82	39,500
14	3	1,193	26	0	3,972	47	12,980	84	41,450
14	6	1,235	26	6	4,126	48	13,540	86	43,450
14	9	1,278	27	0	4,283	49	14,110	88	45,500
15	0	1,322	27	6	4,443	50	14,690	90	47,590
15	6	1,411	28	0	4,606	51	15,280	92	49,730
16	0	1,504	28	6	4,772	52	15,890	94	51,910
16	6	1,599	29	0	4,941	53	16,500	96	54,140
17	0	1,698	29	6	5,113	54	17,130	98	56,420

*Gal./ft. = $5.875D^2$, where D = diameter, ft.

Table 6-52. Volume of Partially Filled Horizontal Cylinders

H/D	Fraction of volume	H/D	Fraction of volume	H/D	Fraction of volume	H/D	Fraction of volume
0.01	0.00169	0.26	0.20660	0.51	0.51273	0.76	0.81545
.02	.00477	.27	.21784	.52	.52546	.77	.82625
.03	.00874	.28	.22921	.53	.53818	.78	.83688
.04	.01342	.29	.24070	.54	.55088	.79	.84734
.05	.01869	.30	.25231	.55	.56356	.80	.85762
.06	.02450	.31	.26348	.56	.57621	.81	.86771
.07	.03077	.32	.27587	.57	.58884	.82	.87760
.08	.03748	.33	.28779	.58	.60142	.83	.88727
.09	.04458	.34	.29981	.59	.61397	.84	.89673
.10	.05204	.35	.31192	.60	.62647	.85	.90594
.11	.05985	.36	.32410	.61	.63892	.86	.91491
.12	.06797	.37	.33636	.62	.65131	.87	.92361
.13	.07639	.38	.34869	.63	.66364	.88	.93203
.14	.08509	.39	.36108	.64	.67590	.89	.94015
.15	.09406	.40	.37353	.65	.68808	.90	.94796
.16	.10327	.41	.38603	.66	.70019	.91	.95542
.17	.11273	.42	.39858	.67	.71221	.92	.96252
.18	.12240	.43	.41116	.68	.72413	.93	.96923
.19	.13229	.44	.42379	.69	.73652	.94	.97550
.20	.14238	.45	.43644	.70	.74769	.95	.98131
.21	.15266	.46	.44912	.71	.75930	.96	.98658
.22	.16312	.47	.46182	.72	.77079	.97	.99126
.23	.17375	.48	.47454	.73	.78216	.98	.99523
.24	.18455	.49	.48727	.74	.79340	.99	.99831
.25	.19550	.50	.50000	.75	.80450	1.00	1.00000

numerically to $\alpha/57.30$. Table 6-52 gives liquid volume, for a partially filled horizontal cylinder, as a fraction of the total volume, for the dimensionless ratio H/D or $H/2R$.

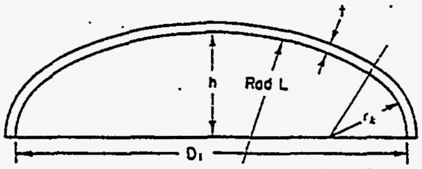
The volumes of heads must be calculated separately and added to the volume of the cylindrical portion of the tank. The four types of heads most frequently used are the standard dished head,* torispherical or A.S.M.E. head, ellipsoidal head, and hemispherical head. Dimensions and volumes for all four of these types are given in "Lukens Spun Heads," Lukens Steel Co., Coatesville, Pa. Approximate volumes can also be calculated by the formulas in Table 6-53. Consistent units must be used in these formulas. It should be remembered that volumes are given for one head but that usually two heads are involved.

A partially filled horizontal tank requires the determination of the partial volume of the heads. The Lukens catalog gives approximate volumes for partially filled (axis horizontal) standard, A.S.M.E., and ellipsoidal heads. A formula for partially filled heads, by Doolittle [*Ind. Eng. Chem.* 21, 322–323 (1928)], is

$$V = 0.00093H^2(3R - H) \qquad (6\text{-}46)$$

where V = volume, gal.; R = radius, in.; and H = depth of liquid, in. Doolittle made some simplifying assumptions which affect the volume given by the equation, but the equation is satisfactory for determining the volume as a fraction of the entire head. This

Table 6-53. Volumes of Heads
(Use consistent units)



Type of head	Knuckle radius r_k	h	L	Volume	% Error	Remarks
Standard dished	Approx. $3t$	......	Approx. D_i	Approx. $0.050D_i^3 + 1.65tD_i^2$	±10	h varies with t
Torispherical or A.S.M.E.	$0.06L$	......	D_i	$0.0809D_i^3$	±0.1	r_k must be the larger of $0.06L$ and $3t$
Torispherical or A.S.M.E.	$3t$	......	D_i	Approx. $0.513hD_i^2$	±8	
Ellipsoidal	......	......	......	$\pi D_i^2h/6$	0	
Ellipsoidal	......	$D_i/4$	......	$\pi D_i^3/24$	0	Standard proportions
Hemispherical	......	$D_i/2$	$D_i/2$	$\pi D_i^3/12$	0	
Conical	......	......	......	$\pi h(D_i^2 + D_id + d^2)/12$	0	Truncated cone h = height d = diameter at small end

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*The standard dished head does not comply with the A.S.M.E. Pressure Vessel Code.

CALCULATION of Bin VOLUME EDF-BSC-001

Bin #2 Pg 36

CALCULATION OF Head Volume

Perry's Ed 5 p 6-87

ASME 144 OD F&D HEAD

Rad of D = 132" = L

ICR = $8\frac{3}{4}$" = r_k

SF = $1\frac{1}{2}$"

$r_k/L = .066$

→ use .066

$D_i = 144 - 2(7/16) = 143.125$

Volume = $.0809\ D_i^3$

$= .0809\left(\frac{143.125}{12}\right)^3 = \boxed{137.26\ ft^3}$

=

STRAIGHT Section Vol

$V = \frac{\pi}{4} D_i^2 \times H$

$V = \frac{\pi}{4}\left(\frac{144 - \frac{1}{2}}{12}\right)^2 \times H = 112.3\ ft^3/ft \times 37.5\ ft$

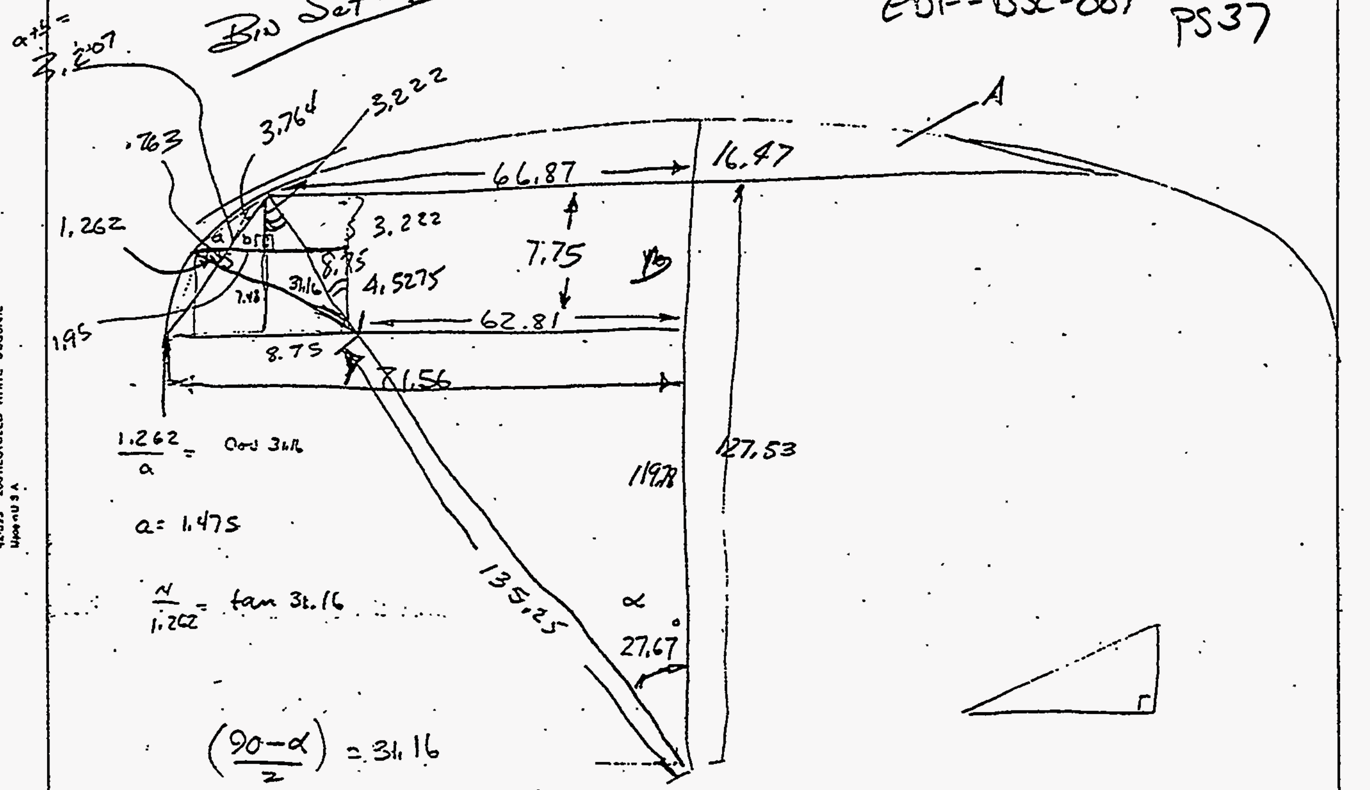
$= 4211\ ft^3$

RAKirkbride Estimated 874.3 m^3/Bin Set or 4396 ft^3/Bin

Production Report estimate 4192 ft^3

Bin Set #2

EDF-BSC-001 PS37



$\frac{1.262}{a} = \cos 31.16$

$a = 1.475$

$\frac{N}{1.262} = \tan 31.16$

$\left(\frac{90-\alpha}{2}\right) = 31.16$

$$Vol\ A = \frac{\frac{\pi}{6}\, 16.47 \left(3(66.87)^2 + (16.47)^2\right)}{1728} \qquad 68.3\ ft^3$$

$$Vol\ B = \frac{\pi}{3}\ \frac{7.75\left(66.87^2 + (71.56)^2 + 66.87 \times 71.56\right)}{1728} = 67.5$$

tot. $\boxed{135.8\ ft^3}$

2nd APPROX.

$$V_{B_1} = \frac{\pi}{3}\ \frac{3.222\left((66.82)^2 + (70.08)^2 + 66.82 \times 70.08\right)}{1728} \qquad 27.45$$

$$Vol\ B_2 = \frac{\pi}{3}\ 4.5275\left((70.08)^2 + (71.56)^2 + 20.08 \times 71.56\right) \qquad 41.28$$

68.73

68.3
68.73
137.03 close to perry's formula

NOT IN LIBRARY WHERE IS IT

BIN SET #2
(SECRET NOTEBOOK #225 (P-115 TO P-139)

ERECTION DATE: 3 MAR 1966

TYPE CALCINE: (WC-136-4 ALUMINUM OXIDE, Al_2O_3); (WC-136-1 ZIRCONIUM OXIDE, ZrO_2)

FILL DATE: 16 FEBRUARY 1972 ICP-1021 (P-3)

CONSTRUCTION MATERIAL: ASTM A 240 TYPE 304 (0.06% CARBON, MAX.)

BIN DESIGN: VIRTICAL CYLINDRICAL — 7 BINS, EA
12-FEET (3.65M) DIAMETER X 42 FEET (12.8M) HIGH X
0.375-INCH (9,525 MM) THICK.

BIN CONTRACTOR: CHICAGO BRIDGE & IRON

CORROSION ALLOWANCE: 0.125-INCH (3.175 MM)

CALCINE VOLUME PER BIN: 4,580 CU. FEET (128.3 M^3)

NUMBER OF BINS PER SET: 7

CALCINE VOLUME PER SET: 32,060 CU. FEET (907.9 M^3)

DESIGN TEMPERATURE: 290°C

CORROSION COUPON DATA:

INSTALLATION DATE: 20 JANUARY 1966

STORAGE IN: WC-136-1, ZrO_2 AND WC-136-4 Al_2O_3

NUMBER COUPONS/BIN: 80 - 4 EA - 405, 304, 304L & 1025

FILL START DATE:

WC-136-1 14 AUG 1968; ZIRCONIUM CALCINE

WC-136-4 1 APRIL 1966 ALUMINUM CALCINE

SAMPLES COVERED DATE:

WC-136-1 20 OCTOBER 1970

WC-136-4 6 DECEMBER 1966

BIN FILL DATE

WC-136-1 5 OCTOBER 1971 (AMB-26-72)

WC-136-4 1 OCTOBER 1967 (AMB-26-72)

COUPON WITHDRAWAL DATE:

WC-136-1 5 OCTOBER 1973

WC-136-4 5 OCTOBER 1973

EDF-BSC-001
PG 39

BIN SET #2

FILL SCHEDULE

CAMPAIGN NUMBER	CAMPAIGN DATES		TYPE CALCINE			TOTAL-PERIOD CALCINE STORED	TOTA STORE
	FROM	TERMINAL	ALUMINUM CU FT	ZIRCONIUM CU FT.	NON-ACTIVE CU. FT		
#2	1 APR '66	22 MAR '68	10,400	1,670	715	12,785 IN 1344	12,78
#3	12 AUG '68	3 JUN '69	242	4,423	485	5,150 IN-1474	17,93-
#4	3 AUG '70	5 JAN '71	104	3,266	779	4,149 ICP-1004	22,084
#5	23 SEP '71	16 FEB '72	61	3944	30	4,035 ICP-1021	26,119
	TOTALS		10807	13,303	2009		26,11

9-20-71

PLUMB MEASUREMENTS OF SELECT WC-136 BINS

Monthly says this Bin Not Done (Amb-175-71)

INSTRUCTIONS - ① THREE SECTIONS OF CORD STRING HAS BEEN PREPARED WITH A LEAD WEIG- ON ONE END AND THE STRING COLOR CODED AS SHOWN ABOVE.

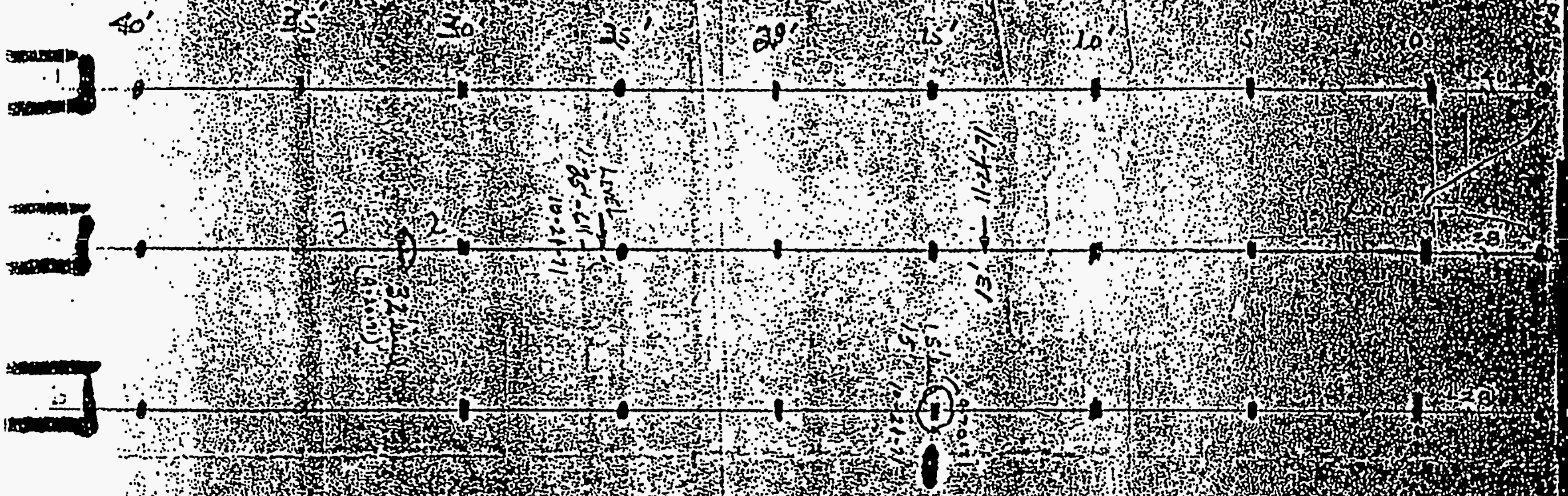
② WHEN THE ACCESS RISER FOR EACH OF THE 3 SOLID STORAGE VAUL- IS OPEN, PLUMB THE STORAGE BIN BY PLACING THE LEAD WEIGHT WITH STRING THROUGH THE OPENING.

③ RECORD THE TAUT STRING MEASUREMENT BY MARKING THE POS- ON THE ABOVE RECORD WHERE THE STRING ENTERS THE ACCESS RISER

④ WHEN COMPLETED, DROP THE STRING INTO THE STORAGE BIN AND RES- THE RISER OPENING. DO NOT ATTEMPT TO RECOVER EITHER STRING LEAD

9-20-71

PLUMB MEASUREMENTS OF SELECT WC-136 BINS



INSTRUCTIONS - ① THREE SECTIONS OF CORD STRING HAS BEEN PREPARED WITH A LEAD WEIGHT ON ONE END AND THE STRING COLOR CODED AS SHOWN ABOVE.

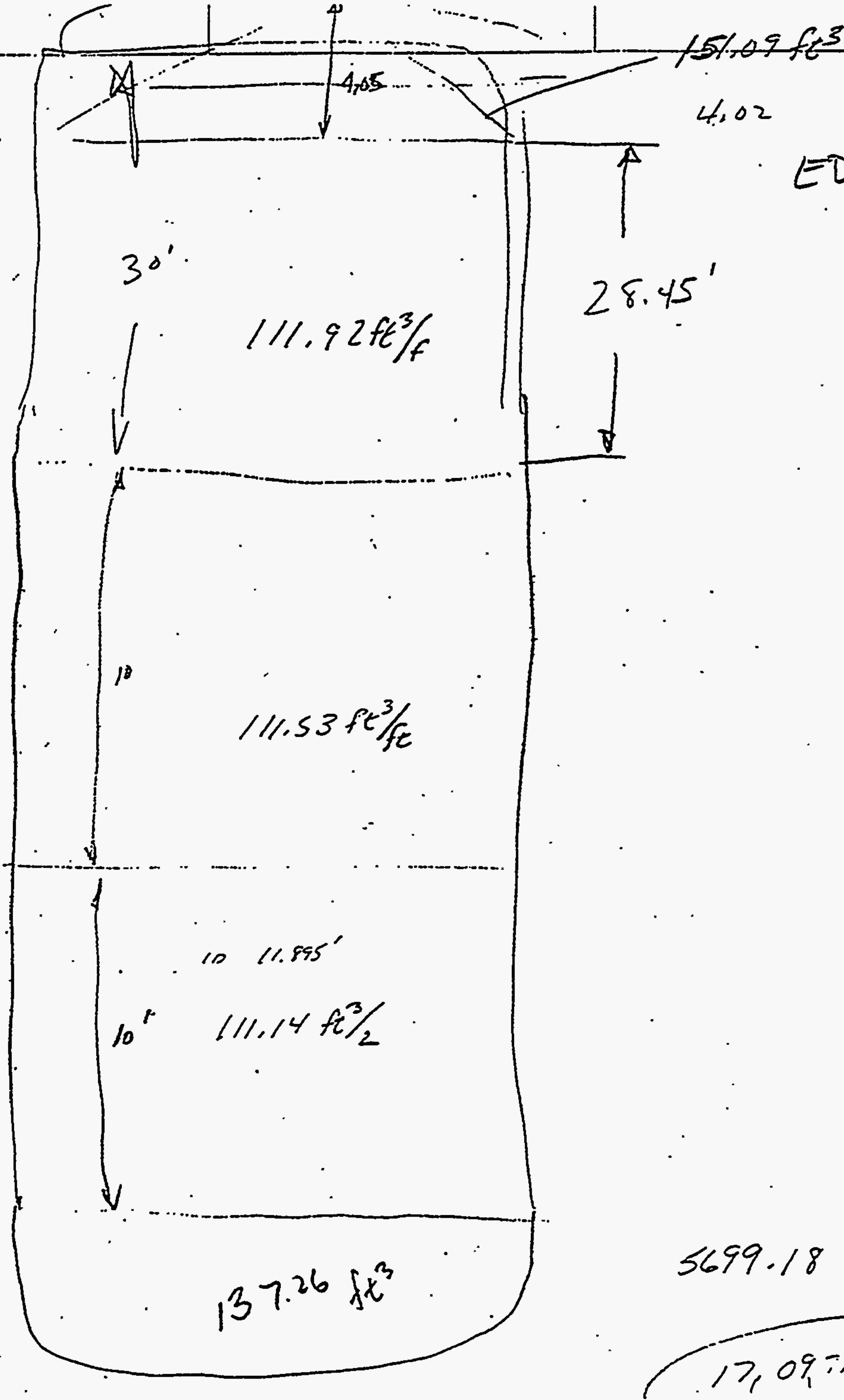
② WHEN THE ACCESS RISER FOR EACH OF THE 3 SOLID STORAGE VAULTS IS OPEN, PLUMB THE STORAGE BIN BY PLACING THE LEAD WEIGHT WITH STRING THROUGH THE OPENING.

③ RECORD THE TAUNT STRING MEASUREMENT BY MARKING THE POSITION ON THE ABOVE RECORD WHERE THE STRING ENTERS THE ACCESS RISER.

④ WHEN COMPLETED, DROP THE STRING INTO THE STORAGE BIN AND RESEAL THE RISER OPENING. DO NOT ATTEMPT TO RECOVER EITHER STRING OR LEA

EDF-BSC-001
PS 41

EDF-BSC-001
PS 42

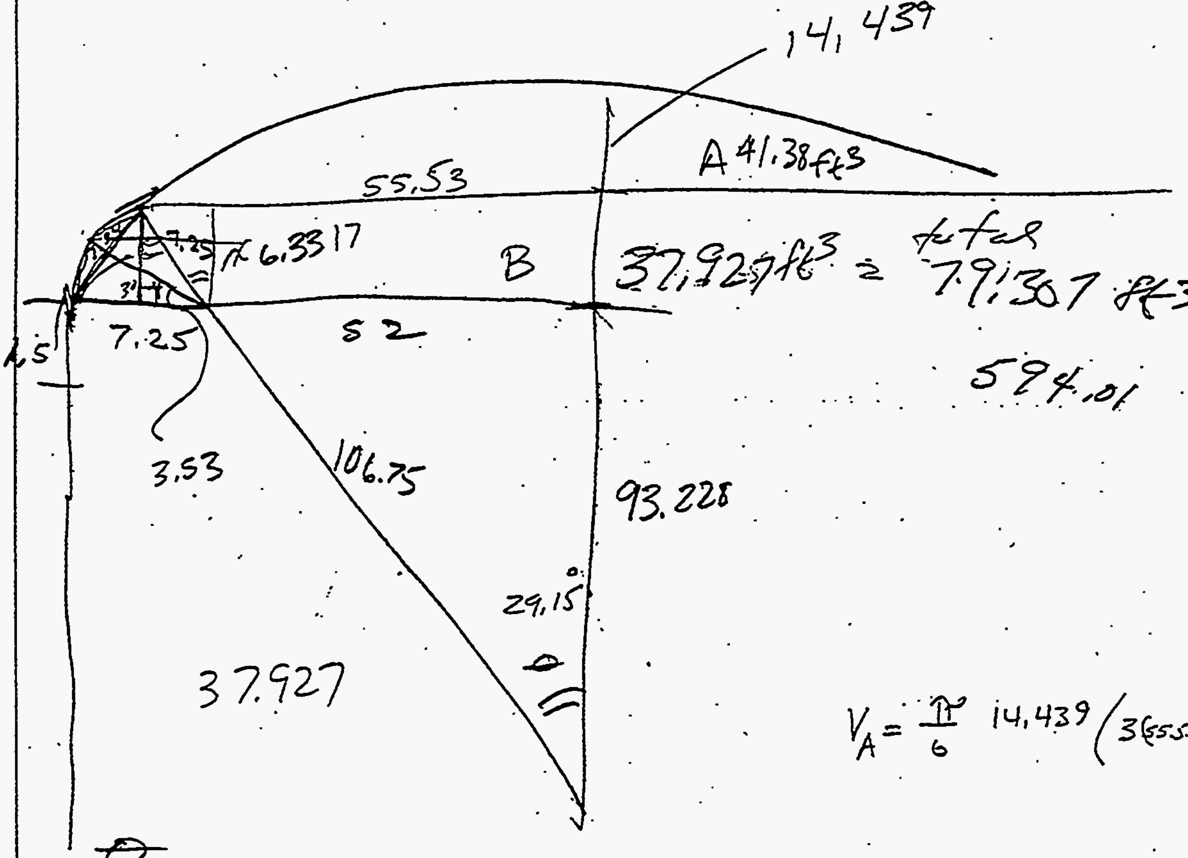


5699.18

17,097.5 ft³

#4

EDF-BSC-001
Pg 43



37.929 ft³ = ~~total~~ 79.307 ft3

594.01

$V_A = \frac{\pi}{6}\ 14.439\left(3(55.53)^2 + (14.439)^2\right)$

$\sin\theta = \frac{52}{106.75} = .487119$

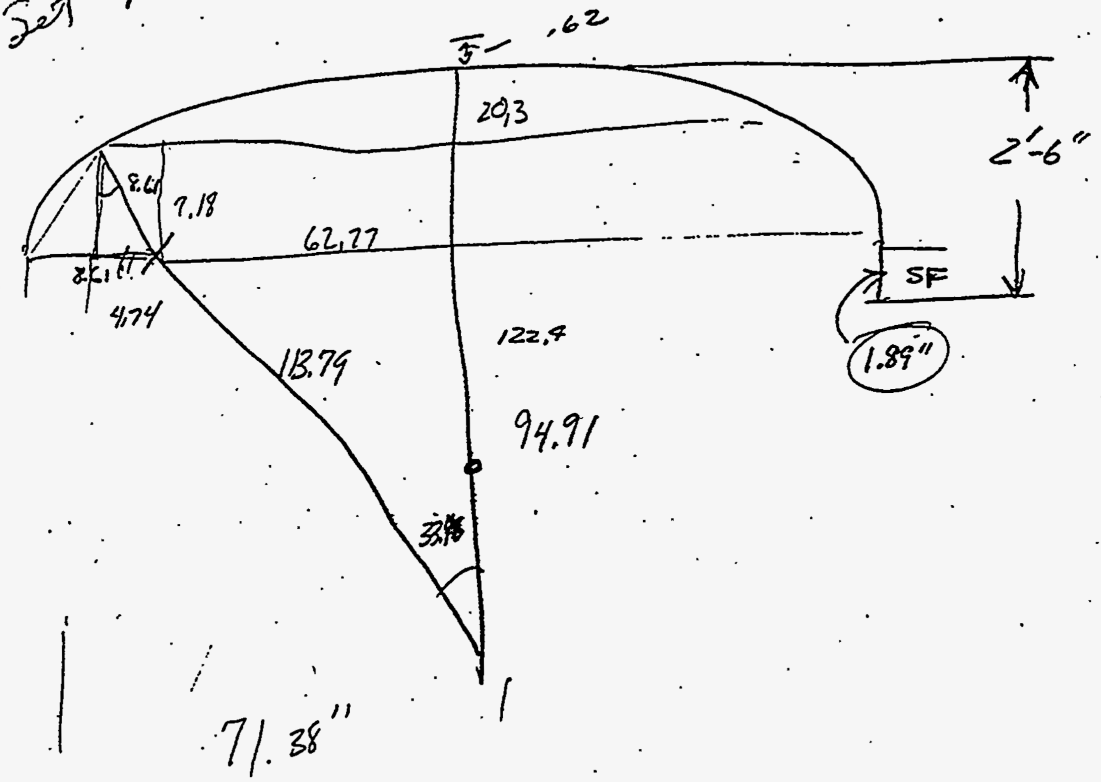
$V_B = \frac{\pi}{3}\ 6.3317\left(55.53^2 + 59.25^2 + 55.53 \times 59.25\right)$

$\theta = 29.15°$

$7.25 \cos 29.15° = A$

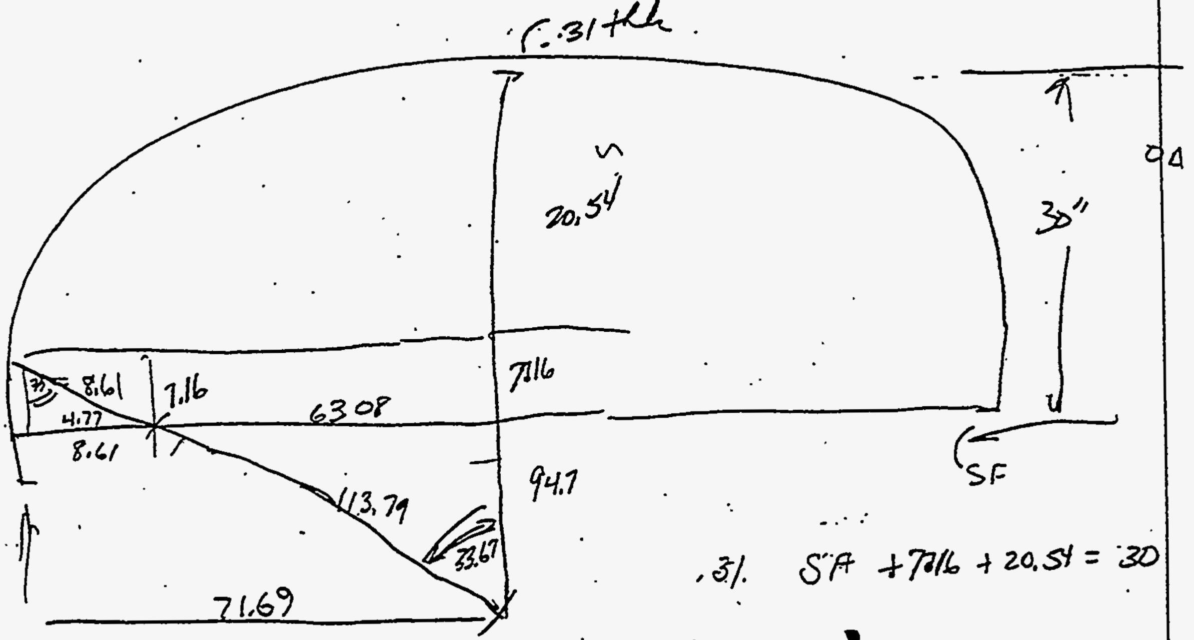
41.38
29.095
70.475 ft³ = 527.8 gal

Pin Set 4



sin 33.48 8.61 =

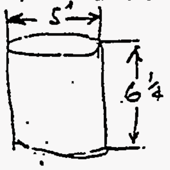
Bottom



.31 SA + 7.16 + 20.54 = 30

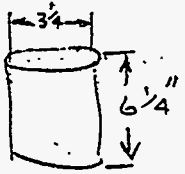
TOP

1. VOLUME OF 2000 ML BEAKER



$$V = \frac{\pi D^2}{4}(h) = (.7854)(25)(6.25) = 122.72 \text{ IN}^3$$

2. VOLUME OF INNER CYLINDER



$$V = (.7854)(10.56)(6.25) = 51.84 \text{ IN}^3$$

3. USABLE VOLUME

$$\text{VOL USA.} = 122.72 - 51.84 = 70.88 \text{ IN}^3$$

$$70.88 \text{ IN}^3 \times 16.38 \frac{\text{CM}^3}{\text{IN}^3} = \underline{1162} \text{ CM}^3$$

ACTUAL MEASURE = 1125 CM^3

4. ACTUAL VOLUME = 1125 CM^3

FILLED " = 1015 CM^3

$$\% \text{ VOID} = \frac{1125 - 1015}{1125} \times 100\% = 9.8\%$$

9.1

5. VOLUME REDUCTION FACTOR

A. AS OF 6/30/64

$$S.S. = 38450\,(.902) = 34682\ \text{gal}$$

$$\text{TOTAL GAL PROCESSED} = \underline{323{,}000}$$

$$\text{VOL. RED FACT} = \frac{323{,}000}{34{,}682} = \underline{9.3}$$

(8.4)

6. ESTM ρ_{BULK} (WM-185)

$$a.\ 66.9\,\frac{\text{gal}}{\text{HR}} \times \frac{\text{gal SOLIDS}}{9.3\ \text{gal FEED}} = 7.19\,\frac{\text{gal SOLIDS}}{\text{HR}}$$

$$b.\ 7.19\,\frac{\text{GAL SOLIDS}}{\text{HR}} \times \frac{\text{FT}^3}{7.48\ \text{gal}} = \frac{0.96\ \text{FT}^3/\text{HR}}{1}$$

$$c.\ \frac{\#\ \text{SOLIDS}}{\text{HR}} = 49.4\,\frac{\#}{\text{HR}} \times \frac{66.9}{61.9\ \text{gph}} = 53.4\,\frac{\#}{\text{HR}}$$

$$53.4\,\frac{\#}{\text{HR}} \times \frac{\text{HR}}{.96\ \text{FT}^3} = 55.6\ \#/\text{FT}^3$$

$$\boxed{\rho_{BULK} = \frac{55.6}{62.4} = 0.89\ \text{g/cc}}$$

$$D.\ \text{EFFECTIVE } \rho_{BULK} = (.89)(.902) = \boxed{.803\ \text{g/cc}}$$

ρ_B by Bin Temperatures

ON WM-185 feed with recycle

A-3 bin averaged 14.9 days for 5 ft or 2.98 days/ft

Volume = 61.88 ft^3/ft

AvgFeed Rate = 59 GPH from WM-185 ≡ 47.75 #/Hr

or $\frac{61.88}{2.98} = 20.77\ ft^3/day$

$47.75\ \#/Hr \times 24 = 1146\ \#/day$

$\frac{1146}{20.77} = 55.2\ \#/ft^3$ or 0.885 g/cc

(1416 GPD)
189.3 ft^3/day

$\frac{189.3}{20.77} = 9.1/1$

WM-187 feed without recycle

115-3 A-2

A-2 bin averaged 7 days for 5 ft or 1.4 days/ft

Volume = 34.4 ft^3/ft

Avg Feed Rate = 68 GPH from WM-187 ≅ (55×0.885) = 48.65 #/Hr

or $\frac{34.4}{1.4} = 24.6\ ft^3/day$

$98.65 \times 24 = 1168$

$\frac{1168}{24.6} = 47.5\ \#/ft^3$ or 0.76 g/cc

WM-185 feed with recycle

A-2 bin averaged 9.6 days for 5 ft or 1.92 days/ft

Avg Feed Rate was 56 GPH ≡ 45.3 #/Hr

$\frac{34.4}{1.92} = 17.92\ ft^3/day$

$45.3 \times 24 = 1087$

$\frac{1087}{17.92} = 60.6\ \#/ft^3$ or 0.97 g/cc

1344 GPD
179.7 ft^3/day

$\frac{179.7}{17.92} = 10/1$

EDF-BSC-001
PS 48

15-2 A-3

WM-187 Feed without recycle

A-3 Bin averages 13.2 days/5 ft or 2.64 days/ft

Avg Feed Rate = 68 GPH ≈ 48.65 #/Hr

$\frac{61.88}{2.64} = 23.4\ ft^3/day$

$\frac{1168}{23.4} = 49.9\ \#/ft^3$ or 0.80 g/cc

68 GPH = 9.09 ft^3/Hr or 218.1 ft^3/day

$\frac{218}{23.4} = \boxed{9.3/1}$

A-2 Annulus

IR = 1.72 ft ; OR = 3.73 ft

Avg. RAD = 2.725

Circumference = (2π)(2.725) = 17.13

$L = \frac{17.13}{8} = 2.14$ ft

Y = (2.14) tan 30° = 1.235 ft

$V_T = 8\left(\frac{2 \times 1.235 \times 2.14}{2}\right) = 21.2$ cubic ft

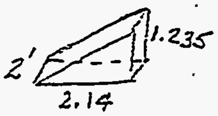
Bin Volume = 688 cubic ft

$\frac{V_T}{V_B} = \frac{21.2}{688} = 3.08\%$

L·C = EDF-BSC-001 PS.49 =>

$L = \frac{c}{8}$; θ = 30°

$\tan 30 = \frac{Y}{L}$



A-3 ANNULUS

IR = 3.91 ft; OR = 5.93 ft; Volume = 1237 ft^3

Avg. RAD = 4.92 ft.

Circumference = (2)(π)(4.92) = 30.95 ft

$L = \frac{30.95}{8} = 3.865$ ft $L = \frac{30.95}{12} = 2.58$

there are [illegible] ($L = \frac{c}{12}$)

Y = (3.865)(tan 30°) = ~~2.235 ft~~ 1.49 ft

$V_T = 8\left(\frac{2 \times 2.235 \times 3.865}{2}\right) =$ ~~69 cubic~~ ft 46

$\frac{V_T}{V_B} = \frac{69}{1237} =$ ~~5.6%~~ $\frac{46}{1237} =$ 3.7%

EXPERIMENT

ID = 3.25"; OD = 5.0"

Avg. DIA. = 4.125";

Circumference = (4.125)(π) = 12.97 inches

$L = \frac{12.97}{8} = 1.62$ inches

Y = 0.935 inches

$V_T = \frac{(0.935)(1.62)(0.875)(8)}{2} = 5.31$ cubic inches

$\frac{V_T}{V_B} = \frac{5.31}{68.7} = 7.75\%$

$\text{Volume} = \left(\frac{\pi}{4}\right)\left(\overset{25}{5.0^2} - \overset{10.56}{3.25^2}\right)(6.25)$

= 71 cubic inches or 1162 cc

Measured Volume = 1125cc or 68.7 cu.in

Measured Void = $\frac{1125-1015}{1125}$ = 9.8%

RADIUS FOR Equal Volume EXPERIMENT

$\frac{V}{2} = 581$ cc or $\frac{71}{2} =$ 35.5 cubic inches

$$35.5 = (\pi)(2.5^2 - R^2)(6.25)$$

$$35.5 = 19.635(6.25 - R^2)$$

$$1.808 = 6.25 - R^2$$

$$R^2 = 4.442$$

$$R = 2.107 \quad , \quad D \doteq 4.214$$

Circumference = $(4.214)(\pi) = 13.24$ inches

$$L = \frac{13.24}{8} = 1.655''$$

$$Y = 0.9555$$

$$V_T = \frac{(0.9555)(1.655)(0.875)(8)}{2} = 5.53 \text{ cubic inches}$$

$$\frac{V_T}{V_B} = \frac{5.53}{68.7} = 8.0\%$$

$\frac{9.8-8.0}{8.0} = \frac{1.8}{8.0} =$ 22.5% increase in void

$$\frac{5.53-5.31}{5.31} = \frac{.22}{5.31} = 4.1\%$$

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PS 51

A-2

$$\frac{V}{2} = \frac{688}{2} = 344 \text{ cu. ft.}$$

$$344 = (\pi)(R^2 - 1.72^2)(20)$$

$$R^2 - 2.96 = 5.48$$

$$R^2 = 8.44 ;\quad R = 2.905$$

$$\text{Circumference} = (2)(\pi)(2.905) = 18.25 \text{ ft}$$

$$L = \frac{18.25}{8} = 2.28 \text{ ft}$$

$$Y = 2.28 \tan 30^\circ = 1.317 \text{ ft}$$

$$V_T = 8\left(\frac{2 \times 1.317 \times 2.28}{2}\right) = 24.0 \text{ cu. ft.}$$

$$\frac{V_T}{V_B} = \frac{24.0}{688} = 3.5\%$$

$$\frac{3.5 - 3.08}{3.08} = \frac{0.42}{3.08} = 13.6\%$$

A-3

$$V/2 = \frac{1237}{2} = 618.5 \text{ cu. ft.}$$

$$(618.5) = (\pi)(R^2 - 3.91^2)(20)$$

$$R^2 - 15.29 = 9.84$$

$$R^2 = 25.13,\quad R = 5.01$$

$$L = (6.283)(5.01)\left(\tfrac{1}{8}\right) = 3.937 \quad L = (6.283)(5.01)\left(\tfrac{1}{12}\right) = 2.6$$

$$Y = \cancel{2.272} \qquad (1.52)$$

$$V_T = (\overset{1.52}{2.272})(3.937)(8) = 71.6 \text{ cu. ft.} \quad 48.7$$

$$\frac{V_T}{V_B} = \frac{71.6}{1237} = 5.8\% \quad (3.85\%)$$

3rd Bin Set Volume Calculation ✓

Lowest Thermocouple 41'8" from Top of Thermowell

DWG # 118888 & 118871 & 188872

~~Calculate~~ Calculates to being 12" above btm of tank

2nd Thermocouple located at start of Straight Section

123.5 ft³

29 5/8

Volume of Head

ASME DGH

$V = .050\ D_i^3 + 1.65\ t D_i^2$

$t = 7/16$

$D_i = 143\ 1/8$

$V = 1.466E5 + 1.479E4$

$V = 1.614E5\ in^2 / 1728$ ~~703~~ 93 ft³

Torospherical

112.3 ft³/ft

172 ft³

14

158 ft³

24.7 ft

Di 160.63

$.0809\ D_i^3$

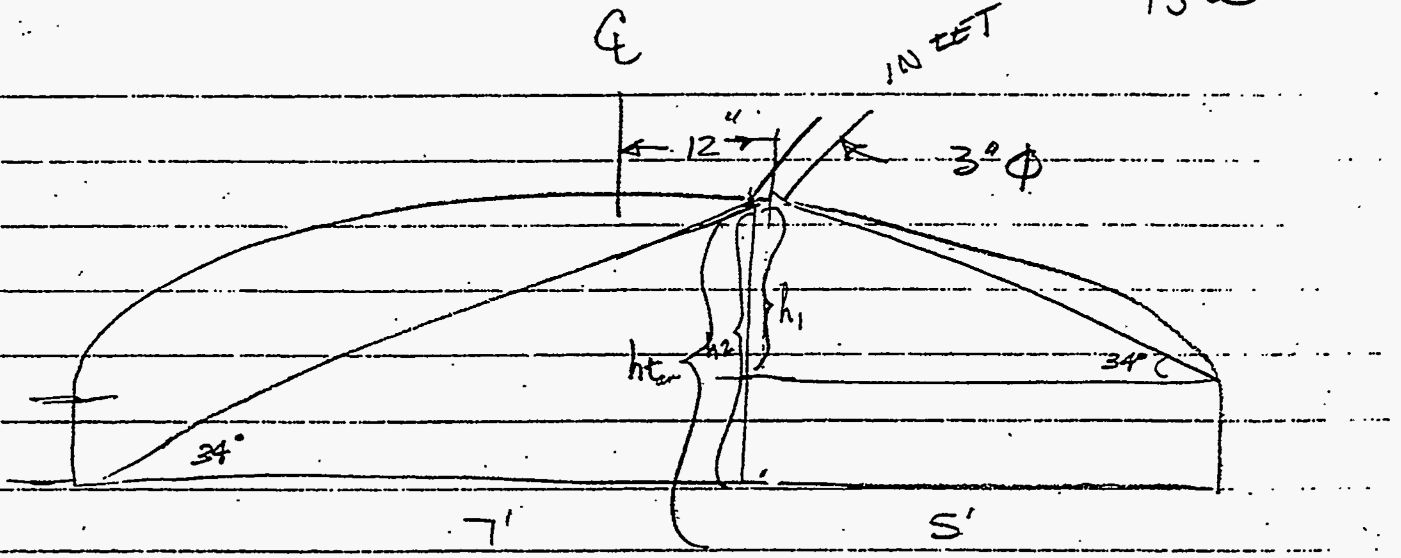
194 ft³

48

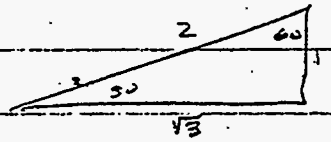
145.61 ft³

102

145 ft³/ft



Assume $h_{1\ \text{tangent line}} = 28''$



$\tan 30° = .577$

$\tan 34 = .674 = \frac{h_2}{7}$

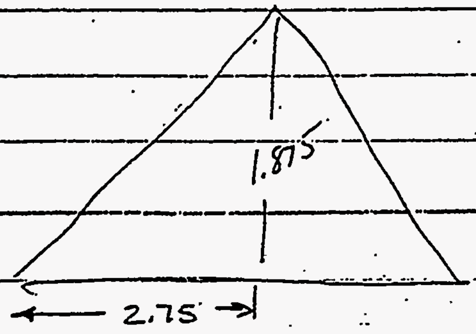
$7 \times .674 = h_2$

$4.72 = h_2$

$\tan 34° = .674 = \frac{h_1}{5}$

$3.37 = h_1$

cylinder not used ~~2.39~~ $4.72' - 2.33' = 2.39'$



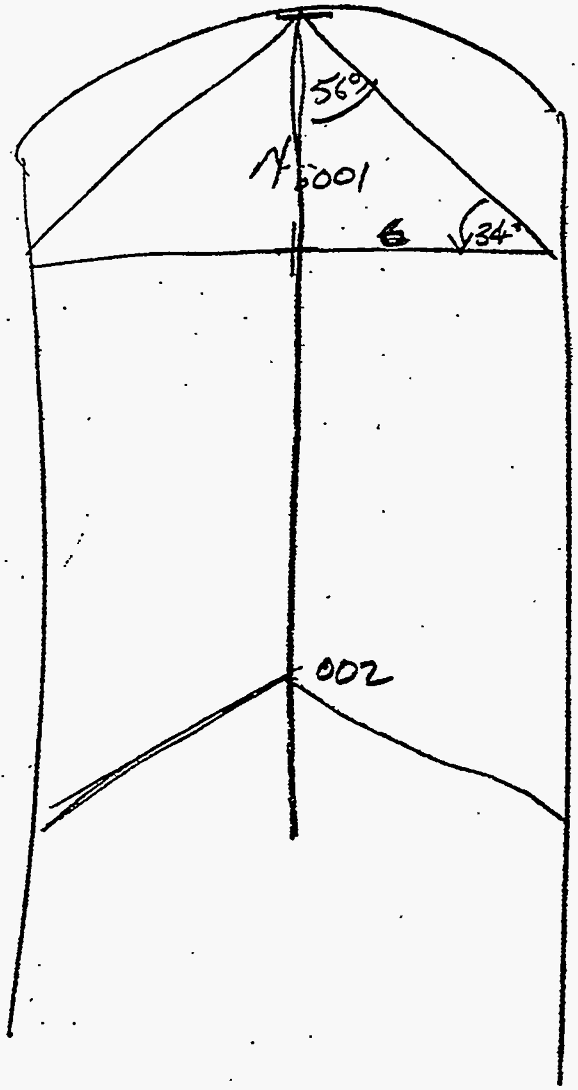
14.84 in^3 × 16.38 ml/in^3 243 3 ml

2.43 ml × 1.49 g/ml = 362.5 gm

1892 Tare 289 $^{289}/_{1087}$ 265 , ft offset

2181 − 2892 = 289 gm 333 gm $^{333}/_{1087}$ .306 q

Bin Set
3



$\tan 34^\circ = \frac{x}{6}$

$6 \tan 34^\circ = x$

$4.05 = x$

$\text{Vol cone} = \frac{1}{3} \pi R^2 h$

$\text{Vol} = \frac{1}{3} \pi\ 6^2 \times 4.05$

$\text{Vol} = 152.7\ ft^3$

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PS 56

V

13^9

15
f 1 - ~~8~~ 7/16
— — 9 7/16

1 - 6 0

1128.1 + 152.7

1297

895.28+ 394.84

389.65+ 895.28
1280
137

1,286

6569

5^6 1
48 8'

INEL

ENGINEERING DESIGN FILE

Form L-0431.2#
(05-96-Rev.#02)

Project File Number 015720

EDF Serial Number EDF-BSC-002

Functional File Number BC-01

Project/Task ICPP BIN SET CLOSURE FEASIBILITY STUDY

Sub task GROUNDWORK FOR DESIGN - MEETING MINUTES

TITLE: Bin Set Closure Discussion with Maria Dumas, Jim Law, Mike Swenson, and Ambika Chakravartty

SUMMARY

A meeting was held on November 3, 1997 at the Idaho Chemical Processing Plant (ICPP) to discuss potential options for closure of the Calcined Solids Storage Facilities (CSSFs), also known as the "bin sets". The opinions of the CSSFs experts were considered for Resource Conservation Recovery Act (RCRA) Clean Closure, RCRA Risk-Based Closure, and RCRA Landfill Closure options. The purpose of this Engineering Design File (EDF) is to present the experts opinions on the topics of discussion.

According to Maria Dumas (CSSF Operations), Jim Law (CSSF Operations), Mike Swenson (CSSF Systems Engineering), and Ambika Chakravartty (CSSF Systems Engineering), RCRA Total Removal Clean Closure is not a favorable closure alternative for the CSSF facility. RCRA Risk-Based Closure and RCRA Landfill Closure should be considered as more viable options for the CSSFs.

The following main categories were discussed with respect to the Calcined Solids Storage Facilities during the meeting:

Decontamination
Calcine Retrieval
Description of Waste
Radiological Concerns
Structural Conditions
Surrounding Soils
Miscellaneous Issues
Overall Opinions
Contacts (names and phone numbers of personnel discussed in this EDF)

Distribution: D. J. Harrell, MS 3211; B. R. Helm, MS 3765; B. C. Spaulding, MS 3765; M. M. Dahlmeir, MS 3765; M. M. Dumas, MS 5111; A. C. Chakravartty, MS 5104, J. P. Law, MS 5111; M. C. Swenson, MS 5104; S. P. Swanson, MS 3765, Project File (Original +1)

Authors	Department	Reviewed	Approved
Steven Swanson S. P. Swanson	MC&IE/4130	Jim Law Date 1-19-98	B. Spaulding Date 1/21/97

Introduction

The information to follow in the body of this Engineering Design File (EDF) is a compilation of opinions from the Calcined Solids Storage Facilities (CSSFs) experts (Maria Dumas – Operations, Jim Law – Operations, Mike Swenson – Systems Engineering, and Ambika Chakravartty – Systems Engineering). Their opinions are based on their areas of expertise and are directed towards the topics of discussion that were derived from the ICPP Bin Set Closure Feasibility Study engineering staff.

Decontamination

According to the experts, decontamination of the bins to a "relatively clean" state might be accomplished using a nitric acid solution, which is currently the only type of acid used at the ICPP for decontamination purposes. The acid would dissolve approximately 90% of the calcine under normal flushing conditions and approximately 99% when soaking is permitted. However, the experts claim that a large amount of secondary waste would be generated during the decontamination process and that the cost for nitric acid decontamination could not be justified. If nitric acid is used for decontamination, its use must be closely monitored, as the acid is not compatible with concrete and 400 series stainless steel components (CSSF 1 only, other CSSFs have 304 or 304L stainless steel components); nitric acid may compromise secondary containment (the vault) and thus not be applicable. Dissolving the calcine in the bins with nitric acid, flushing equipment, and performing rinsing operations will remove much of the contamination. However, some of the contamination is fixed to the bin surface (due to bin irregularities, i.e. weld seams) and will always be found during a survey. Wet decontamination methods will not be successful enough to allow sampling by smear methods. Further study is required to determine whether or not nitric acid can be used on the CSSF piping and bins.

The CSSFs experts state that water will not dissolve calcine in the piping and bins and will not pass a Toxicity Characteristic Leaching Procedure (TCLP) test. As a result, water should not be used as a decontamination agent.

Carbon dioxide blasting is a viable option for decontamination of the bins. While surface jet-blasting decontamination methods could possibly push contamination further into the material, it is anticipated that the process would actually break particles free from the imperfections present on piping and bin walls. To facilitate this method, numerous modifications would have to be made to the heating, ventilating and air conditioning (HVAC) system. Julia Tripp can help determine how clean the bins would have to be after decontamination methods are applied.

At the present time, the vaults for all of the CSSFs are clean. The vaults are closed systems with all utility and process lines penetrating the vault walls from above grade for CSSFs 4 through 7. The cyclone vaults for the second and third CSSFs could, however, be contaminated. Other members of the group indicate it is likely that all of the cyclone vaults are contaminated.

CSSFs experts indicate that the distributor below each cyclone will catch calcine and will not be retrievable without wet dissolution; "nooks and crannies" will prevent surface jet-blasting from removing all the calcine. The distribution fill lines, expansion joints, and piping blinded tees will also have calcine deposits in them. As a result of these calcine traps, in conjunction with limited access to the bins, the calcine within the bins will be harder to remove than the waste left in the Tank Farm Facility (TFF).

If water were introduced into the vaults for decontamination purposes, the bins in the vault would float to the surface of the water. The bins are not structurally secured to the floor of the vaults.

The CSSFs experts preferred two decontamination options: (1) grouting without decontamination and (2) using a surface jet-blasting method (i.e. carbon dioxide) to blow out contamination: Nitric acid dissolution could be another option, if it is permitted.

Calcine Retrieval

The Second and Third CSSFs have one access/retrieval line to each round bin. The First CSSF does not possess any access/retrieval lines. The piping within the First CSSF is more convoluted than piping in the other storage facilities and will be harder to decontaminate.

The First CSSF utilizes "c" channel beams in the interior of the bins for structural support or stiffening. These supports will make it difficult to retrieve waste from within the bin as the supports catch calcine on their protruding ledges and "nooks and crannies". Each of the twelve "vessels" in the First CSSF contains these structural supports. It should be noted that for the First CSSF, two annular "vessels" surround a central "vessel" in each bin. There are four bins in the First CSSF.

According to the experts, sintering should not be a problem within the CSSFs. If sintering has occurred, it should not be difficult to break up. Feed batches were controlled at the beginning of each campaign to ensure that the calcine does not sinter (cake). All of the calcine that has been retrieved from the bins has been free flowing. However, the top layer of the calcine could be slightly crusty due to contact with humidity. This layer should not be difficult to break up.

After the bulk of the calcine is removed, a thin layer of calcine will remain on the walls and floor as the calcine is not hydroscopic. This layer will be similar to a layer of dust.

According to Jim Law, approximately 99% of the calcine can be removed from the bins and piping. To be conservative, however, it was assumed that approximately 95% of the calcine within the bins can be retrieved using a standard retrieval system. Published numbers are available from Barry O'Brien. Jim Law was part of a project that looked at retrieving the calcine from the bins. The retrieval equipment should be capable of removing 95% of the waste from the First CSSF and should retrieve higher percentages with the other calcined solids storage facilities; retrieval should be more complete for the second through seventh CSSFs as there are fewer obstacles present inside of the bins. Dan Griffith is a good contact for questions concerning retrieval. He has performed mock up tests on the storage facilities.

In order to successfully retrieve the maximum amount of calcine with a standard retrieval system, additional access lines might be added to the older bins (CSSFs 1, 2 and 3).

At this time, the CSSFs do not possess equipment designed to retrieve the calcine. A limited amount of calcine was removed from the Second CSSF with a standard soils-type sampler. Calcine has not yet been retrieved with an air-jet/vacuum system (used to fluidized the calcine and vacuum out the airborne contaminants).

Description of Waste

According to Maria and Jim, CSSFs one through four could pass Resource Conservation Recovery Act (RCRA) Risk-Based Closure as there are no RCRA listed wastes present in the bins. It may be possible to not consider the waste within these bins as listed waste as the waste was placed into the bins before RCRA regulations were implemented. However, Mike and Jim agree that it is unlikely the waste can be considered not listed. Further study is required to determine the correct viewpoint. At this time, Jim Law is working on a RCRA Delisting Petition for the CSSFs.

Materials within the bins should be considered hazardous by nature. Zinc, chromium, mercury, cadmium, and lead are all characteristic wastes but are not RCRA listed wastes.

The experts agree that calcine particle sizes differ according to the type of calcine present in the bins. Calcine within the First CSSF is bigger than the other calcine and has an approximate average diameter of .5 millimeters, while the other calcine has an average diameter of .4 millimeters. The consistency of the calcine is similar to sand. The radiation levels from the different calcines differ as a result of the differing constituents. Some of the other calcine properties are as follows: (1) the First CSSF calcine particle sizes range from between microns and .8 mm, (2) the particle sizes for the second through seventh CSSFs range between .3 and .5 mm, (3) the calcine's specific gravity is between 1.1 and 1.6 grams/cubic centimeter, and (4) the hardness of calcine varies from very soft to very hard (calcine has eroded cyclones, pipe angles/joints, and other equipment).

Waste within the bins will be a mixture of product and fines. The fines are similar in consistency with powdered sugar or clumped powdered sugar, while product is granular like sand. Product is separated from fines during processing and is sent to the storage bins in specific batches. However, fines are sent to the storage bins on a continual basis. As a result, the two will be intermixed within the bins. Although the ratio of fines to product differs within each bin, at least 50% of the calcine volume is fines.

Radiological Concerns

Jim Law indicated that radiation levels within the bins are on the order of hundreds to thousands of R/hr. After removing the calcine from the bins, the radiation levels could still be above tens of R/hr. Calcine is self-shielding and 350 R/hr at 10 feet from the top of the bin should be typical before calcine removal (these numbers where obtained from the First CSSF and were assumed as typical for the other bin sets). Dan Staiger's report has good information on radiological levels.

The Sixth CSSF will have the lowest radiation fields due to the nature of its lower radiological content wastes. CSSFs one through five should have similar radiation field levels.

The CSSFs experts stated that alpha contamination is not a major issue during retrieval and D&D (decontamination and decommissioning) activities for the bins. Alpha radiation is not a major concern due to the shielding already provided by the vaults. Cesium, which is present in the calcine, is a gamma emitter and will require additional shielding to limit personnel exposure.

Structural Conditions

According to Ambika, the First CSSF was made primarily of 415 stainless steel. The Second and Third CSSFs are primarily 304 stainless steel, and the fourth through seventh CSSFs are primarily made of 304L stainless steel. Piping within the new bins (CSSF four through seven) contains Nitronic 60. CSSFs one through three contain 304 stainless steel lines. The Fourth CSSF is mostly 300 series stainless steel or possibly Nitronic 60. Due to the carbon concentrations, 400 series stainless steel does not react well with acid and should be monitored closely during any nitric acid dissolution processes. Brad Norby has done a study on the effects of acid on 400 series stainless steel. The steel could probably withstand a single flush with nitric acid, but should not be permitted to soak. Drawings of the bins should be reviewed to verify the materials.

The First CSSF is set up to fill the center bin first. Once the center bin is full, overflow is sent to the next annular bin. Calcine will be trapped in "nooks and crannies" within these fill lines. The First CSSF vault has been surveyed and was is considered free of contamination. Constant Area Monitors (CAMs) are located on the outlet of the vault's exhaust system to monitor the radiation levels of particles leaving the vault. The vault vents to the atmosphere under normal conditions.

Piping in the cyclone cells could be cut and capped where the lines enter the main vault. There should be no reason to enter the vaults during decontamination activities. The cyclone vaults do not obstruct the retrieval lines to the bins and should be left in place.

All of the welds within the bins and piping are continuous. The bottoms of the vessels are bowl-shaped with the exception of the First CSSF, which is flat. All of the bins have smooth walls and possess expansion joints on the fill lines between the bins and the distributors.

The transport system between the New Waste Calcining Facility (NWCF) and CSSFs 5 through 7 has blinded tees in areas where the pipes bend. These blinded tees allow calcine to be deposited at corners. As a result, the calcine trapped at the piping bends is constantly receiving the erosive forces from incoming calcine, rather than the pipe itself. By doing so, the piping does not wear as quickly. The system is also designed to trap calcine in other locations to prevent erosive conditions (i.e. distributor traps).

In general, the vaults are placed directly over bedrock and are approximately 50% buried. The vaults are designed to be watertight and the retrieval lines are the only way to get into the bins. All of the piping entering the bins penetrates the vault near the top of the bins. A firewater line was broken outside of the First CSSF and water leaked into the vault. This is the only known incident where water has accumulated on a vault floor. Natural evaporation removed the water. There is no procedure for removing water from the vaults at the present time.

The design pressures for the storage bins vary between –6.5 and 8.5 psi. Mike and Maria have summary sheets of the design pressures. The bins are designed to withstand hydrostatic pressures. The vaults are operating under at atmospheric pressure and currently breathe to the atmosphere. They can breathe through HEPA filters in the event that contamination is detected. A new HVAC system will be installed on each set of bins as part of the calcine retrieval project. The First, Second, and Third CSSFs are connected to the Atmospheric Protection System (APS), while the Fourth and Fifth CSSFs vent to the atmosphere. The Sixth CSSF alternates between venting to the APS and to the NWCF.

The First CSSF is structurally unsound according to seismic criteria. Tom Borschell's project was looking at retrieving calcine from the First CSSF and placing it in the Sixth CSSF. Denis McGee is a good contact for information on thermal, structural, and seismic studies that have been performed on the CSSFs.

The First CSSF does not have a lot of extra room on the top of the bins for access lines. In order to grout the bins with fewer access lines, a self-leveling grout would most likely be necessary.

The transport filling lines between WCF and the storage facilities have been capped at the WCF. The transport filling lines are sloped toward the calciner. Transport filling lines for the newer CSSFs (four through seven) are double contained and slope back to NWCF.

Surrounding Soils

CSSFs one, two, and three are surrounded by soils (berms) that were contaminated by calcine spills. The calcine stored in the first three storage facilities was produced by the Waste Calcine Facility (WCF). Soils surrounding bins four through seven are comparable to soils around the rest of the ICPP facility (relatively clean).

The berms surrounding the First CSSF are very restrictive with respect to load limitations. Berms and soil surrounding CSSFs two through seven can handle heavy equipment; however, vehicles can not be driven up the berms. CSSFs two and three do have steam, air, water and transport lines buried in the berms. Denis McGee is a good contact for information on the load limitations.

Miscellaneous Issues

The cyclones in the Second and Fourth CSSFs are full of calcine, while the cyclones in the First and Third CSSFs are not full of calcine. The cyclone for the Fifth CSSF is probably full of calcine, while the Sixth CSSF is currently being filled. The First and Third CSSF bins have not been completely filled with calcine. CSSF bins two, three, and four may be full, but it is has not been verified.

Dolomite is composed of 50% calcium carbonate and 50% magnesium carbonate. It is clean until it enters the bin; at this time it becomes contaminated. Less than 5% of the volume for each bin is dolomite. This material was used as a starting fluidized bed (seedbed) in the calcining facilities. Dolomite doesn't burn, is inexpensive, and is mixed with the calcine throughout each of the bins.

Due to the amount of thermal lines within the bins, a large amount of grout will be needed to encapsulate or stabilize contamination. Diane Croson's group should be a good contact to learn about grout being made out of calcine.

Process piping removed from the vaults and bins can be sent to a debris treatment facility for disposal. Double contained piping is recommended according to best management practices during residual calcine removal. The vault acts as the secondary containment for piping within the vault structure.

Overall Opinions

The experts state that it is better for personnel and the environment to leave the calcine in its present location. The bins are well designed and have double containment for the waste.

Mike and Maria commented that it is best to add grout after the calcine is removed. No other actions should be taken (decontamination). However, if RCRA Clean Closure is the optimum option, wet decontamination is thought to be the best methodology. Air jets will remove a lot of contamination, but not all of it.

Bruce Staples has written a report on the results from the calcine removed from the Second CSSF. None of the other bins have been sampled. At this time, there is no information on volatile organic compounds (VOCs). However, the CSSFs experts indicate that there is no reason to expect the presence of any VOCs.

According to the experts, total removal is not worth the cost, time, or exposure to personnel. The storage facilities are not designed to be taken apart. RCRA Risk-Based Closure, according to Jim Law, could probably be achieved once the waste is retrieved and the bins are shut.

Problems may arise in the future if retrieval regulations change. They may require lower levels of decontamination and retrieval residuals in the bins and piping. Regulations on grouting are not likely to change.

The experts agree that RCRA Clean Closure by total removal is not a reasonable option since: (1) there would be excessive secondary waste generation, (2) a pilot plant for processing the waste is not worth the cost, and (3) personnel exposure would be higher than if the waste was left in place.

Contacts

Name	*Phone*	*Building*	*Mail Stop*	
Maria Dumas	6-3290	CPP 699	5111	Operations Engineer for the CSSF.
James Law	6-3091	CPP 699	5111	Operations for the CSSF.
Mike Swenson	6-3576	CPP 668	5104	Systems Engineer for the CSSF.
Ambika Chakravartty	6-5701	CPP 668	5104	Systems Engineer for the CSSF.
Barry O'Brien	6-3120	CPP 637	5218	Barry has published numbers on the capabilities of retrieval systems.

Dan Griffith	6-3760	CPP 637	5218	Dan is a good contact for questions concerning retrieval. He has performed mock up tests on the storage facilities
Brad Norby	6-3084	CPP 637	5217	Brad has done a study on the effects of acid on 400 series stainless steel.
Tom Borschell	6-1112	CPP 1604	5227	Tom's project is looking at retrieving calcine from the First CSSF and placing it in the Sixth CSSF.
Diane Croson	6-3402	CPP 637	5218	Diane's group should be a good contact to learn about grout being made out of calcine.
Bruce Staples	6-3449	CPP 637	5218	Bruce has written a report on the results from the calcine removed from the Second CSSF.
Denis McGee	6-4486	CPP 668	5104	Denis is a good contact for information on seismic, structural, or thermal calculations that have been performed on the storage facilities.
Julia Tripp	6-3876	CPP 637	5218	Julia could help define how clean the bins must be before closure is complete.
Dan Staiger	6-3122	WCB	3211	Dan has information on radiological levels for the storage facilities.

INEL

ENGINEERING DESIGN FILE

Form L-0431.2#
(05-96-Rev.#02)

Project File Number 015720
EDF Serial Number EDF-BSC-003
Functional File Number ED-01

Project/Task BIN SET CLOSURE STUDY
Sub task Decontamination Scheme Using CO_2

Title: USING CO2 FOR REMOVAL OF RADIOACTIVE WASTE

SUMMARY

Carbon dioxide blasting works by introducing dry ice particles (shavings or pellets) into a high velocity stream (typically air). The dry ice particles are made by taking liquid CO_2 and expanding it to atmospheric pressure. This makes a CO_2 snow, which can then be compressed into a pellet of any predetermined shape and density. The cleaning capabilities of CO_2 blasting primarily result from the momentum transfer between the dry ice particles and the contamination particulate when the dry ice particles impact the surface to be decontaminated and sublime (change from a solid directly to a gas, skipping the liquid phase). Secondary cleaning results from the thermal-mechanical shock resulting from the significantly cooler CO_2 impacting the surface to be decontaminated, which is at ambient temperature, and reverse fracturing. Reverse fracturing is the process by which the solid CO_2 molecules penetrate through the contamination, sublime, thus becoming gaseous and expanding, and push the contamination away from the surface to be decontaminated. This process loosens the contamination and entrains the particles in the gaseous CO_2. In this way, the contaminants can be removed and disposed of without generating any secondary waste. In addition, CO_2 is one and a half times heavier than air, which will help minimize the level of airborne contamination during the decontamination process.

Carbon dioxide blasting has been shown to be one of the most effective means of cleaning radioactive waste[1-6]. In addition, carbon dioxide blasting does not create secondary waste, removes smearable and most fixed contaminants, is nondestructive, can be operated remotely, is readily available and inexpensive, and is safe under normal operating conditions.

Approximately 60 to 72 pounds of CO_2 per hour will be consumed during the decontamination cleaning process.

Several nozzles are available for carbon dioxide blasting. Various nozzles are discussed in more detail in Appendix B.

Both one and two hose systems are available for surface blasting using CO_2. The two hose system is more efficient, as it reduces the degree to which the CO_2 melts before it reaches the nozzle.

(Continued on next page)

Distribution: B.C. Spaulding, M.M. Dahlmeir, B.R. Helm, D.J. Harrell and Project File (original #1) [Note: Distribute the first 2 pages (pages 1 and 2) only]

Authors	Department	Reviewed	Approved
K.D. McAllister	4130	M.M. Dahlmeir	B.C. Spaulding
Date 1-13-98		Date 1-13-98	Date 1/13/98

Summary (Continued),

As per conversations with Russ Lawler, Alpheus Cleaning Technologies Corp. representative (800-445-6131 ext. 254):

1. Dry ice shavings (shaved from CO_2 blocks) are recommended for bin decontamination.
2. A 200 cfm, 50 hp air compressor is recommended for bin decontamination.
3. A 1 inch hose is necessary to connect the air compressor to the CO2 blasting machine.
4. An air dryer/separator must be installed between the air supply and the CO_2 blasting machine to prevent complications resulting from water collecting inside the machine.
5. The Alpheus model SDI CO_2 blasting machine is recommended for bin decontamination. This model is completely pneumatic and has a 120-pound CO_2 block or pellet capacity.
6. Two ¾ inch hoses connect the SDI pellet blasting machine to the nozzle.
7. Up to 100 feet of ¾ inch hose can be used without affecting the decontamination cleaning ability.
8. Nozzle-end generates 25 psi back thrust, or 200 psi pressure. The nozzle pressures can be eliminated with a commercially available nozzle attachment.
9. Nozzle must be 3-8 inches away from the surface for effective decontamination.

Appendix A

Reference papers pertaining to CO_2 blasting studies.

Appendix B

Vendor information

References:

1. "Decontamination Technology Investigation Report", Joe Manhardt, April 1994.
2. "CO_2 Pellet Blasting Literature search and Decontamination Scoping Tests Report", K.E. Archibald, Dec. 1993,
3. "EG&G Rocky Flats Plant Waste Minimization program Carbon Dioxide Cleaning Pilot Project", L. Knight and T.E. Blackman, Dec. 1992,
4. "Innovative Approaches to improve Decontamination—The TECHXTRACT Technology", R.E. Borah, M.W. Bonem, April 1994,
5. "Evaluation of Pelletized Carbon Dioxide As a Fluidized Abrasive Agent For Removal of Radioactive Contamination", R.J. Dabolt.
6. "CO_2 Pellet Blasting Studies", K.E. Archibald, January 1997, INEL/EXT-97-00117

APPENDIX A

REFERENCE PAPERS

EG&G ROCKY FLATS PLANT
WASTE MINIMIZATION PROGRAM

CARBON DIOXIDE CLEANING PILOT PROJECT

Prepared by:

LaVelle Knight
Thomas E. Blackman

December 21, 1992

REVIEWED FOR CLASSIFICATION/UCNI
By M.D. [illegible]
Date 12.21.92

Following construction of the containment structure[2], two testing periods were established: one for 30 days, the second for 45 days. Each period consisted of a contractor bringing in a machine to be evaluated based on the following criteria: pellet density, carbon dioxide usage, equipment performance, decontamination effectiveness, pellet production capacity, and equipment reliability.

The first equipment system tested was an Alpheus Model 250 supplied by Environmental Alternatives, Inc. (EAI). The test period for this system lasted approximately 35 days. The second equipment system evaluated was a Cold Jet Model RDS 1000J provided by Environmental Control Division, Inc. (ECD). The evaluation period for this system lasted approximately 20 days. The test period was reduced from the anticipated 45-day time frame when it was learned that extensive containment structure modifications would be required in order to solve problems experienced with the equipment.

Although differing in design, each system uses essentially the same basic method to clean material. The method is to create a carbon dioxide "snow" from liquid carbon dioxide. This snow is then pushed through a die compressing the snow and creating hard pellets of carbon dioxide.

In the Alpheus system, these pellets are inserted into a high pressure (40 to 250 psi) dried air stream and shot at a high velocity at the material to be cleaned. The pellets, upon impact with the material to be cleaned, penetrate through the surface coating to the substrate. When the pellets impact the substrate, they sublime into a carbon dioxide gas expanding 400 times the pellet's original volume. This action acts as a "gas wedge" separating the surface coating from the substrate. After the pellets sublime, they become part of the atmosphere and there is no secondary waste requiring disposal. (For our purposes, secondary waste is considered to be by-products often associated with other cleaning methods, such as abrasive grit or solvents.)

In contrast, the Cold Jet process uses the CO_2 pellets to create a thermal shock effect causing a rapid change in the temperature of the material on the substrate. The material contracts and freezes, separating the radioactive material from the substrate.

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[2] The dimensions of the containment structure are 20 feet long x 12 feet wide x 10 feet high. The materials utilized for the containment structure are 20 gauge brushed stainless steel quarter-inch thick Lexan (a type of Plexiglass) panels. The structure was manufactured by Item Products, Inc. It had a modular construction method that allowed easy modification as well as assembly. This feature was especially useful during the assembly of the structure when it was determined that it was too large for the available space. We had to shorten the width from 16 feet so that forklifts would have clearance on one side. We also had them attach brackets for two (2) roughing filters for the air movers with HEPA filters. We also had them attach a row of three (3) intake filters on the roof and one (1) intake filter on a wall.

EQUIPMENT OPERATION

Both machines use a pelletizer to manufacture pellets, an air compressor, an air dryer, and a liquid carbon dioxide storage tank. One difference in equipment operation is the Cold Jet combines the pellets with the dried air in another piece of equipment called a hopper and delivers the pellets to the nozzle of the gun by means of a single hose. The Alpheus uses a patented two-hose delivery system where the dried, high pressure air and the pellets are delivered to the gun in separate hoses. This is done to try to maintain pellet size and shape from the pelletizer to the gun.

One advantage of the Cold Jet one-hose system is that it is more mobile than the Alpheus system. (Alpheus does market other equipment with a similar mobility.) A disadvantage in the one-hose system design was discovered when a rock entered the system and lodged in the nozzle of the gun. This caused all of the pellets to sublime before exiting the nozzle. Had the Cold Jet had a closed system, this would not have been a problem[3].

The two systems used slightly different ways of producing pellets, but the end result was dramatically different. The Alpheus system utilized a mechanical roller that continuously pushes the carbon dioxide snow through a die. As the product exits the die, the material is cut into uniform lengths and density. In contrast, the Cold Jet utilizes a hydraulic ram that packs snow against the die and then pushes the snow through the die. As the product exits the die, the material breaks off as a result of its own weight, producing pellets of uneven length and consistency.

Another observation learned during the test period was that neither machine is totally efficient in its use of pellets. When the trigger of the Alpheus system is not operating, the pelletizer discharges its pellets to the ground. On the other hand, since the Cold Jet pellets are made at a slower rate than the nozzle discharges them, the operation of this system requires a supply of pellets to be on-hand before cleaning operations are initiated. This also requires that when the cleaning procedure starts, pellets have to be manually moved from insulated containers to the hopper, as well as directly from the pelletizer to the hopper. In addition, once cleaning operations were started, the equipment contractor recommends not allowing the trigger of the nozzle to be shut off until all the pellets in the hopper are used. Consequently, pellets are wasted using this system, as well as when cleaning operations cease. Although each system has some pellet waste associated with it, this cost is not considered significant.

Another consideration is that because the Cold Jet uses a hydraulic system, there is a possibility the seals could leak and contaminate the pellets with hydraulic fluid. This possibility is unique to the Cold Jet design, but neither RFP nor the vendor that operated the equipment (ECD) has ever experienced this problem.

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[3] It is thought that a shovel used to load pellets into the hopper must have been dirty, thus allowing debris to become mixed with the pellets.

TEST PROCEDURE AND DATA

An operational goal of the test program was to achieve the most efficient operation as possible - that is, to get as much material cleaned and prepared for disposal in the shortest time. To meet the free-release criteria, the material needed to meet the following standards as established by RFP Health and Safety Practices manual, Section 18.10:

	Removable	Fixed Plus Removable
Alpha	20 dpm/100 cm2	500 dpm/100 cm2
Beta and Gamma	1,000 dpm/100 cm2	5,000 dpm/100 cm2

All material cleaned in this program met or exceeded these residual radioactivity reduction criteria.

Another goal of the project was to better define the cleaning operation, that is, to define what production rates could be achieved given their operating conditions, and to determine how the operation could be made more efficient and economical.

ECONOMIC ANALYSIS

The primary avenue for disposing of low-level waste material at RFP today is to ship it by truck to the Nevada Test Site (NTS). Any alternative disposal method considered has to be measured against this practice. The cost of preparing and shipping a standard 5,000 pounds of waste to Nevada is calculated to be $16,851[4].

It is estimated that the cost of operating the Alpheus system is $297 per hour[5]. If the system were capable of cleaning 100 pounds of material per hour, the cost of cleaning the standard 5,000 pounds would be $14,850; a savings of $2,001 relative to the $16,851 cost of shipping 5,000 pounds to Nevada. In comparison, if the cleaning rate were 50 pounds per hour, the cost of cleaning 5,000 pounds of material would be $29,700, or a cost increase of $12,849 relative to the standard cost. Using this same calculation process, it was determined that the cleaning rate necessary to break even would be approximately 90 pounds per hour[6].

With this benchmark reference established, a primary objective of the study was to determine if the carbon dioxide cleaning system was economical. To get the data required to make such an

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[4] See Appendix 1, Page 8, for cost breakdown.

[5] See Appendix 1, Page 9, for exact cost breakdown.

[6] See Appendix 1, Page 10, for comparison of various rates.

assessment, a data sheet assigning a control number to each item to be cleaned was established. Information, such as estimated weight for each item, time spent cleaning the item, dimensions, and final radiological conditions were recorded.

RFP solid waste operations personnel were utilized to record necessary information to complete each data sheet. An equipment operations log was also maintained to track equipment downtime, carbon dioxide usage, cleaning time, and material items cleaned referenced by control number.

Each contractor was required to have personnel onsite for 15 working days to run their equipment and clean material. During this period, RFP personnel were trained on how to operate the equipment. The equipment manager would stay for the duration of the testing period to run the equipment and provide any assistance to newly trained RFP personnel after the 15 day period.

TESTING PROBLEMS

Neither machine performed flawlessly. In the third week of operation, the Alpheus developed problems in the pellet production process. After extended periods of operation, the pellet-making equipment would freeze preventing further production of pellets until the equipment thawed and dried out. The problem was later determined to be caused by a screw loose during transportion of the machine to RFP. EAI decided after two attempts to correct the problem in the field. It would be more prudent to replace the machine to minimize the amount of downtime. To regain lost time, the test period was extended one week. Other small problems occurred, such as the diesel compressor battery failing to hold a charge, resulting in small periods of downtime. There were no problems with the nozzle-gun or the operations inside the containment structure.

With the Cold Jet, more serious problems were experienced that proved to be too difficult to resolve in the test period. The difficulty was that the equipment created hazardous working conditions for personnel in the containment structure, namely carbon dioxide levels were too high and oxygen levels were too low. With the ventilation rate at 2,000 cubic feet per minute (cfm) in the containment room, it was possible to keep the carbon dioxide levels within the threshold limit value (TLV) of 5,000 parts per million (ppm) for an eight-hour period while operating the Alpheus equipment. However, while operating the Cold Jet equipment, carbon dioxide levels increased significantly and were measured at 25,000 ppm, one minute after beginning operations. Oxygen levels during this same period ranged from 18.8% to 19.4% within a three minute period. The Occupational Safety and Health Administration (OSHA) required range for oxygen is 19.5% to 22.0%.

Another problem experienced was moisture. The Cold Jet machine lowered the temperature of the object being cleaned so much that ice formed during cleaning. The ice eventually melted, but the cleaning process caused moisture to build up in the room as the water evaporated. The roughing filters used to capture larger particles as air exited the containment room became clogged with moisture, lowering the efficiency of the air movers and taking longer for the air in the room to change over. Further, this caused the dew point to drop, forcing more water to condense, clogging the filters even more. This cycle aggravated the carbon dioxide and oxygen problems discussed earlier.

The only way to break this cycle would be to add more air movers and a de-mister filtration system. This would have required re-engineering and modification of the containment structure. Given the short time frame to work with, this was not possible. The test was canceled.

TEST ANALYSIS AND TRENDS

The cleaning rate for the entire period the Alpheus machine was being evaluated averaged 52.3 lbs/hr. This rate included a three week training period for RFP personnel. Once the personnel became proficient in operating the equipment, the rate jumped to 72 pounds per hour. During five of the last 14 days of the evaluation period, a cleaning rate of more than 90 lbs/hr was achieved[7].

A regression analysis performed on the data shows that the average had not yet reached its highest point[8]. With more time, the overall average would have increased.

Another trend discovered is that although the material items being cleaned have similar sizes and shapes, the amount of material that can be cleaned in a given time period increases. Experience in cleaning the material seems to be a more important factor than does the surface area when it comes to increasing the cleaning rate.

The value of experience is easily explained by an example. During one four day cleaning period, workmen achieved a cleaning rate of 50 pounds per hour for the first two days while cleaning angle and channel iron. The rate climbed to above 90 pounds per hour during the second two-day period as their experience level increased. Not only do the personnel know the best cleaning methods after cleaning similar items, but they also get familiar with the contamination level[9] so they know what rate to move the gun over the surface of the material.

One area that we did not measure was the difference in cleaning heavily contaminated items versus lightly contaminated items. That was going to be tested during test of the Cold Jet equipment, but since the testing period was curtailed, this was not possible.

DISCUSSION AND RECOMMENDATIONS

As recently as three years ago, it was a common practice to clean material as was used in this project using solvents and other hazardous chemicals, such as Methylene Chloride. However, since the passage of the Resource Conservation and Recovery Act (RCRA), this option is no longer available, and offsite disposal has become the acceptable practice. However, even this practice has its consequences, and viable alternatives are sorely needed.

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[7] See Appendix 2, Page 11, for detailed information.

[8] See Appendix 2, Page 12.

[9] Contamination is measured by a RPT using standard survey techniques.

This project should demonstrate that carbon dioxide cleaning is an alternative cleaning system that merits further consideration. As has been seen, this process is capable of removing low-level contamination from material in a production setting. Once the material is decontaminated, another option is now available - recycling. This material would have otherwise been sent to NTS as low-level waste since cleaning with a solvent is not permitted, and the labor intensive method using scrub brushes is prohibitively expensive. The process of using carbon dioxide has the advantage of leaving no secondary waste requiring disposal. The radioactive particles that are blasted off of the material are filtered out of the air using a HEPA filter.

This pilot test program has shown that the break even cleaning rate of 90 pounds per hour has been achieved and surpassed thereby providing evidence that an economical alternative to shipping material offsite does exist.

The technology of carbon dioxide cleaning is new. Given technological improvements, increased personnel experience, and expanded facilities, it is logical to conclude that improved cleaning rates will be achieved making this process an even more economically viable alternative to offsite disposal.

In November 1992, 406 pieces of metal cleaned using the carbon dioxide process and subjected to stringent inspection requirements were approved for unconditional release. This action provides strong evidence of the viability and value of this cleaning technology. Without this project, this material would have been crated and shipped away for underground disposal at a cost of approximately $17,000 per 5,000 pounds.

In light of the political sensitivity of sites such as NTS, a system such as the carbon dioxide cleaning process, should be given serious consideration as a solution to solving low-level waste issues at all DOE sites.

APPENDIX 1

COMPARISON OF SHIPPING VS. CO_2 CLEANING

Transporting Cost (Labor)	Shipping	CO2 Cleaning
Within 800 area, an average of 5 times	$ 85.00	$ 85.00
From within 800 area to outside of 800 area.	62.00	62.00
Subtotal	$ 147.00	$ 147.00
Size Reduction		
Labor	$14,553.00	$11,286.00
Non-Labor	464.00	.00
Real-Time Radiography	134.00	.00
Certify Waste and Load Traveler	193.00	.00
Subtotal	$15,345.00	$11,286.00
NTS Shipment		
Cost per Truckload ($2,150.00)		.00
Crates per Truckload (9)		
Cost for One Crate	239.00	
NTS Disposal ($10.00/f^{3})	1,120.00	.00
Subtotal	$16,851.00	$11,433.00

This assumes the CO_2 rate of cleaning is 130 lbs/hrs

APPENDIX 1 (cont.)

COST ANALYSIS FOR RUNNING CO_2 BLASTER WITH IN-HOUSE EQUIPMENT
(UPDATED AUGUST 10, 1992)

BLASTER USAGE COST

• Cost for in-house Kilowatt Hour	$		.04
• Kilowatt usage of C02 Blaster		17	
• Cost due to electricity usage (per hour)			.68
• Average cost of liquid C02 (per pound)	$		.07
• Average amount of C02 used (lbs/hr)		250	
• Cost due to C02 (per hour)			17.50
Subtotal	$		18.18

COMPRESSOR USAGE COST FOR 250 psi UNIT

• Average amount of diesel fuel used (gal/hr)		14	
• Average cost of diesel fuel used (per gal)	$		1.11
• Safety factor of estimating		1.5	
• Cost due to compressor fuel usage (per hr)			23.31
Subtotal	$		23.31

LABOR COST

• Number of people to clean material		2	
• Foreman		1	
• RPT coverage time	$		.25
• Average pay per person (per hour)			78.50
• Cost due to labor per hour			255.12
Subtotal	$		255.12
Total Cost per Hour	$		296.70

APPENDIX 1 (cont.)

Rate of Cleaning (lbs/hr)	Amount to be Cleaned (lbs)	Hours Required	Total Cost of Cleaning
10	5,000	500	148,500
20	5,000	250	74,250
30	5,000	167	49,599
40	5,000	125	37,125
50	5,000	100	29,700
60	5,000	83	24,651
70	5,000	71	21,087
80	5,000	63	18,711
90	5,000	56	16,632
100	5,000	50	14,850
110	5,000	45	13,365
120	5,000	42	12,474
130	5,000	38	11,286

Initial capital-cost for $C0_2$ Blaster and support equipment.

$ 107,000	Alpheus Model 250 with gun and hose
81,000	Compressor
46,000	$C0_2$ storage tank
21,000	Air Dryer
$ 255,000	**Total Cost**

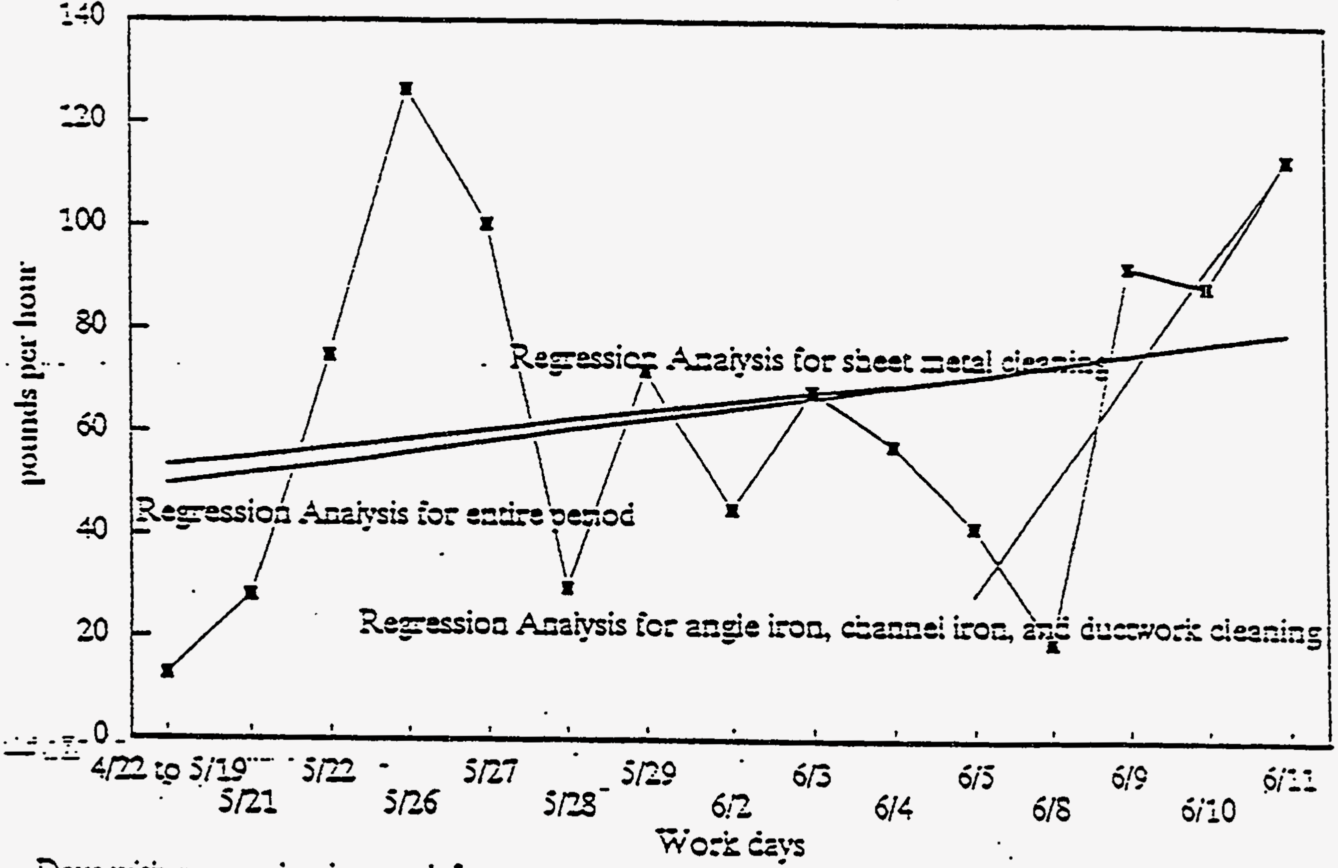
APPENDIX 2

PRODUCTION OF MATERIAL ANALYSIS FOR ALPHEUS CO_2 BLASTER

Date	Minutes Spent Cleaning	Weight of Material Cleaned (lbs)	Production (lbs/hr)
4/22	0	0	
4/23	40	0	
4/24	40	35	
4/27	60	0	
4/28	165	0	
4/29	70	15	
4/30	180	?	
5/1	175	?	
5/4	120	?	
5/5	160	?	
5/6	55	?	
5/7	125	?	
5/8	90	?	
5/11	90	?	
5/19	160	68.4	25.65
Summation of 4/22 to 5/19	1,530	321.9	12.62
5/20	0	0	0.00
5/21	120	56.5	28.25
5/22	180	224.8	74.93
5/26	130	274.5	126.69
5/27	340	570	100.59
5/28	190	94	29.68
5/29	350	420	72.00
6/1	0	0	0.00
6/2	320	240	45.00
6/3	370	420	68.11
6/4	375	360	57.60
6/5	115	80	41.74
6/8	120	38	19.00
6/9	375	577	92.32
6/10	280	414	88.71
6/11	90	170.5	113.67
Summation of all	4,885	4,261.2	52.34
Summation of second half	3,355	3,939.3	70.45
Average excluding first three weeks and 5/21:	3,235	3,882.8	72.01
Average daily production rate with the first two weeks as one day:			61.23

Pounds per Hour

for ALPHEUS CO2 blaster APPENDIX 2



Days with no production are left out

APPENDIX 3
CONTROL NUMBER RECORD

		Length						
Control Number	Type	Width (Inches)		Height (Inches)	Volume (Inches)	Time Period	Weight (pounds)	Total Weight
1	sheet	20	48	0.125	120	4/22 to 5/19	30	30
2	sheet	23.38	48	0.125	140.25	4/22 to 5/19	35	35
3	sheet	20	48	0.125	120	4/22 to 5/19	30	30
4	sheet	20	48	0.125	120	4/22 to 5/19	30	30
5	pallet	30	48	0.125	150			
	support	4	40	1.5	47.5			
	total				197.5	4/22 to 5/19	35	35
6	pallet	30	40	0.125	150	4/22 to 5/19	62.5	62.5
7	pallet	24	24	0.125	72	4/22 to 5/19	19	19
8	support	3	24	2	24	4/22 to 5/19	6	6
9	support	3	24	2	24	4/22 to 5/19	6	6
10-66	sheet	12	12	0.125	18			
	with round							
	hole of							
	10.5 diam				10.8238			
	total				7.17623	4/22 to 5/19	1.2	68.4
67								
68	sheet	20	48	0.125	120	5/21	30	30
69	channel	42	5	2	52.5			
	angle	6	3	0.125	2.25		-	
	total				54.75	5/21	26.5	26.5
70-213	sheet	12	12	0.125	18			
	with round							
	hole of							
	10.5 diam				10.8238			
	total				7.17623	5/22	1.2	172.8
214-221	sheet	16	16	0.125	32			
	with round							
	hole of							
	12 diam				14.1372			
	total				17.8628	5/22	6.5	52
222-254	sheet	16	16	0.125	32			
	with round							
	hole of							
	12 diam				14.1372			
	total				17.8628	5/26	6.5	214.5
255	sheet	20	48	0.125	120	5/26	30	30
256	sheet	20	48	0.125	120	5/26	30	30
257-275	sheet	20	48	0.125	120	5/27	30	570
276	sheet	20	48	0.125	120	5/28	30	30
277	sheet	20	48	0.125	120	5/28	30	30
281	ductwork	8	28	0.125				
	flange	27	14	0.125		5/28	17	17
282	ductwork	8	28	0.125				

Control Number	Type	Length Width (inches)		Height (inches)	Volume (inches)	Time	Period		Weight (pounds)	Total Weight
	flange	27	14	0.125		5/28			17	17
283-288	sheet	20	48	0.125	120	5/29			30	180
289-293	sheet	20	48	0.125	120	5/29,	6/2		30	150
294	sheet	20	48	0.125	120	5/29			30	30
295	sheet	20	48	0.125	120	5/29,	6/2,	6/3	30	30
296	sheet	20	48	0.125	120	5/29,	6/2		30	30
297-300	sheet	20	48	0.125	120	6/2			30	120
301-304	sheet	20	48	0.125	120	6/2			30	120
305-318	sheet	20	48	0.125	120	6/3			30	420
319-330	sheet	20	48	0.125	120	6/4			30	360
333	sheet	20	48	0.125	120	6/5			30	30
334	sheet	20	48	0.125	120	6/5			30	30
335	angle	48	3	2 ✓	12.75	6/5			20	20
330a	angle	3	3	40.5 ✓	30.375	6/8			17	17
331a	channel	5	2	32.5	36.5625	6/8			21	21
332a	angle	3	3	33 ✓	24.75	6/9			13	13
334a	channel	5	2	45	50.625	6/9			25	25
335a	channel	6	2	48 ✓	60	6/9			44.5	44.5
335b	channel	3	2	44 ✓	33	6/9			15.5	15.5
336	channel	3	2	43.5 ✓	38.0625	6/9			15.5	15.5
337	angle	3	3	33 ✓	24.75	6/9			13.5	13.5
338	angle	3	3	42 ✓	31.5	6/9			17	17
339	channel	5 .75	2	28 2.33 ✓	31.5	6/9			15	15
340	channel	4 .66	2	31.5 2.62 ✓	31.5	6/9			19	19
341	channel	5 .75	2	33 2.75	37.125	6/9			18.5	18.5
342	angle	5 .75	2	33 2.75 ✓	28.875	6/9			13.5	13.5
343	channel	6 .83	2	60 5.00	75	6/9			54	54
344	channel	5 .75	2	55 4.58 ✓	61.875	6/9			32.5	32.5
345	channel	5 .75	2	47 3.91	52.875	6/9			28	28
346	channel	5 .75	2	28 2.33 ✓	31.5	6/9			20.5	20.5
347	angle	3 .75	3	15.5 1.29 ✓	11.625					
	angle	3 .75	3	15.5 1.29	11.625					
	angle	3 .75	3	11 .91	8.25					
	square	6		10 .83 ✓	7.5					
	total				39	6/9			21	21
348	channel	5 .75	2	11 .91 ✓	12.375	--				
	angle	2 .5	2	13 1.08	6.5					
	total				18.875	6/9			11	11
349	channel	5 .75	2	11 .91 ✓	12.375					
	angle	2 .75	2	13 1.08 ✓	6.5					
	total				18.875	6/9			11.5	11.5
350	angle	3 .75	3	12 1	9					
	angle	3 .75	3	2 .167	1.5					
	square	6		10 .83	7.5					
	total				18	6/9			10	10
351	channel	4 .66	2	48 4.00	48	6/9			28.5	28.5

Control Number	Type	Length		Volume (inches)	Time	Period	Weight (pounds)	Total Weight
		Width (inches)	Height (inches)					
352								
353								
354	channel	4 .66 2	48.5 4.04	42.4375				
	channel	4 .66 2	2.5 .170	2.1875				
	total			44.625	6/9		30.5	30.5
355	channel	3 .58 2	43.5 3.6	32.625	6/9		15.5	15.5
356	channel	3 .54 2	43 3.5	32.25	6/9		15.5	15.5
357								
358	angle	3 .75 3	8.5 .70	6.375	6/9		3.5	3.5
359	channel	6 .83 2	13 1.06	16.25	6/9		12	12
360	angle	3 .75 3	8.5 .70	6.375	6/9		3.5	3.5
361	angle	3 .75 3	7.5 .62	5.625	6/9		3	3
362	angle	3 .75 3	8.25 .687	6.1875	6/9		3.5	3.5
363	channel	6 .83 2	14.5 1.2	18.125	6/9		13.5	13.5
364	angle	3 .75 3	12.5 104	9.375				
	angle	3 .75 3	7 .58	5.25				
	angle	3 .75 3	2.5 .20	1.875				
	sheet	10 .83	6 .5	7.5				
	total			24	6/9		13.5	13.5
365	angle	3 .75 3	47.5 3.9	35.625	6/9		20	20
366	angle	3 3	39 3.25	29.25	6/9		16	16
367	angle	3 3	30 2.5	22.5	6/10		12.5	12.5
~~368~~	~~angle~~	~~3 3~~	~~31 2.58~~	~~23.25~~	~~6/10~~		~~12.5~~	~~12.5~~
369	angle	3 3	48 4.0	36	6/10		20	20
370	angle	3 3	48 4.0	36	6/10		18.5	18.5
371	angle	3 3	37.75 3.14	28.3125	6/10		15.5	15.5
372	angle	3 3	33 2.75	24.75	6/10		13	13
373	angle	3 3	33 2.75	24.75	6/10		13.5	13.5
374	angle	3 3	28 2.33	21	6/10		11.5	11.5
375	angle	3 3	37.75 3.14	28.3125	6/10		15.5	15.5
376	angle	3 3	36 3.0	27	6/10		14.5	14.5
377	angle	3 3	38.5 3.2	28.875	6/10		16	16
378	angle	3 3	36 3.0	27	6/10		14.5	14.5
379	angle	3 3	38.25 3.18	28.6875	6/10		16	16
380	angle	3 3	39.5 3.29	29.625	6/10		16.5	16.5
381	angle	3 3	31 2.58	23.25	6/10		12	12
382	angle	3 3	36.5 304	27.375	6/10		15	15
383	angle	3 3	26 2.16	19.5	6/10		10	10
384	angle	3 3	36.5 3.04	27.375	6/10		15	15
385	angle	3 3	15 1.25	11.25	6/10		6	6
386	angle	3 3	37.25 3 0	27.9375	6/10		15.5	15.5
387	angle	3 3	12.75 1.06	9.5625	6/10		5	5
388	angle	3 3	31.5 2.6	23.625	6/10		13	13
389	angle	3 3	37.5 3.12	28.125	6/10		15.5	15.5
390	angle	3 3	36.75 3.06	27.5625	6/10		15	15
391	angle	3 3	35.25 2.9	26.4375	6/10		14.5	14.5
392	angle	3 3	34 2.83	25.5	6/10		14	14
393	ductwork	10. 5	50.5 4.20	49.5782	6/10		16	16

		Length							
Control Number	Type	Width (inches)		Height (inches)	Volume (inches)	Time	Period	Weight (pounds)	Total Weight
394	ductwork	10	5	50.5 10.5	49.5782	6/10		17.5	17.5
395	ductwork	12	6	53 13.356	62.4391	6/10		20	20
396	ductwork	10	5	55 11.45	53.9961	6/11		20	20
397	ductwork	10	5	55 11.45	53.9961	6/11		16.5	16.5
398	ductwork	8	4	48 8	37.6991	6/11		14	14
399	ductwork	8	4	48 8	37.6991	6/11		14	14
400	ductwork	10	5	56 11.6	54.9779	6/11		18.5	18.5
401	ductwork	10	5	56 11.6	54.9779	6/11		19	19
402	ductwork	12	6	25 7.5	29.4524	6/11		14	14
403	ductwork	12	6	35 10.5	41.2334	6/11		15.5	15.5
404	ductwork	12	6	34 10.2	40.0553	6/11		13.5	13.5
405	ductwork	12	6	27 8.16	31.8086	6/11		11.5	11.5
406	ductwork	12	6	32 9.6	37.6991	6/11		14	14

5

2.5 → 30

4.58

36 → 3.6

18

18" 12" 6

30"

WINCO-1180
December 1993

CO$_2$ PELLET BLASTING LITERATURE SEARCH AND DECONTAMINATION SCOPING TESTS REPORT

K. E. Archibald

IDAHO NATIONAL ENGINEERING LABORATORY
Managed by the U.S. Department of Energy

Prepared for the
U.S. Department of Energy
Idaho Field Office
Under DOE Contract No. DE-AC07-84ID12435

Westinghouse Idaho Nuclear Company. Inc.
Idaho Falls, Idaho 83403

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ABSTRACT

This evaluation report is a summary of the research efforts and scoping tests using the CO_2 pellet blasting decontamination technique. The purpose of these scoping tests was to determine the effectiveness of this decontamination technique in a variety of situations.

CONTENTS

FIGURES

TABLES

ACRONYMS

DF	decontamination factor
ICPP	Idaho Chemical Processing Plant
NWCF	New Waste Calcine Facility
SIMCON	simulated contamination
WINCO	Westinghouse Idaho Nuclear Company
XRF	x-ray florescence
EG&G	Edgerton, Germeshausen and Grier
ECD	Environmental Control Division

CO_2 Pellet Blasting Literature Search And Decontamination Scoping Tests Report

1.0 INTRODUCTION

Past decontamination and solvent recovery activities at the Idaho Chemical Processing Plant (ICPP) have resulted in the accumulation of 1.5 million gallons of radioactively contaminated sodium-bearing liquid waste. Future decontamination activities at the ICPP could result in the production of 5 million gallons or more of sodium-bearing waste using the current decontamination techniques of chemical/water flushes and steam jet cleaning. Chemical decontamination flushes have been used and studied for the last ten years and have provided a satisfactory level of decontamination. However, this method requires repetitive flushes to achieve a clean surface while generating large amounts of sodium-bearing secondary waste. Steam jet cleaning has also been used with a great deal of success but cannot be used on concrete or soft materials. With the curtailment of reprocessing at the ICPP, the focus of decontamination is shifting from maintenance for continued operation of the facilities to decommissioning. As decommissioning plans are developed, new decontamination methods must be used which result in higher decontamination factors and generate lower amounts of sodium-bearing secondary waste.

Treatment of sodium-bearing waste is a particularly difficult problem due to the high content of alkali metals in the sodium-bearing liquid waste. It requires a very large volume of cold chemical additive for calcination. This is due to the low melting points of the sodium and potassium salts which contribute to the agglomeration of salts in the bed of the calciner. In addition, the sodium content of the sodium-bearing waste exceeds the limit that can be incorporated into vitrified waste without the addition of glass-forming compounds (primarily silicon) to produce an acceptable immobilized waste form.

The primary initiatives of the WINCO Decontamination Development Program is the development of methods to eliminate/minimize the use of sodium-bearing decontamination chemicals and to minimize all liquid decontamination wastes. One method chosen for cold scoping studies during FY-93 was CO_2 pellet blasting. CO_2 pellet blasting has been used extensively by commercial industries for general cleaning. However, using this method for decontamination of nuclear materials is a fairly new concept. The following report discusses the research and scoping tests completed on CO_2 pellet blasting. (Statements relating to particular products are not intended as factual certainties but rather reflect the opinion and belief of the author).

2.0 LITERATURE RESEARCH

The CO_2 pellet blasting system consists of liquid CO_2 at 200-300 psig, which is transported through a hose to a pelletizer machine where rapid expansion of the liquid in the chamber converts the CO_2 to a solid state of dry ice or snow. The snow is then compressed into pellets which are transported through a hose at 40 psig to a blasting nozzle. At the nozzle, the pellets are entrained in high pressure air (40-250 psig) and propelled from the nozzle onto the workpiece at 75-1000 feet per second. Another alternative is to transport the pellets through the hose with the high pressure air. The CO_2 pellet penetrates the coating (mechanical abrasion), "mushrooms" under the coating as it strikes the substrate, and then sublimes causing the coating to fall off leaving only the coating as waste while the CO_2 pellet returns to its natural state.

CO_2 pellet blasting is a non-destructive decontamination method. NDC (Non-Destructive Cleaning) has conducted studies and comparisons of CO_2 pellet blasting and water based decontamination systems. In their studies, they found that a laminar boundary layer of the water-based decontamination systems prevents the water from getting into the small fissures in the metal to remove contamination. Since the laminar boundary layer of the CO_2 gas is such smaller, the gas is able to penetrate the smaller fissures and remove more contamination.

2.1 Technical Performance

2.1.1 Operability/Simplicity

There are two basic CO_2 pellet blasting systems used in commercial and private industries. The two systems use the same basic equipment, but vary in the transportation and manufacturing of pellets. The Cold Jet System combines the pellets with dry air into one hose. The Alpheus System uses a two hose system, one hose for air and one for pellets.[7] The major problem with a one hose system is any kind of obstruction (such as an obstruction in the nozzle) causes the pellets to begin to sublime before they exit the nozzle.

The manufacturing of pellets also varies depending on the CO_2 pellet system being used. The Cold Jet utilizes a hydraulic ram that packs carbon dioxide snow against and then pushes the snow through a die. As the product exits the die, the material breaks off as a result of its own weight, producing pellets of uneven length and consistency. The Alpheus system utilizes a mechanical roller that continuously pushes the carbon dioxide snow through the die. As the product exits the die, the material is cut into pellets of uniform length and density.

Pellet usage and production by both systems is not totally efficient. When the trigger of the Alpheus system is not operating, the pelletizer discharges its pellets to the ground. From complete shutdown to start-up, the Alpheus system takes 20 minutes to produce pellets. Because the Cold Jet pellets are made at a slower rate then the nozzle discharges them, this operation requires a supply of pellets to be on hand or a waiting period must be considered before operations are initiated.

Rocky Flats has done a comparison of both the Cold Jet System and the Alpheus System.[1] They found that neither system performed flawlessly. The Alpheus System problems were more mechanical type problems like screws being loose or the failure of the diesel compressor battery. The Cold Jet System problems were more cleaning and design type problems. The Cold Jet System created hazardous working conditions for personnel in the contamination structure, namely the carbon dioxide levels were too high and the oxygen levels were too low. This indicates a large ventilation system will be required. Also, the Cold Jet System lowered the temperature of the object being cleaned so much that ice formed during cleaning. Although the ice eventually melted, the cleaning process caused moisture to build up in the room as the water evaporated. The roughing filters used to capture larger particles as they exited the contaminated room became clogged with moisture, lowering the efficiency of the air movers and taking longer for the air in the room to change. Therefore, Rocky Flats recommend the Alpheus system.

Vermont Yankee Nuclear Power Plant decontamination personnel indicated one of the most puzzling problems encountered when first using the Alpheus System was the inconsistent decontamination rates.[2] Irregular production and delivery of the CO_2 pellets was finally determined to be the cause. To correct the problem, the air dryer was adjusted to eliminate the frost build-up that was restricting the flow of pellets.

The CO_2 pellet blasting system can been used either inside or outside a module, depending on what is being decontaminated. For decontaminating in nuclear facilities, modules are usually built on site, however, there are companies that build modules that contain CO_2 pellet blasting systems. One module of particular interest is constructed of steel which combines a CO_2 pellet blasting system and a liquid abrasive grit blasting system into one module. It can be switched from one to the other by a switch on the outside panel. The module has a collection tray covered by a metal grating located at the bottom of the module for collection of both liquids and solids. The inside walls are covered with rubber liner to reduce noise and help protect the walls. All items being decontaminated are placed on a rolling tray inside the module. After the system has been used for long periods of time, the walls and floor are cleaned using the CO_2 pellet blaster.

There is also a CO_2 pellet blasting system which is located inside a mobile decontamination facility. The facility is housed in a stand alone, transportable, steel enclosure which can range in size from 16 x 20 to 16 x 40 feet in size. The only external service that the mobile facility requires is electrical power. The mobile decontamination facility has a decontamination room, decontamination cell room, count room, and HVAC equipment located inside. Most companies have opted to build their own module because of size restrictions and location of where they want to have the system.

Operation of the CO_2 pellet blasting system requires a minimum of two people; one person to work with the CO_2 pellet blasting nozzle and one to watch gauges and control the equipment. This system can also be used in a glovebox for work on small parts.

(There have been modifications made to the Environmental Alternatives system after companies have encountered problems with the pressure control devices of the system. More gauges have been added to make the system easier to use and help prevent the system from being shut down due to either high or low pressures).

2.1.2 Cleaning Rates and Decontamination Factors

Both CO_2 systems have been proven to be effective in removing loose contamination from stainless steel, carbon steel, concrete, glass, herculite, wood, plastic, weld slag, electric components, paints, lead, aluminum, rubber, handtools, small parts, and pumps (Appendix A, Tables A-1.0 & A-2.0). CO_2 pellet blasting does have a problem cleaning fixed contamination along with epoxy coated concrete, carbon steel, rusted carbon steel, complex geometries, and inside pipes.

The decontamination factors (DF) for this system range from 2 to 10 (Appendix A, Table A-2.0) depending on which material is being cleaned and which method is used. Pellet density, angle of impact, pressure changes, nozzle design, and stand-off distance are all factors in decontaminating material. All these factors need to be considered when using the CO_2 pellet blasting system.

The cleaning rate of CO_2 pellet blasting varies depending on the experience of the operators. A demonstration of CO_2 pellet blasting was conducted by Rocky Flats personnel and it was found that when the operators first used the system they could clean lead bricks on an average of 52.3 lbs./hr. After the system had been on site for a month, the rate of cleaning jumped to 72 lbs./hr.[1] Other companies have been able to process 70 to 90 lead bricks per day which equates to an average of 10,400 lbs. per week.

2.2 Remote Applicability

The CO_2 pellet blasting system can be used both in a in-situ and ex-situ decontamination situations. Decontamination can also be done remotely with this system. A nozzle mounted on a automatic computerized controlled remote arm is used.

2.3 Waste Considerations

The reduction of secondary waste while using CO_2 blasting systems has been investigated and found to be highly favorable. Chem-Nuclear Systems, Inc. found that the only secondary waste generated during testing of this system was the disposable protective clothing, a vacuum cleaner filter, and the roughing filter installed in the ventilation duct.[3] A calculation was performed to estimate the amount of waste that would be generated to remove 3 mil thick layer of paint from a 20,000 square foot floor. The result was 5 cubic feet of loose paint, that could be disposed of in one 55 gallon drum. A comparison of CO_2 pellet blasting to sandblasting was made and removal of this paint by sandblasting would require approximately 10 pounds of sand per square foot of area to be cleaned. The cleaning of 20,000 ft^2 would require 222 drums for disposal.

The system is fully compatible with ICPP processes. The CO_2 goes to the atmosphere after being vented through HEPA filters. Spent HEPA filters will require treatment (like the filter-leach system) if they are considered mixed waste. The solid waste can be collected in drums.

2.4 Environmental, Safety and Health Considerations

Ventilation (air changes) is the biggest concern while using this system. The ventilation off-gas (VOG) system must be able to handle the large amount of system off-gas. There have been modifications to some systems which involved removing the roughing filters and inserting removable in-line filters. These filters can be removed periodically to determine the amount of contamination passing through the system. Tests have been run to determine the amount of contamination passing through the system as well as the location of the contamination after decontamination. Environmental Alternatives conducted a CO_2 pellet blasting test on a piece of material with a spot reading of 30 mR. After the test was complete and the filters were examined no contamination could be found on the filters. The conclusion was that the contamination was dispersed throughout the filter.

Chem-Nuclear Systems, Inc. conducted tests on concentrations of airborne radioactive materials before, during, and after decontaminating materials with the CO_2 pellet blasting system (Appendix A, Table A-3.0)[3] .Three types of air samples were collected during testing. First, a high volume air sampler was positioned adjacent to the workpiece during decontamination activities. Second, a low volume air sampler was used to sample the air in the cell area outside of the decontamination booth. A sample was collected every 15 minutes from the sampler. Third, a continuous air monitor was positioned to collect samples at the entrance to the decontamination booth. All samples were counted for one minute. The highest concentration of airborne activity occurred during decontamination of the hot spots on the concrete floor, but was still less than 10% of the NRC limit for working without respiratory protection. The airborne concentrations during all other decontamination activities remained below the NRC maximum permissible for unrestricted release to the environment.

The safety concerns of CO_2 pellet blasting have been researched. Personnel using this system have found that even when then the CO_2 pellets have hit bare or covered skin, there is a stinging effect but no penetration. A respirator is required but a bubble suit with a fresh air supply would be better. The noise level of the system varies from about 75 to 125 dB, depending on the operating pressure.[4] Hearing protection would be required to use the system.

In order to operate the system at the ICPP in a full production mode, air permitting would be required. The question of the effect on atmosphere of releasing the CO_2 gas has been addressed by CO_2 Cleanblast personnel.[4] About 90% of commercial CO_2 is produced as a by-product of other chemical processes. Gas that would have been discharged into the atmosphere is actually reclaimed. By reclaiming this gas and purifying it, and then by getting useful work from it, the commercial CO_2 market is not a true source of CO_2 pollution. A CO_2 system operating one shift per day returns about a ton of CO_2 into the atmosphere each day. This quantity is very low considering the more significant sources of CO_2 in the US. A typical American family of three generates 34 tons of CO_2 annually, from direct and indirect consumption of fossil fuels. A single 100 KW coal-fired generator plant releases 1,850 tons of CO_2 daily. That is the equivalent of more than 1,500 CO_2 pellet blast systems.

2.5 Costs

The development costs of using CO_2 pellet blasting will be low due to the recent development of this technique throughout industry. The full scale equipment costs range from \$250 K to \$300 K. Labor costs are low due the simplicity of the system.

3.0 SCOPING TEST

The literature investigation clearly demonstrated that CO_2 pellet blasting was a viable alterative to the liquid based methods traditionally utilized at the INEL. The existing literature base lacks the data needed to evaluate the facility air permitting impacts or cleaning results of various lead shapes, and decontamination factors achieved for the range of materials and levels of radioactive contamination common at the INEL and throughout the DOE complex. This report will give the results and evaluation of the CO_2 pellet blasting demonstration that was conducted at the ICPP.

The demonstration consisted of performing tests to validate quantified air emissions from the application of this technology, media/performance standard applicability for debris treatment, cleaning results of various lead shapes, and decontamination factors achieved for the range of materials and levels of radioactive contamination common at the INEL. This demonstration was a joint venture between WINCO and EG&G. The work was completed under a NEPA CX (Categorically Excluded) permit approval and an exemption to state air permitting.

After the literature review was complete, it was determined that the Alpheus equipment was more suited for the particular application at the INEL. Consequently, the request for proposal was written around the performance achieved by the Alpheus based CO_2 pellet blasting system. However, the low bidder, Environmental Control Division (ECD) out of Denver, Colorado uses the Cold Jet system and was awarded the contract. ECD was able to meet the specifications in the proposal by enhancements made to their system by Clean-Kool and Mercer Engineering Research Center such that it can achieve the same performance as an Alpheus based system. This resulted in an additional purpose for the verification testing, to test the claim that the modifications to the Cold Jet equipment do in fact result in performance equal to the Alpheus based system.

The specific enhancements deal with pellet consistency and integrity. Clean-Kool, Inc. installs a pellet making upgrade for the Cold Jet Equipment that improves the hardness and pellet integrity such that a consistent quality of pellets is produced throughout the desired range of sizes and hardness. The second enhancement is to the delivery system. The liquid nitrogen enhanced delivery system developed by Mercer Engineering Research Center lowers the temperature of the pellet air stream at the pellet hopper to eliminate almost all of the pellet degradation experienced by conventional systems.

3.1 Experimental Equipment

The cold and hot testing was performed in the Hot Shop of the New Waste Calcining Facility (NWCF). The Hot Shop is a 40'x 55' room adjacent to the decon area of the NWCF with a stainless steel floor, HEPA filtered ventilation, and direct outside access. Figure 1 shows general layout of the CO_2 pellet blasting system which was located outside the Hot Shop. Figure 2 shows the layout of the enclosure inside the Hot Shop. To operate the CO_2 pellet blasting system, a large generator was brought on-site, along with liquid nitrogen, liquid carbon dioxide, and fuel supply tanks. All of the equipment except the nozzle and hose were located outside the Hot Shop.

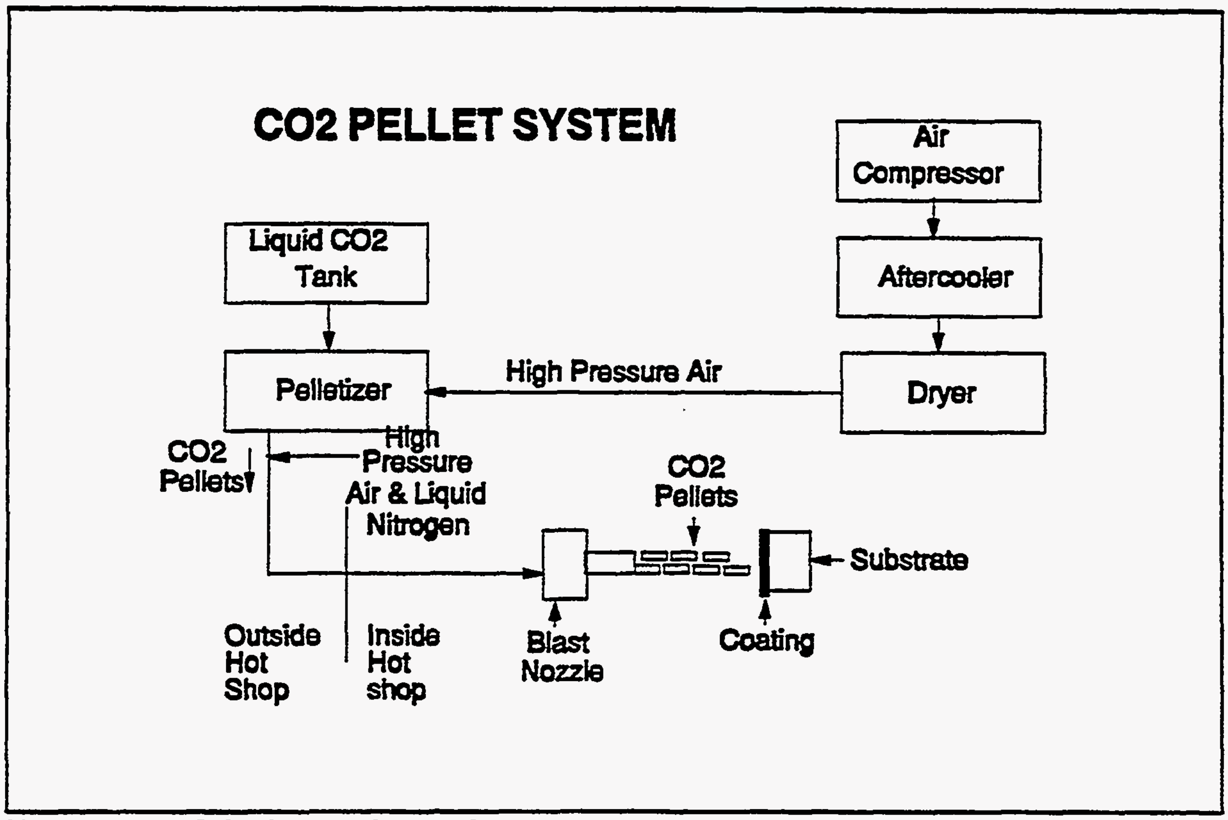

Figure 1 - CO_2 Pellet Blast System

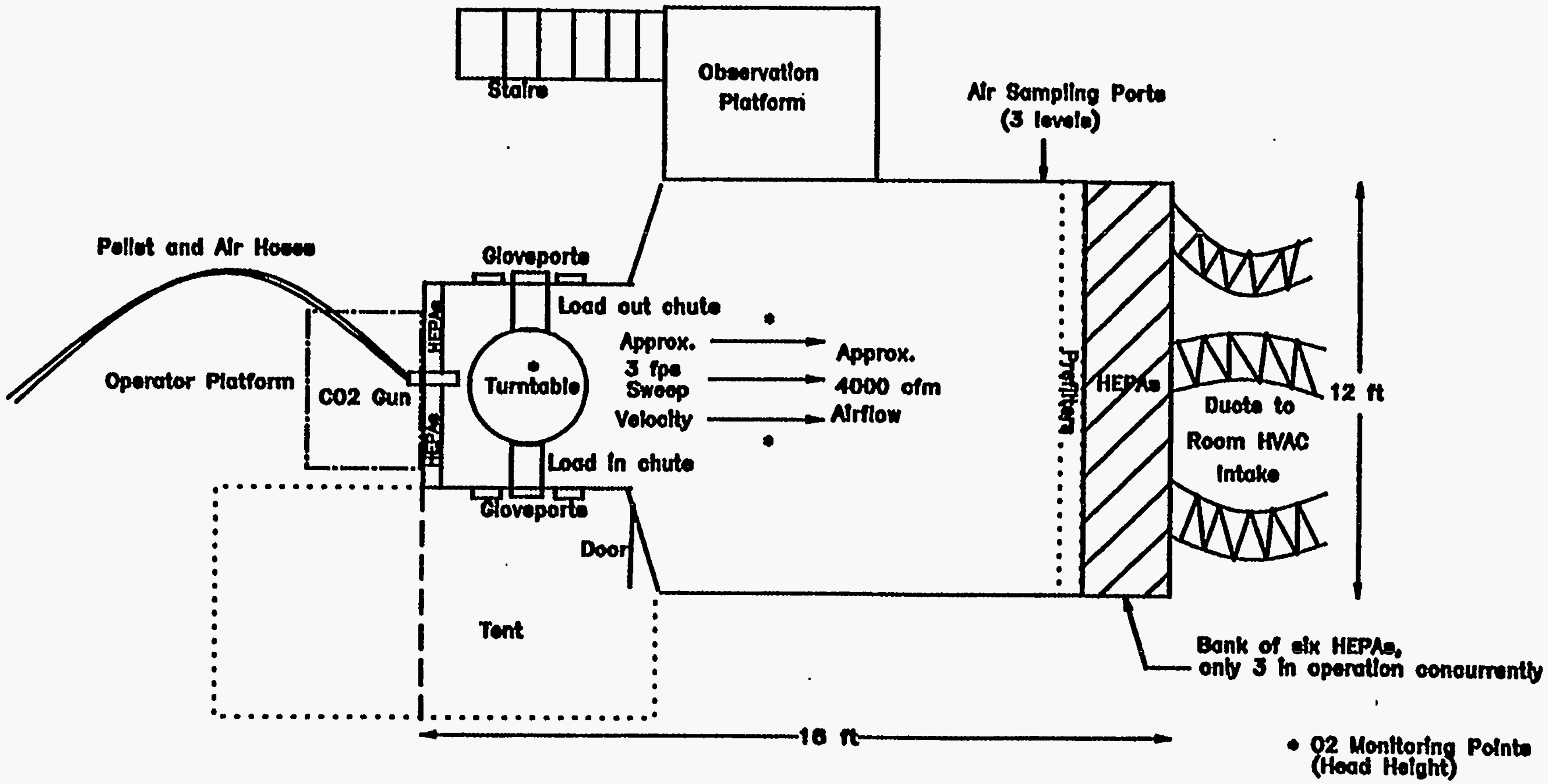

Figure 2 – CO2 Demonstration Enclosure Layout

The Cold Jet blasting system used for this demonstration is a portable unit which means that the pelletizer, hopper, and air handling units were all separate components making it more maneuverable. These components all fit into a 15' long X 8' wide trailer. The large stationary unit combines all of these components into one single unit.

A large generator had to be brought on site because of the power required to run this CO_2 pellet blasting system (480V/ 3 phase / 200 amp circuit) is not standard. ECD is working on converting their system so that it can be used with standard power supplies (480V/ 3 phase / 70 amp circuit) .

The enclosure was supplied by ECD from a design by Los Alamos Technical Associates Inc. (LATA) for doing decontamination work. The enclosure walls were 3 inch white vinyl-faced hardboard with a plexiglass ceiling. The front panel of the containment structure was replaced with a aluminum panel containing louvers to aid in air flow. WINCO modified these louvers by covering them with HEPA filters to prevent contamination backflow out of enclosure. WINCO provided a plexiglas window with a port hole for the front of structure so that the gun could be placed into the containment structure while the operator stood outside the structure and shoots the CO_2 pellets into the containment structure. WINCO also provided gloveports for bagin & bagout and a tented entry way for the enclosure for contamination control.

The nozzles that were used during the demonstration were rectangular in shape and varied in sizes from 1 to 8 inches in width with a 1/2" to 1-1/2" nozzle opening.

3.2 Experimental Procedure

The testing of the CO_2 pellet blasting system was organized in three distinct phases. The first phase concentrated on cold surrogate materials to verify the effectiveness of the containment, ventilation, cleaning abilities, and to gather initial data of operating parameters prior to hot operation. The second phase involved testing, both for decontamination and debris treatment, of low-level radioactively contaminated materials and tools. As lower levels of contamination were successfully handled, the testing progressed to higher levels of contamination. The final phase of testing encompassed radioactively contaminated lead. The testing varied the key operating parameters (pellet density, nozzle type, pressure, stand-off distance, and angle of nozzle) to gather data for optimizing performance. Data was also gathered on atmospheric conditions inside and outside the containment structure during blasting operations. The data showed that the O_2 levels did not fall below the limits specified in 29 CFR 1910.1025. The usage rates of liquid CO_2, liquid nitrogen, and fuel for operating the air compressor will be supplied in a report from ECD which is currently being prepared.

The cold testing was made up of the following two parts:

1) **General Cleaning Ability.** Rust, tape, polyken wrap, and enamel paint were removed from the stainless steel, plastic, concrete, wood, and carbon steel. Substrate removal from wood and concrete was also tested.

2) **Simulated Contamination Cleaning Ability.** The cleaning ability of the system was tested by determining the amount of known simulated contamination (SIMCON) that could be removed from stainless steel coupons. SIMCON 1 coupons consisted of cold zirconium and cesium dried onto the surface. SIMCON 2 coupons consist of cold zirconium and cesium dried onto the surface and then baked in an oven at 700 deg C for 24 hours. SIMCON 1 is comparable to loose surface contamination and SIMCON 2 is comparable to fixed contamination.

   Two tests were run using SIMCON coupons. During the first test, pressure and die size were varied. During the second test, pressure and die size were held constant and the cleaning time was varied.

The hot testing was made up of the following two parts:

1) **Low Level Radioactively Contaminated Materials.** The cleaning ability of the system was tested by determining the amount of fixed and loose contamination that could be removed from construction type tools and materials. The free release criteria for ICPP is as follows:

   1) <200 dpm Beta/Gamma (smearable)

   2) <10 Alpha dpm (smearable)

   3) <100 cpm > background Beta/Gamma (fixed)

   4) No detectable Alpha (fixed)

2) **Radioactively Contaminated Lead Bricks.** The cleaning ability of the system was tested by determining the amount of fixed and loose contamination that could be removed from lead bricks. The portion of testing was conducted by EG&G.

3.3 Analysis

XRF (X-Ray Florescence) analysis was used to determine the amount of zirconium and cesium on the SIMCON coupons both before and after cleaning. The zirconium and cesium levels were measured in micrograms. The XRF is capable of measuring down to 1 microgram, anything below 1 microgram is considered below detectable limits. The effectiveness of the CO_2 pellet blasting system was determined by the ability to reduce the amount of zirconium and cesium to below detectable limits (less than 1 microgram). Therefore 100% reduction would mean that the zirconium or cesium was reduced to below detectable limits.

3.4 Results

General Cleaning Ability - The results from cold testing indicate that the CO_2 pellet system is very effective for general cleaning. The system removed rust , tape, polyken wrap, and enamel paint from a variety of materials. Substrate removal was also investigated using wood and concrete. The system removed the substrate from wood, but was very limited on concrete. The only part of the substrate removed from the concrete was the top layer which consisted of cement and sand. After the top layer was removed and aggregate was exposed, the system was not effective.

Simulated Contamination Cleaning Ability - The first test performed involved maintaining a constant cleaning time of 1 minute and varying the pressure and die size. The pressure used varied from 125-205 PSI. All of the pressures and dies were effective on cleaning SIMCON 1, however, the system was not as effective on SIMCON 2. The average removal rates for both SIMCON 1 & 2 can be seen in Tables 1 and 2.

TABLE 1
SIMCON 1
Percent Removal

Pressure	205 psi	150 psi	125 psi
Die .080	Cs-94% Zr-93%	Cs-93% Zr-93%	Cs-94% Zr-94%
Die .125	Cs-91% Zr-92%	Cs-95% Zr-96%	Cs-89% Zr-92%

TABLE 2
SIMCON 2
Percent Removal

Pressure	205 psi	150 psi	125 psi
Die .080	Cs-15% Zr-83%	Cs-39% Zr-78%	Cs-35% Zr-80%
Die .125	Cs-18% Zr-78%	Cs-20% Zr-70%	Cs-54% Zr-80%

After the data was evaluated from SIMCON 1 and 2 coupons, it was determined that the .125" die and 150 psi had the highest cleaning efficiency for SIMCON 1. For SIMCON 2 the highest cleaning efficiency was obtained using the .125" die at 125 psi. From this data a second test was run using the same type of coupons but using a pressure of 150 psi, a .125" die, and varying the cleaning time. The average removal rates for both SIMCON 1 & 2 can be seen in Tables 1A and 2A.

TABLE 1A
SIMCON 1
Percent Removal

Time	:30 sec.	1:30 min.	2:00 min.
Die .125	Cs-83% Zr-87%	Cs-91% Zr-92%	Cs-90% Zr-92%

TABLE 2A
SIMCON 2
Percent Removal

Time	:30 sec.	1:30 min.	2:00 min.
Die .125	Cs-41% Zr-79%	Cs-63% Zr-78%	Cs-57% Zr-74%

When this data was evaluated and compared to the first tests ran on SIMCON coupons, it was determined that to obtain the highest cleaning efficiency for SIMCON 1 would be to use the .125" die at 150 psi for 1:00 minute. To obtain the highest cleaning efficiency for SIMCON 2 the cleaning time would have to be increased to 1:30 minutes.

During the cleaning of the coupons, the system was also tested to determine if liquid nitrogen would enhance the cleaning efficiency. One set of coupons was cleaned without using the liquid nitrogen enhancement and results indicated that the cleaning efficiency was reduced by 2-3 percent. In order to obtain a better feel for whether the system is better with or without the liquid nitrogen, more testing would have to be performed.

Low Level Radioactively Contaminated Materials- The tested performed used a feed rate of 70% and the optimum pressures of 125 psi and 150 psi using the .125" and .080" dies that were found during the first phase of testing. These pressures and dies produced a "clean release" of the construction tools. The results from this testing can be seen in Table 3.

TABLE 3
Tools Cleaned At ICPP

TEST PIECE	FIXED β/γ c/m	FIXED β/γ c/m	SMEARABLE β/γ/α d/m	SMEARABLE β/γ/α d/m
	BEFORE	**AFTER**	**BEFORE**	**AFTER**
Wire Brush	500	<100	<200 β/γ <10 α	<200 β/γ <10 α
Pipe Cutter	1,000	120	962 β/γ <10 α	<200 β/γ <10 α
Hammer	1,200	500	937 β/γ 14 α	<200 β/γ <10 α
Pliers	1,600	1000	2125 β/γ 142 α	<200 β/γ <10 α
Screw Driver	450	<100	800 β/γ 40 α	<200 β/γ <10 α
Jack Handle	350	100	600 β/γ 42 α	<200 β/γ <10 α
*Crit. Barrier (top)	22,000	1,000	328 β/γ <10 α	<200 β/γ <10 α
*Crit. Barrier (bottom)	10,000	200	218 β/γ <10 α	<200 β/γ <10 α

*Criticality barrier used for fuel storage spacing made of 304L stainless steel.

Radioactively Contaminated Lead Bricks- The final phase of the CO_2 pellet blasting demonstration was conducted by EG&G Idaho at the ICPP with support from WINCO's Decontamination Development Group in the Applied Technology Department. During this testing phase, lead bricks with high alpha levels were decontaminated.

At the start of this phase, ECD was asked to lower the blasting pressures to a range of 40-50 psi to help prevent the possibility of driving the contamination into the surface of the lead. WINCO Decontamination Development suggested the lower pressures because research, including conversations with vendors who have successfully decontaminated lead, indicated the best results could be obtained at these pressures using Alpheus equipment. Additionally, the lower blasting pressures were recommended because ECD had no experience in decontaminating lead and WINCO was unable to obtain information on decontaminating lead using Cold Jet equipment. The Cold Jet equipment was not designed to work at these low pressures. The only way ECD could get their equipment to reach the pressures was to bypass the shut off switch (at 100 psi) and reduce the feed rate of pellets to help prevent the auger from freezing.

The first attempt at decontamination was performed on nine lead bricks with fixed contamination to determine if the system could adequately maintain the low pressures.

The second part of the test involved blasting bricks with both loose and fixed contamination with high levels of alpha. During this blasting, WINCO noticed that when the feed rate was reduced to 25-35%, no noticeable pellets came out of the nozzle. This indicated that the system was not cleaning properly. The feed rate was then increased to 70% which caused the auger in the hopper to freeze. ECD then had to stop blasting for the day so that the auger could thaw. Additionally, the amount of liquid nitrogen introduced into the system had to be adjusted according to the pressure and feed rate used to help prevent further freezing. These problems were encountered throughout the lead decontamination testing.

After the first several high alpha contaminated bricks were blasted, EG&G was concerned about the possibility of cross contamination of the brick while being pushed through the load out chute. A method of moving the brick across the table and through the chute without it being in direct contact with the table or chute was needed. EG&G developed a small pull cart that was placed on top of the turntable. The pull cart had a set of spikes mounted on top of the pull cart so the bricks could be held without direct contact with the table. After the bricks were blasted, a bag was placed over the top of the bricks, the cart pulled over to the load out chute where the brick was then pulled through the chute. This new method helped reduce the amount of cross contamination.

EG&G decided to use higher pressures part way through the demonstration was due to conversations with ECD president and because of a video EG&G had seen that showed lead brick being cleaned by a CO_2 pellet blasting system. No bricks were cleaned to "free release" criteria but levels of alpha contamination were greatly reduced. WINCO feels that lead cleaning has been successfully completed by other companies, vendors, and government sites using CO_2 pellet blasting. This technique is proven successful but the equipment used for lead cleaning is a very important factor. A more detailed report of the results from this part of the test is being prepared by EG&G[5].

3.5 Conclusions / Recommendations

From the first set of tests conducted it is clearly evident that the CO_2 pellet blasting system is effective for every day type cleaning. The second test showed this method of decontamination is highly effective for cleaning radioactively contaminated tools and materials. When evaluating the results from this demonstration, it can be seen that this decontamination method is more effective on cleaning loose contamination than fixed. However, during the testing it was noticed that the system does remove large amounts of fixed contamination. This testing confirmed what all of the reports and vendors have said about the system being non-destructive. The tests also showed that to achieve the best cleaning results for stainless steel 304L, construction tools and materials with Cesium and Zirconium type contamination that the pressure should range from 125 psi to 150 psi using the .125" and .080" pellet die. However, during the first phase of testing, it could be seen that depending on the substrate and type of contamination, pressures and die sizes will have to be varied to achieve better cleaning efficiency. This method of decontamination is an alternative to some of the current liquid decontamination methods that are currently being used at the ICPP. Also, during this demonstration it should be noted that not only did the CO_2 pellet blasting system work with a great deal of success but the system did not produce any secondary waste beyond the filters and enclosure. Installation of CO_2 pellet blasting at the NWCF will not eliminate all of the chemical decon but will help reduce the amount of sodium waste that is being generated with the current decon techniques.

5.0 REFERENCES

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APPENDIX A

TABLES

Table A-1.0 Environmental Alternatives

PRE-DECONTAMINATION	POST-DECONTAMINATION
Scaffolding-2mR/Hr Gamma, 8mR/Hr Beta (contact), 20kDpm/100 Cm_2, (smearable)	<100 ccpm-Direct Frisk, <1000 Dpm/100 Cm_2
Contractors Jacks-3 to 4 kDpm/100 Cm^2 in tight locations	<100 ccpm-Direct Frisk, <1000/100 Cm^2
Chain Hoists-200 ccpm on swivel joint, 5kDpm/100 Cm^2 (smearable)	<100 ccpm-Direct Frisk, <1000 Dpm/100 Cm^2
CDR Motor Cover-50 kDpm/100 Cm^2,250 ccpm on remote spot	<1000 Dpm/100 Cm^2, <1000 ccpm-Direct Frisk
RHR Orifice Plate- 8mR/Hr Beta (contact), 16 mR/Hr Beta (smearable)	10,000 to 20,000 ccpm, <1000 Dpm/100 Cm^2.
Safety Injection Orifice-32 mR/Hr Beta (contact), 50,000 Dpm/100 Cm^2 (smearable)	200 ccpm-Direct Frisk, <1000 Dpm/100 Cm^2
Safety Injection Orifice-12mR/Hr Beta (contact), 7000 Dpm/100 Cm^2 (smearable)	10,000 ccpm-Direct Frisk, <1000 Dpm/100 Cm^2
Safety Injection Orifice-<1mR/Hr Gamma (contact), 20,000 to 50,000 Dpm/100 Cm^2	200 to 2000 ccpm-Direct Frisk, <1000 Dpm/100 Cm^2
Motor for operation-200 to 400 ccpm, 5kDpm/100 Cm^2 (smearable)	<1000 Dpm/100 Cm^2, <100 ccpm-Direct Frisk

Table A-2.0 Chem-Nuclear Systems, Inc. - Contamination Levels (dpm/100 cm^2)

TEST PIECE	FIXED	FIXED	SMEARABLE	SMEARABLE	DECON FACTORS AND RATES (1)
	BEFORE	AFTER	BEFORE	AFTER	
Bare Concrete Floor General Area	120mR/Hr	120mR/Hr	1000	254	3:1 @ 90 Ft^2/Hr
Concrete Block	10,000	2400	1420	N.D. (3)	4:1 @ 10.7 Ft^2/Hr
Drywall	7,000	1000	1622	802	7:1 @ 20 Ft^2/Hr
Carbon Steel Sprocket	10,000	1000	888	196	10:1 @ 160 in^2/Hr
2 x 4 x 24 Wooden Block	4,000	N.D. (2)	68	79	4000:1 @ 8 Ft^2/Hr
2 x 3 x 8 1/4 Angle Iron	5,000	N.D. (2)	1250	231	5000:1 @ 8Ft^2/Hr
Carbon Steel Gear Puller	8,000	2000	1500	184	4:1 @ 10 in^2/Hr
Stainless Steel Cylinder 2"0 x 24"	10,000	2000	1600	126	5:1 @ 5 Ft^2/Hr

(1) Decontamination factors and rates given are for removal of fixed contamination.
(2) N. D. - None detectable, less than 52 CPM.
(3) Decontamination factors and rate for hot spots were 6:1 @ 2.6 Ft^2/Hr.

Table A-3.0 Airborne Activity Conc. During Co_2 Decon Tests

	INITIAL CONCENTRATIONS
Cell	**2.24×10^{-11} uCi/ml**
Decontamination Booth	**2.06×10^{-10} uCi/ml**
	CONCENTRATIONS DURING TESTING
Workpiece	Airborne Concentration (uCi/ml)
Gear Puller	1.69×10^{-10}
Stainless Steel Cylinder	1.69×10^{-10}
Bare Concrete Floor	9.25×10^{-10}
Concrete Block	1.02×10^{-10}
Drywall	6.4×10^{-10}
Carbon Steel Sprocket	1.02×10^{-10}
Wooden Block	1.99×10^{-10}
Angle Iron	2.76×10^{-10}

Evaluation of Pelletized Carbon Dioxide As A Fluidized Abrasive Agent For Removal of Radioactive Contamination

Prepared by:

Richard J. Dabolt
Chem-Nuclear Systems, Inc.
220 Stoneridge Drive
Columbia, SC 29210

Prepared for:

Martin Marietta Energy Systems
RSI Recovery Project
2200 Mellon Court
Decatur, Georgia

TABLE OF CONTENTS

ABSTRACT

Pelletized carbon dioxide has been fluidized in a stream of compressed air, and can be used as an abrasive or non-abrasive media for cleaning a variety of surfaces in industrial applications. Interest has recently developed concerning the application of this technology for the decontamination of surfaces contaminated with radioactive materials.

Tests were conducted at the Radiation Sterilizers, Inc., Decatur, Georgia, to determine the effectiveness of this technology in a radioactively contaminated environment. Tests were performed on several different materials, coatings, and shapes. The data that was collected includes decontamination factors, decontamination rates, effects on materials and effects on airborne contamination rates. This report presents that data, descriptions of the equipment, tests performed, conclusions and recommendations for future applications.

ACKNOWLEDGEMENTS

This test program was conducted by Chem-Nuclear Systems, Inc. and MPW, Inc. in cooperation with Martin Marietta Energy Systems, Radiation Sterilizers, Inc. and the Georgia Department of Natural Resources and Human Resources. The cooperation given by these organizations and their representatives is sincerely appreciated.

The assistance of the following individuals in the presentation and review of procedures and in the actual performance of this test program is especially appreciated.

Jay Armstrong, MPW Industrial Services
Kelley Dagenhart, MMES (DOE Project Manager)
Jim Hardeman, Georgia Department of Natural Resources
Tom Hill, Georgia Department of Human Resources
Angus Hinson, CNSI Project Supervisor
Earnest Ingram, RSI, General Manager
Larry Sears, CNSI Project Manager
Rowland Weiskittel, CNSI Radiation Control Supervisor

1.0 INTRODUCTION

This report describes the testing performed at Radiation Sterilizers, Inc. (RSI) to determine the applicability and effectiveness of pelletized carbon dioxide (CO2) for the removal of radioactive contaminants from the surface of several materials. Additionally, evaluations of the generation of secondary wastes and airborne radioactivity are reported.

1.1 Process Description

Chem-Nuclear Systems, Inc. (CNSI) and MPW, Inc. combined their respective expertise to produce a prototypical system for the decontamination of material surfaces. This system was demonstrated and tested at RSI on March 20, 21, 1989 in Decatur, Georgia. The RSI facility was designed for the sterilization of materials via gamma irradiation. It is primarily constructed of poured concrete and brick, contains a considerable quantity of steel and other structural and construction materials.

Leakage of some of the Cs-137 sources resulted in the contamination of the storage pool water and a subsequent spread of the contamination throughout the remainder of the facility. CNSI is under contract to Martin Marietta Energy Systems for the decontamination of this facility.

1.2 Process Description

The CO2 cleaning system utilizes pelletized CO2 fluidized in a compressed air stream as an abrasive and non-abrasive to remove surface coatings and contamination from materials. Liquid CO2 is compressed into pellets at 110°F which are fed by gravity into a compressed air stream. The mixture of air and solid CO2 is continuously fed through a nozzle at high velocity, and impinges on the article being cleaned. The collision between the pellets and the workpiece causes the kinetic energy of the pellets to be rapidly converted to heat which subsequently causes the CO2 to sublime.

The exact mechanism responsible for the removal of contaminants has not been thoroughly studied. However, it is believed that a combination of operations is at work. First, the mechanical abrasion caused by the movement of one solid material against another. The second is the spalling of the material surface that is caused by the rapid expansion of the CO2 during its conversion from a solid to a gas. The relatively small volume solid is forced by pressure to completely fill the pores of the material and then to rapidly expand, resulting in removal of a microscopic surface layer via hydraulic fracturing.

Thirdly, the dry-ice pellets establish a thermal differential between the substrate and coating, each of which will expand and contract at different rates. Following such expansion(s) and contraction(s), the mass/density/velocity relationship of the CO2 pellets will initiate separation of the coating from the substrate.

The abrasiveness or lack thereof, of the CO2 pellets relative to substrate being cleaned, is determined by the composition of the substrate components, the mass and density of the CO2 pellets, the velocity of the CO2 pellets as they impact upon the surface of the substrate, the dwell time of the CO2 pellets contacting the substrate, and the angle of impact.

1.3 Objective

The objective of this test was to determine the applicability of this new technology to the decontamination of the RSI facility. Applicability in this case means the ability of the system to significantly reduce the volume of secondary waste generated, and to reduce the time required for decontamination; thereby, reduce the total project cost and operator exposure to radiation.

A secondary objective was to identify and evaluate any potential of the system to result in negative impacts on personnel, safety, environmental, quality, schedule or costs.

1.4 Scope

The scope of this test was restricted due to concern about the potential for the production of airborne radioactive materials and a subsequent recontamination of previously cleaned areas. The originally proposed scope would have permitted decontamination of large areas and structural member of the facility. However, due to the previously mentioned concerns, the testing was limited to relatively small samples in a tightly controlled area.

2.0 SUMMARY AND CONCLUSIONS

The CO2 decontamination technology was successfully demonstrated for the removal of both fixed and smearable radioactive contamination. The demonstration included cleaning of a variety of materials and shapes including concrete, steel, wood and machine components. The following conclusions have been drawn from review of the data collected and observation of the testing as it was performed.

1) The CO2 decontamination technology is viable; however, the equipment is still at the prototype stage of development. Several modifications should be made prior to using this system for large scale decontamination projects.

2) This technique can significantly reduced occupational exposures by reducing decontamination labor requirements.

3) The generation of airborne radioactivity is minimal for the contamination levels tested, and can be controlled.

4) This technology can significantly reduce the quantity of dry active waste generated during decontamination, and produces no liquid waste.

5) The technology could be employed to reduce costs by decreasing schedules, cleaning items to unrestricted release levels and minimizing secondary waste generation.

3.0 DESCRIPTION OF TEST

The following sections describe the conduct of the test, the materials tested, and the other pertinent systems and controls used during the test and in the evaluation of the results.

3.1 Equipment Description

The primary equipment employed for this test included:

1) Liquid CO2 storage tank
2) The control panel, pelletizer and CO2 feeder
3) Air compressor
4) Diesel driven generator
5) Decontamination shroud
6) HEPA filter-ventilation system and radioactive materials detection equipment.

CO2 Storage Tank

The liquid CO2 storage tank is mounted on a transport trailer. Although it complies with the pertinent regulations for storage of compressed gases, it does not meet the requirements of the DOT for liquid transport. Therefore, the tank was empty when it arrived on-site. A local vendor was contracted to transport CO2 to the site and transfer it to the storage tank. The tank has a capacity of 12,000 pounds of liquid CO2. It is equipped with pressure gauges, quantity gauges, liquid and gaseous CO2 removal lines, and a pressure relief valve. The tank was charged with 6,000 pounds of CO2 prior to the test.

Control Panel, Pelletizer

The control panel, pelletizer and CO2 feeder are mounted on a moveable dolley that is secured in a 40 foot van for support. This unit can be removed from the van at the site, and located close to the work station.

The panel is equipped with connections for: compressed air supply, liquid CO2 supply, CO2 vapor return, 480 volt power supply and pelletized CO2 discharge. The liquid CO2 is fed to the hydraulically-driven pelletizer which compresses it into pellets of variable size. The pellets are discharged into a surge hopper and fed by gravity through a rotary feed valve into the fluidizing compressed air stream. The controls on the panel permit adjustment of the pellet production and feed rates. Figure 3.1.1 presents a general arrangement of this unit.

Air Compressor

The air compressor is diesel-driven and mounted inside the transport van. A separate moisture separator and surge tank is mounted beneath the deck of the van. The surge tank is an ASME code stamped vessel, and is equipped with a pressure relief valve.

Diesel Generator

The diesel generator is a commercially available unit supplied by a local vendor. It is trailer-mounted, and produces 460 volts of 3-phase alternating current at 100 amperes. This unit would not be required at sites that could supply the required power from existing sources.

Decontamination Shroud

The decontamination shourd was a prototype designed for application at RSI under test conditions. It is equipped with a nozzle for vacuum connection to a HEPA vent system and rollers to guide it along flat surfaces. It also has a sealed orifice for attachment to the decontamination nozzle. The shroud is shown in Figure 3.1-2. This test has shown the need for a redesign of the shroud.

HEPA Ventilation System

The HEPA ventilation system used for this test was the RSI in-house system. It contained separate roughing and HEPA filters with a differential pressure indicator across the HEPA filter. The system is rated for 5000 SCFM.

Radioactive Materials Detection Equipment

This equipment was provided by CNSI and is calibrated in accordance with CNSI procedures. Three types of air samplers, two fixed contamination detection instruments and a bench type detection instrument were used in monitoring this test. These instruments are as follows:

Air Samplers:

- Staplex High Volume
- Eberline, Regulated Air Supply Pump (RASP), low volume
- Eberline, AMS-3, Continuous Air Monitor with strip chart recorder set to alarm at 6000 CPM. Maximum range 100,000 CPM.

Fixed Contamination Instruments:

Eberline, E-120 Portable Frisker, Range: 0-10,000 CPM in 3 scales:
Eberline, R0-2, Range: 0-5000 mr/hr in 4 scales.

Bench Type Detector:

Eberline, MS-2, Range: 0-100,000 CPM in 4 scales.

All smears and air samples were counted for one minute and corrected for the geometry and efficiency of the counter.

3.2 Equipment and Test Area Arrangement

The equipment and test area were arranged as shown on Figures 3.2-1 and 3.2-2, respectively. The transport vans and generator were positioned in the parking lot east of the building and in front of the materials receiving doors. These required an area of approximately 1300 square feet to permit access and work around the vehicles.

The pelletizer skid was located inside the limited area approximately 80 feet from the test area. However, 130 feet of CO2 transfer hose was required due to the circuitous route from the warehouse into the cell.

3.3 Ventilation Control

A wood frame and plastic decontamination booth were fabricated directly below the HEPA ventilation system intake. The door opening in the booth was sized to maintain an air velocity of 9 fps into the booth during setup activities. This dropped to 7.4 fps during actual decontamination. The warehouse ventilation supply fans were cut off, and the cell ventilation intake was sealed prior to and during the test. This ensured that the HEPA ventilation system would provide a negative pressure in the decontamination booth, and a positive flow of clean air from outside of the building through the warehouse, machine room and cell into the booth.

3.4 Description of Test Materials

Decontamination of seven different materials was tested. They include a carbon steel sprocket, gear puller painted carbon steel angle iron, concrete block, wood, stainless steel pipe and uncoated concrete floor.

The test pieces and the floor were surveyed prior to, during and after the test. Both removable and fixed contamination levels were recorded. Table 5.2-1 presents a summary of the activity levels before and after the decontamination operations.

3.5 Sampling and Analysis

The concentrations of airborne radioactive materials were also measured before, during and after the test. Three types of air samples were collected during this test. First, a high volume air sampler was positioned adjacent to the workpiece during decontamination activities. Secondly, a low volume air sampler was used to sample the air in the cell area outside of the decontamination booth. A sample was collected every 15 minutes from this sampler. Third, a continuous air monitor was positioned to collect samples at the entrance to the decon booth. All samples were counted for one minute.

4.0 CONDUCT OF OPERATIONS

4.1 Control of Test Activities

All test activities were conducted under CNSI approved procedures. The test program and data collection requirements were identified in and directed by and Engineering Test Instruction. This delineated the tests to be performed, their sequence and data collection points. The prerequisites for the test, area setup and ventilation controls were established and governed by an RSI Project Work Instruction. Additionally, a Radiation Work Permit was issued to identify the radiological conditions in the area, and to prescribe the required radiological controls.

4.2 Personnel Training

The technicians employed in the contaminated work area were trained and certified under CNSI's technician training program. One-site training and hands-on experience were provided in a non-radiation area for the manipulation and operation of the CO2 decontamination system for these technicians.

The MPW technicians were given instruction in the site specific requirements for work in non-radiation/contamination areas at RSI.

Additionally, pre-job conferences were held prior to initiation of the work in the contaminated area. Each step of the applicable procedures was reviewed at these pre-job conferences.

4.3 Decontamination Activities

All decontamination activities were conducted in the specially designed decontamination booth. The test pieces were individually clamped onto the worktable and decontaminated. The transfer pressure and feed rate of the CO2 pellets were adjusted as appropriate for each test piece. The nozzle standoff and angle of impingement were also modified for the individual pieces.

The nozzle was inserted through the decontamination shroud and directed at the test piece. A HEPA filter and vacuum source was connected to the shroud to collect dislodged particles and minimize the spread of contamination.

5.0 TEST EVALUATION AND RESULTS

5.1 Equipment Performances

The equipment used for this test performed well, with two exceptions: The hydraulic oil used to drive the pelletizer continuously ran at 192° to 195°F. This is not acceptable for continuous operation. An inspection performed after the test revealed that the fan for the oil heat exchanger was inoperable. This has been repaired and has alleviated the high temperature problem.

Difficulties were also encountered with the decontamination shroud. The shroud was cumbersome, and the HEPA vacuum system was inadequate to contain all of the dislodged particles.

5.2 Decontamination Factors and Rates

The decontamination factors and rates were acceptable, but less than anticipated. The factors and rates achieved are listed in Table 5.2-1. The best decontamination factors for fixed contamination, 50:1 at 10 square feet per hour, were achieved on the carbon steel angle iron and on the concrete block for smearable contamination.

Significant reductions in fixed contamination were achieved on the bare concrete floor. A small area reading 120 mrad/hr was reduced to 20 mrad/hr in less than 2 minutes. The smearable activity was reduced by a factor of 4 at a rate of 90 square feet per hour.

The CO2 was effective for cleaning the drywall. However, it also destroyed the test piece. Approximately 1/4 inch of the 1/2 inch thickness of the piece was removed in 1 minute.

Decontamination of the sprocket and gear puller was very successful for both the fixed and smearable contamination. It demonstrated that intricate machine components could be decontaminated with minimal disassembly. Although the rates were slower than those for other test pieces, they are much faster than could be achieved via conventional disassembly and decontamination techniques.

The stainless steel cylinder was decontaminated from 10,000 dpm fixed, and 1,6000 dpm smearable to 2,000 dpm and 126 dpm, respectively, at a rate of 5 ft^2/hr. This could be improved by a better nozzle design. Due to the curved surface of the cylinder, a considerable quantity of the CO2 pellets struck the cylinder at less than a 90° angle. This allowed them to slide across the surface, resulting in poor energy efficiency.

Decontamination of the wood was also successful. The CO2 removed a layer of the wood surface. This could be controlled via reduced pressure or increased standoff. This application would be a viable option to either direct disposal or operations in which the wood is sent to a processor for mechanical removal of the surface.

5.3 Airborne Activity Concentrations

The airborne activity concentrations in the decontamination booth, at the workpiece and in the general cell area were monitored before, during and after the test. Additionally, a roughing filter was installed in the exhaust duct from the decon booth to minimize transport of large particles.

The initial air activity in the booth and cell were 2.06×10^{-10} μCi/ml and 2.24×10^{-11} μCi/ml, respectively. The airborne concentrations at the workpieces during decontamination are presented in Table 5.3-1. The highest concentration occurred during decontamination of the hot spots on the concrete floor. These spots had fixed contamination readings up to 120 mrad/hr. They were cleaned down to 20mrad/hr. This gross contamination produced airborne concentrations of only 9.25×10^{-10} μCi/ml which is less than 10% of the NRC limit for working without respiratory protection.

The airborne concentrations during all other decontamination activities remained below the NRC maximum permissible for unrestricted release to the environment. The airborne concentrations in the decon booth and the cell remained below the NRC limit for unprotected work during all of the decontamination testing.

5.4 Secondary Waste Generation

The only secondary waste generated during this test was the disposable protective clothing, a vacuum cleaner filter and the roughing filter in the ventilation duct. Any increase in the differential pressure across the roughing filter and HEPA filter was below the detection capability of the installed gauge. The vacuum cleaner filter did not have a differential pressure gauge; however, the dose rate on contact with the filter housing did not increase during decontamination operations.

Since the filters showed no measurable increase in their loading, it is difficult to project an accurate life expectancy. Therefore, a waste generation rate such as cubic feet of spent filters per square foot of cleaned surface cannot be projected.

However, a simple calculation can serve as an example of estimating the waste generation rate. Removal of a 3 mil thick layer of paint from a 20,000 square foot floor would produce 5 cubic feet of loose paint. If this were collected in a bag type drum filter, it could be disposed of in one 55 gallon drum.

Removal of this paint by sandblasting has been estimated as follows for comparison:

> General coating removal requires approximately 10 pounds of sand per foot of area to be cleaned. Then the 20,000 ft^2 floor would generate 200,000 pounds of waste. This would require 222 drums for disposal at 120 pounds per square foot.

5.5 Personnel Exposure

Four technicians, plus representatives of the Georgia Department of Natural Resources and CNSI engineering and management were in the radiation area during this test. The total exposure for all individual was less than detectable on the self-reading dosimeters that were used. Therefore, the exposure is judged to be minimal.

6.0 RECOMMENDATIONS

This test provided answers to several questions concerning the applicability of pelletized CO2 as a decontamination media. It has also identified areas that could improve its performance. The following recommendations are based on the information gained during the test:

1) An air handling system must be provided for complete control of particles during decontamination. This system must have a high efficiency filter in it to permit the release of the air into the work area.

2) An alternate method must be developed for startup and shutdown to eliminate the discharge of CO2 to the area around the pelletizer.

3) The system should be employed on a larger scale to more accurately assess the achievable decontamination factors and secondary waste generation rates.

TABLE 5.2-1

CONTAMINATION LEVELS (dpm/100 cm^2)

	Fixed		Smearable		
Test Pieces	Before	After	Before	After	Decon Factors and Rates(1)
Bare Concrete Floor (2) General Area	120 mrad/Hr	120 mrad/Hr	1000	254	3:1 @ 90ft^2/Hr
Concrete Block	10,000	2400	1420	N.D. (2)	4:1 @ 10.7ft^2/Hr
Drywall (3)	7,000	1000	1622	802	7:1 @ 20ft^2/Hr
Carbon Steel Sprocket	10,000	1000	888	196	10:1 @ 160 in^2/Hr
2 x 4 x 24 Wooden Block	4,000	N.D.(4)	68	79	>4000:1 @ 8ft^2/Hr.
2 x 3 x 8 1/4 Angle Iron	5,000	N.D.	1250	231	>5000:1 @ 10ft^2/Hr.
Carbon Steel Gear Puller	8,000	2,000	1500	184	4:1 @ 720 in^2/Hr.
Stainless Steel Cylinder 2"0 x 24"	10,000	2000	1600	126	5:1 @ 5ft^2/Hr.

Notes:

(1) Decontamination factors and rates given are for removal of fixed contamination.

(2) Decontamination factors and rates for hot spots were 6:1 @ 2.6 ft^2/Hr.

(3) Drywall completely destroyed.

(4) N.D. - None detectable, less than 52 CPM.

(2628U-14)

Table 5.3-1

AIRBORNE ACTIVITY CONCENTRATIONS DURING CO2 DECONTAMINATION TESTS

Initial Concentrations

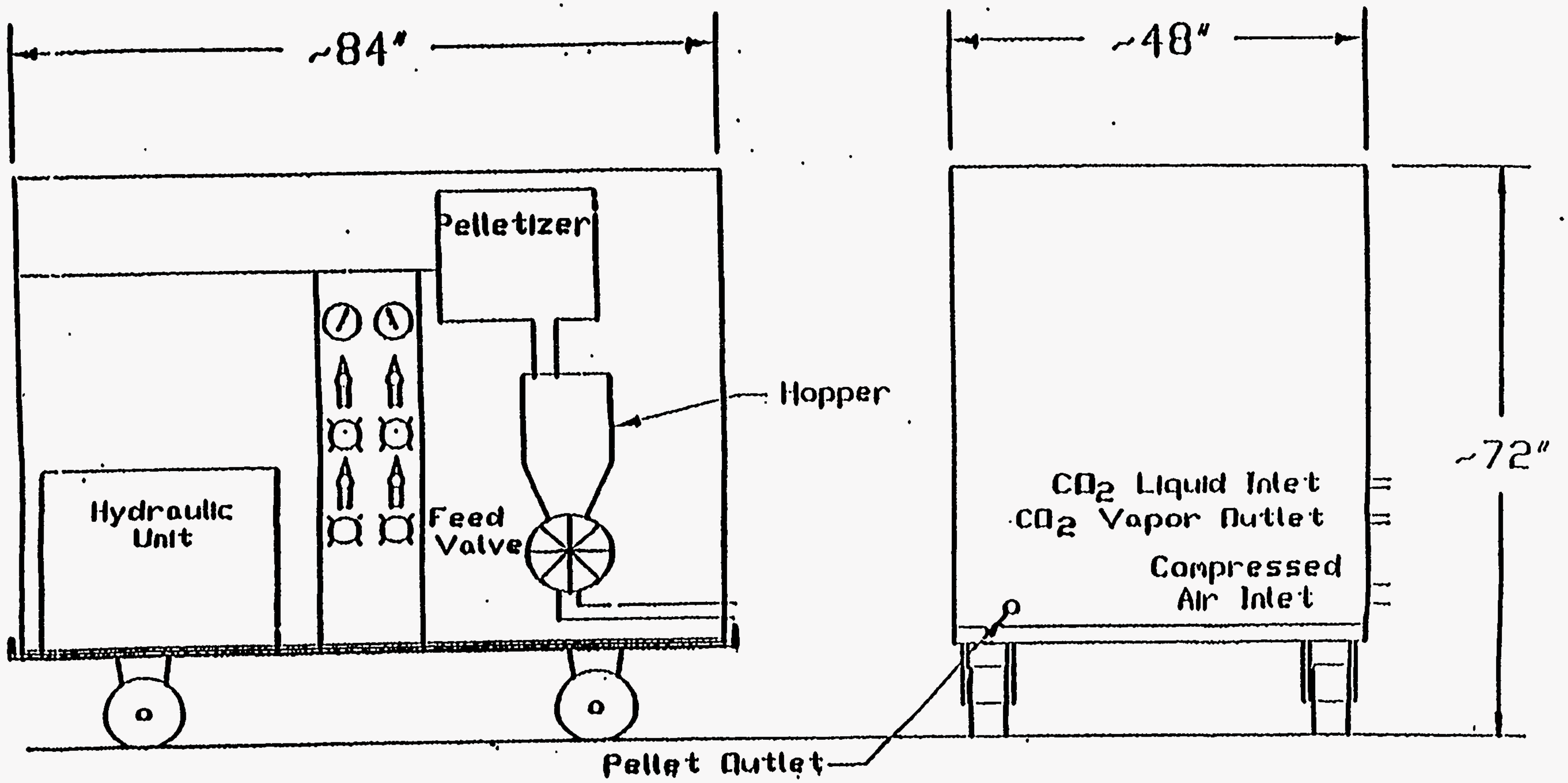
Cell	2.24 x 10-11 µCI/ml
Decontamination Booth	2.0 x 10-10 µCi/ml

Concentrations During Testing

Workpiece	Airborne Concentration (uCi/ml)
Bare Concrete Floor	9.25×10^{-10}
Concrete Block	1.02×10^{-10}
Drywall	6.4×10^{-10}
Carbon Steel Sprocket	1.02×10^{-10}
Wooden Block	1.99×10^{-10}
Angle Iron	2.76×10^{-10}
Gear Puller	1.69×10^{-10}
Stainless Steel Cylinder	1.69×10^{-10}

Notes:
The maximum permissible concentrations for Cs-137 are 5×10^{-10} µCi/ml for unrestricted release to the atmosphere, and 1×10^{-8} µCi/ml for the working environment without respiratory protection per 10CFR20.

(2628U-15)



CO_2 DECONTAMINATION TEST
CONTROL PANEL AND PELLETIZER
FIGURE 3.1-1

Decontamination Technology Investigation Report

INEL

Joe Manhardt

April 1994

ABSTRACT

This report summarizes the findings of the Idaho National Engineering Laboratory's decontamination technology investigation study. A comprehensive review of currently available decontamination techniques was performed. The various cleaning technologies and techniques were evaluated. The CO_2 based decontamination technique was chosen as the best technology for remote and robotic applications. It should be noted that several ongoing CO_2 demonstrations are being performed or planned at various DOE sites. At the time of this report, data from the FY-93 CO_2 demonstrations at WHC and the INEL were not available.

ACRONYMS

ALARA	As Low As Reasonably Achievable
CAAA	Clean Air Acts Amendment of 1990
DOE	U.S. Department Of Energy
FY	Fiscal Year
HEPA	High Efficiency Particulate Air (filter)
HVAC	Heating, Ventilation, and Air Conditioning
INEL	Idaho National Engineering Laboratory
LANL	Los Alamos National Laboratory
LDUA	Light Duty Utility Arm
ORNL	Oak Ridge National Laboratory
OTD	Office of Technology Development
RCRA	Resource Conservation and Recovery Act
SRS	Savannah River Site
TTP	Technical Task Plan
WHC	Westinghouse Hanford Company
TWRS	Tank Waste Retrieval System

CONTENTS

1.0 Introduction

This document summarizes the findings of the Idaho National Engineering Laboratory's (INEL's) decontamination technology investigation study with applications for remote and robotic systems (with emphasis on applications for underground storage tanks). This document closes out the requirement for Technical Task Plan (TTP) TTP ID-432002 which updated the original Investigation Report which was issued as a "living document" in Fiscal Year (FY)-93.

This study examines the scope of decontamination operations required, identifies potential decontamination methods capable of accomplishing that scope, documents each method's capabilities/limitations, and defines the requirements of a decontamination system to satisfy the needs of a robotic application.

1.1 Problem Statement

In 1989 the Hanford Federal Facility Agreement and Consent Order, or Tri-Party Agreement, was signed initiating a 30-year program to clean up hazardous chemical and radioactive wastes at the U.S. Department of Energy (DOE) Hanford Site, located in southeastern Washington state. A major portion of this program is directed towards the stabilization and remediation of dangerous wastes accumulated in underground storage tanks.

The DOE's Office of Technology Development (OTD) is sponsoring this work to support Waste Operations missions, including tank safety programs, tank characterization and surveillance assessment, and retrieval technology development.

Due to its related experience with the decontamination of robotic systems, specifically the Light Duty Utility Arm (LDUA) program, the INEL has been chosen to investigate decontamination methods for use with other robotic applications.

1.2 Work to Date

The LDUA project uses a robotic manipulator, in a storage tank, to investigate, characterize, and map the interior of the tank. The INEL has been in charge of designing a decontamination system for the LDUA since 1991 and has invested significant resources into researching and investigating various decontamination techniques. For this reason, the INEL is well qualified to address the functions and requirements for a decontamination system and to evaluate and recommend the most effective decontamination method.

2.0 Assumptions

In order to determine the optimum decontamination technology for robotic applications, certain assumptions were made and documented. The following assumptions were used in evaluating the various decontamination systems and technologies:

- If the decontamination system is to be used in an underground storage tank, the tank is held at a negative pressure during all retrieval operations by the tank ventilation system.

- If the decontamination system is to be used in an underground storage tank, the tank atmosphere may contain combustible gases such as hydrogen.

- Highly abrasive decontamination techniques may damage robotic hardware and its associated hardware.

- The decontamination system will remove contamination to As Low As Reasonably Achievable (ALARA) standards.

- Any contamination outside the decontamination system environment will be the result of an unforeseen leak or system problem. This condition will be of minimal concern due to the secondary containment systems designed into the equipment.

- Cleaning media used during decontamination operations may be deposited in the tank, but this is not necessarily the preferred approach.

- Regulatory permitting requirements will not be considered in the selection of a decontamination method.

- The robotic hardware and associated systems will be designed to provide a smooth accessible geometry with minimal hidden surfaces to simplify decontamination operations.

- The decontamination technique shall be capable of removing both smearable and fixed contamination.

- The decontamination technique shall generate a minimum of secondary waste.

- The decontamination technique shall be nonsparking and nonheat generating.

- The decontamination technique shall be capable of being operated either remotely or manually.

- The decontamination technique shall be nondestructive to the equipment.

- The decontamination technique shall be a proven technology and readily available.

- The decontamination technique shall be easy to operate and maintain.

3.0 Survey of Decontamination Techniques

Numerous decontamination technologies have been used throughout the DOE complex in a variety of different decontamination scenarios. Certain decontamination techniques are better suited for particular situations than others. For example, the vibratory decontamination technique, in which objects are placed in a tub of abrasives in a chemical solution and vibrated to remove contamination, may be well suited to decontaminating loose tools but would be ineffective in decontaminating a concrete wall.

The following section briefly describes the major decontamination technologies used at the various DOE sites. In Section 4, these techniques are evaluated considering specific requirements.

3.1 Descriptions of Available Decontamination Technologies

This section of the report describes and summarizes the various decontamination techniques evaluated.

Abrasion

Abrasive cleaning is an effective method of removing adhered surface contamination. Three variations of abrasive cleaning are available: dry blasting (sandblasting), shot peening, and solution grit (slurry jet) blasting. Blasting pressures for the dry grit process are expected to be less than 100 psi, while solution grit blasters may exceed 1,000 psi. Dry blasting equipment is relatively simple and inexpensive. However, this method generates contaminated airborne particulates during cleaning that poses a risk to personnel safety as well as a risk of recontamination. Slurry jet blasting provides improved recontamination control and simplifies waste clean-up. Shot peening can be an effective cleaning method, but it can severely damage sensitive equipment.

Abrasive cleaning can be used on large cell applications with remote equipment or in enclosed, glove box-type units. Generally this application is limited to the decontamination of metal items, as recontamination occurs with softer or porous materials. This decontamination technique is relatively easy to use, can usually provide a visual indication of object cleanliness to the operator, can be labor intensive if performed manually, and can be expensive. Spent radioactively contaminated grit can be dried and grouted. Significant secondary waste is created when using this method.

Chemical

The decontamination of equipment using chemicals is one of the most widely used decontamination techniques. Chemical washing provides contamination removal from the interior and exterior of equipment, cracks, porous materials, and otherwise unreachable locations. However, chemical washing has lost favor within the industry because recently enacted Environmental Protection Agency (EPA) regulations have resulted in permitting and waste disposal difficulties. Chemical regeneration and recycling offer the potential for resolving these concerns. Chemical washing has proven to be relatively inexpensive and effective, although the use of hazardous chemicals does present some personnel safety concerns.

CO_2 Blasting

The carbon dioxide cleaning technology (CO_2 blasting) was originally developed by the aerospace industry to clean and depaint large commercial aircraft. While the use of CO_2 for surface preparation dates back almost 20 years, it is only recently that the technology has been developed to the point where it is commercially available as a decontamination alternative.

The CO_2 cleaning process introduces dry ice particles (either snow or pellets approximately the size of a grain of rice) into a high velocity stream (typically air). This high velocity stream propels these particles of dry ice toward the surface of the substrate, that, upon impact, sublime (i.e., change from a solid to a gas), leaving only the removed contaminants for disposal. By adjusting the media parameters (size, velocity, and quantity), it is possible to safely clean a wide spectrum of surfaces and materials ranging from plastic films to steel ship hulls. When used properly in well ventilated, nonradioactive environments, CO_2 blasting requires no special gear for handling other than adequate protection against skin and eye contact to prevent freezing of tissues.

The dry ice particles are manufactured by taking liquid CO_2 and expanding it to atmospheric pressure. The resulting product is CO_2 snow. This dry ice snow can then be used as the cleaning media or can be compressed into a pellet of predetermined shape and density. The CO_2 media is applied in the solid phase (i.e., pellets or snowflake), and cleaning occurs in the gaseous phase. It is essential when using this technology in an enclosed environment that a well-designed High Efficiency Particulate Air filter (HEPA) system be incorporated into the design. A HEPA intake must be close to the cleaning area with sufficient surface area and intake velocity to capture the high velocity contaminants as they are being blasted off. Routine or constant monitoring of the HEPA system is necessary as the contaminants may concentrate in the filters. The fact that CO_2 is 1.5 times heavier than air should assist in keeping the airborne activity confined to the lower areas of the enclosure. Therefore, it is recommended that a floor, scavenger-type HEPA system be incorporated into the design. As CO_2 displaces air, oxygen levels within the enclosure will vary depending the degree of ventilation in the area.

A number of technology programs over the last few years have demonstrated that CO_2 cleaning is an extremely effective method of decontaminating objects of a variety of materials and configurations. Decontamination activities include hot cell decontamination, paint removal, and tool and equipment cleaning.

The cleaning action of CO_2 blasting results primarily from momentum transfer between the pellets and particulates when the dry ice particles impact the object surface and sublime. Secondary cleaning results from the thermal-mechanical shock (the CO_2 is generally significantly cooler than ambient conditions) and through reverse fracturing. Some cooling of the substrate takes place but is not expected to exceed a decrease of 40° F. The likelihood of damage due to cooling is remote. Reverse fracturing is the process by which the solid and liquid CO_2 molecules enter through the pores of the contaminant. As the molecules turn into a gas and begin to warm up, the expanding gas will push the contamination from underneath, further assisting in the removal process. The collisions loosen particles from the surface where they are entrained in the gaseous CO_2 and swept away from the surface, leaving only the removed contaminant for disposal. The decontamination method itself does not generate any additional waste.

CO_2 cleaning is cost-effective because liquid CO_2 is readily available and inexpensive. An additional advantage of this technology is the cost savings resulting from the elimination of the secondary waste generation currently associated with industrial cleaning technologies such as hydrolasing and grit blasting. CO_2 cleaning is also time efficient compared with competing liquid spray cleaning methods, which require prolonged spray times. CO_2 cleaning is nondestructive, nonsparking, nonheating, and environmentally acceptable. $C0_2$ is a nonconductive medium, ideally suiting it for electrical applications. It is nonreactive and nearly inert, making it compatible for use in reactive environments, such as highly flammable hydrogen gas. CO_2 does not become radioactive when cleaning radioactively contaminated hardware. At the end of the process when the CO_2 sublimes to the atmosphere, its release is not regulated under the Resource Conservation and Recovery Act (RCRA) or the Clean Air Act Amendments (CAAA) of 1990.

Electropolishing

Electropolishing of metals, essentially the opposite of electroplating, works by the same electrochemical process. The process can be performed insitu or exsitu and does not affect the metal surface layer (the crystalline structure). The object being decontaminated generally serves as the anode and is submerged in an electrolytic solution. The passage of electrical current results in the progressive anodic dissolution of the surface material and removal of the majority of radioactive contamination. In certain situations when the surface can be passivated, the object surface must serve as the cathode. Surfactants are used as foaming agents that suppress the spattering of solution caused by gas evolution. Hydrogen gas explosion potential does exist and sufficient safety precautions must be taken. If bath purity is a concern to minimize recontamination, then high waste volumes can be expected because the bath solution must be changed frequently. High equipment costs are also a concern.

Electropolishing does have some definite limitations as a decontamination technique. Although the throwing power of electropolishing solutions is good, the ability to remove contamination from deep cracks, crevices, holes, and other areas that are shielded from the cathode is limited, unless the geometry is favorable for the use of an internal cathode. The surfaces to be decontaminated must be conductive and free of paint, grease, tape, heavy layers of corrosion products, and any other surface material that might inhibit the electropolishing action.

Freon

Freon decontamination methods were not considered in this survey because of the industry ban on the use of fluorocarbons.

Hand Wiping

Wiping and hand scrubbing methods were not addressed in this survey because they are well established methods of decontamination that result in high personnel radiation exposure and are labor intensive.

Hydrolasing

Cleaning of equipment and facilities using hydrolasing is a well-established decontamination technique. High pressure water from 1,000 to 20,000 psi is sprayed at the object to be decontaminated to remove the surface contamination. Hydrolasing can be performed insitu, exsitu, or remotely. This method is not a finishing technique and should not be used on concrete or soft materials because of the amount of surface material that would be removed. Hydrolasing produces large volumes of waste water that requires additional processing. One advantage of hydrolasing is that no chemicals are used. Therefore, there are no additional safety concerns with respect to hazardous chemicals.

Surfactants, caustic solutions, and chemical cleaners have been added to the hydrolasing water to increase the solution's depth of penetration and the method's overall effectiveness. This high pressure chemically enhanced method could also involve solvents such as acetone to dissolve desired contaminants. Though development and testing of these decontamination enhancements could help reduce the amount of waste generated, chemical safety and regulatory requirements must be considered. Hydrolasing also presents a pressure-related safety concern and potential for higher radiation exposure to personnel because it is labor intensive.

Ice Blasting

The ice blasting or "wet ice" blasting process was originally conceived for aircraft depainting and has produced excellent decontamination factors during tests at Oak Ridge National Laboratory. This technology uses low pressure air and ice chips to readily remove radioactive contamination or surface coatings through the processes of momentum transfer, crack formation, and propagation without resulting in substrate damage. A high level of decontamination was evidenced on stainless steel, carbon steel, wood, rubber, concrete, plastic, lead, copper, aluminum, and coated surfaces. Ice blasting uses water as its medium and generates approximately 15 gallons of waste water per hour.

The ice blasting system is portable, though equipment intensive, and must be used in a controlled area. The ice maker, refrigeration unit, ice sizing unit, air compressor, and generator can be located outside the area being decontaminated. Only the nozzle and hose assembly, which can be controlled remotely, are located in the area being decontaminated.

Light Ablation

Surface contamination and coatings may be removed by this technique. Light pulses can heat a surface film to 1,000° to 2,000° F in microseconds, while the substrate remains virtually unaffected. The light pulse decontamination mechanism occurs in three phases: sublimation or vaporization of the contamination (absorption of the light energy by the contaminant), ablation or thermal-mechanical shock (stress fracturing ejects solids from the surface), and scouring (vapors and particles ejected by previous processes scour the nearby surfaces). This method has been applied to remove epoxy paints, adhesives, corrosion products, and airborne and surface pollution. Light ablation is currently being developed for radioactive decontamination.

Several advantages and disadvantages accompany this technique. The effectiveness of light ablation can be substantial, potentially removing surface contamination completely for clean release. This decontamination technique also demonstrates waste minimization potential since secondary waste generation is limited to the off-gas filtering system that is required. By using remote equipment or robotics, personnel radiation exposure is lowered. However, the technique may be expensive, because development for radioactive decontamination is currently limited. Also, a number of personnel safety concerns exist: exposure to acoustic shock (noise) can approach 90 dB, exposure to laser light, and exposure to high voltages. Problems dealing with removal of radioactive vapors and ablated material through exhaust systems are anticipated and are currently being examined.

Plastic Beads

Plastic bead or particles are propelled at the object in a 20 psi to 80 psi stream of dry air. The impact of the beads removes contamination. This technique is often-used to clean contaminated hand tools in the nuclear industry. The beads produce a "wiping," rather than a "biting" action, limiting effective removal of fixed contamination. Glass or Aluminum Oxide beads can be used (in place of the plastic beads) to remove fixed contamination, but the beads cannot be recycled, and damage to sensitive components may occur. A relatively small amount of plastic is used if the beads can be recycled (i.e.., in enclosed, controlled environments); however, when oily, dirty, or greasy objects are cleaned, the plastic cannot be recycled. This technique produces solid contaminated waste. The beads are certified incinerable. The beads will not damage sensitive equipment. This technique is often combined with other techniques to remove both fixed and smearable contamination.

Scabbling and Spalling

Scabbling (pummeling which results in scarification or chipping) and spalling (breaking off in layers) are proven concrete surface removal techniques. About 2.5 cm of surface can be removed with scabbling or scarification equipment. Most of the surface contamination in concrete can be completely removed using inexpensive equipment. If deeper contamination exists, spalling methods involving drilling and slicing into the surface can be employed. By removing the entire surface, these methods can accomplish concrete decontamination more efficiently than most other techniques, often resulting in clean release of the residual concrete. However, problems do exist. Since both methods rely mostly on operator, "hands-on," labor-intensive work, larger radiation exposures can be expected. Contaminated concrete dust and rough surfaces will be produced, resulting in the potential for recontamination of the cleaned surfaces. Since the concrete surface is roughened, it will require resurfacing or sealing if reuse is required.

Steam Jet

High pressure steam is sprayed to remove surface contamination. This method should not be used on concrete or soft materials; the same general surface considerations as for hydrolasing are involved. Disadvantages of steam jet cleaning are the personnel safety concerns working with high pressures and temperatures, working in high radiation exposure environments, and creating large volumes of liquid waste. However, the radiation exposure and waste volume generated are typically lower than with hydrolasing. Steam jet cleaning also has the advantage over hydrolasing of surface thermal shock (immediate local material expansion or contraction) to assist in decontamination. This method tends to be labor intensive.

Strippable Coatings

Loose contamination may be removed by using selected strippable coatings. If contamination is not bound to a surface, then "fixing" it with a strippable coating (e.g., latex paint) that is easily removed from the surface creates an avenue for decontamination. Coatings can be applied by spraying or brush/roller equipment. These coatings are used both as protective coatings to prevent contamination and as a means of removing contamination from surfaces. Advantages of the technique are minimizing area contamination spread by spray application to quickly fix contamination and an initial reduction in radiation exposure compared to hand scrubbing. Small amounts of secondary waste are generated, but most strippable paints are considered nonhazardous. Hand work required to remove the coating offsets potential decreases in radiation exposure except in areas of low radiation fields or when hydrolasing is used to remove the paint.

Vibratory Cleaning

The vibratory decontamination process takes place in a vibrating tub of loose media (ceramic or metal) through which flows a chemical solution or water. The energy from the tub (ultrasonic) causes the media to scrub the surfaces of the objects being decontaminated, while the liquid compound flushes away the material removed by the scrubbing action. The liquid solution used can also be designed to use chemical reactions to assist in decontamination. Materials that can be effectively decontaminated include stainless steel, carbon steel, glass, rubber, Plexiglas, and miscellaneous plastics. The process is an exsitu process and may require cutting materials to a length necessary to fit into the tub. The solution can be recycled, but filter plugging problems and greater potential for recontamination result when compared to a single-pass-through process. Vibratory cleaning is relatively time consuming. Two other limitations should be noted: (1) soft metallic surfaces gain in fixed contamination, though there will be no detectable smearable contamination (contamination becomes impregnated) and (2) some chemicals will allow recontamination or deposition on the vibrating media that can then recontaminate. This technology is capital intensive but yields low personnel radiation exposure when compared to other decontamination techniques.

3.2 Where The Decontamination Techniques Have Been Used

Table 1 indicates which DOE sites have used the previously discussed decontamination techniques.

Table 1. DOE sites where various decontamination techniques have been used.

	WHC	INEL	LANL	ORNL	ROCKY FLATS	SRS	WEST VALLEY
ABRASION	X					X	
CHEMICAL		X				X	X
CO_2 BLASTING		X		X	X		
ELECTROPOLISHING	X					X	
FREON WASHING	X						
HAND WIPING							X
HYDROLASING		X	X	X		X	X
ICE BLASTING				X			
LIGHT ABLATION	X	X					
PLASTIC BEADS							
SCABBLING/SPALLING						X	X
STEAM JET		X					
STRIPPABLE COATINGS		X				X	
VIBRATORY	X					X	

4.0 Decontamination Technology Evaluation

Although there are many ways to clean contaminated objects, only one technique will be recommended as the preferred decontamination method to be used with robotic systems. In this section, the criteria used in evaluating the various decontamination methods are defined. The techniques are then compared based on these criteria. Through this comparison, the best system for use as the primary decontamination system will be determined.

4.1 Evaluation Criteria

There are a wide range of criteria that should be used in the comparing various decontamination techniques. Figure 1 below presents evaluation criteria in a logical breakdown structure.

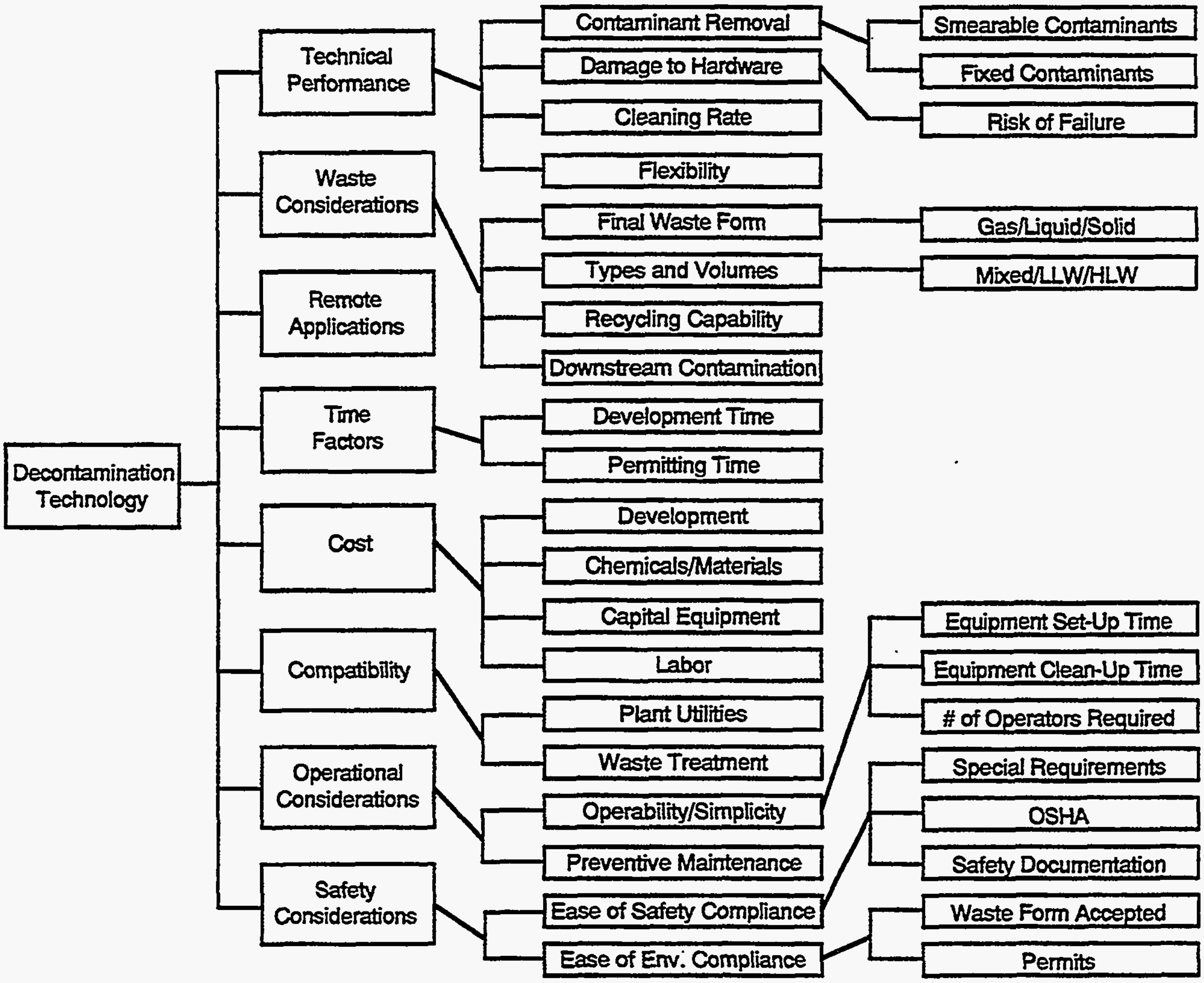


Figure 1. Decontamination system design considerations.

The following list contains a subset of the criteria presented in Figure 1. Although these criteria will be used for evaluating the various decontamination technologies in a quantifiable manner, the entire set of evaluation criteria is considered when reaching a final decision. Section 4.2 will investigate these criteria as they pertain to each decontamination method. The evaluation criteria reflect the fact that the primary application of the decontamination system is to clean and be used with robotic hardware.

- **REMOVES SMEARABLE CONTAMINANTS**
  The effectiveness of the technology in removing smearable contaminants. A system that cannot remove smearable contaminants will not be considered.

- **REMOVES FIXED CONTAMINANTS**
  The effectiveness of the technology in removing fixed contaminants. A technology that cannot remove fixed contaminants will not be considered.

- **EQUIPMENT RISK**
  Is the decontamination method destructive to equipment (metals, electronics, lenses and robotics)? A system that damages critical components will not be considered.

- **GENERATES GASEOUS WASTES**
  Is gaseous waste generated? Is oxygen displaced by off-gases? Gaseous waste generation generally requires special ventilation equipment. A system that generates an excessive amount of gaseous waste may not be economical to use.

- **GENERATES LIQUID WASTES**
  Is liquid waste generated? Liquid waste generation generally requires special drainage equipment. A system that generates an excessive amount of liquid waste may not be economical to use.

- **GENERATES SOLID WASTES**
  Is solid waste generated? Solid waste generation generally requires special collection and/or ventilation equipment. A system that generates an excessive amount of solid waste may not be economical to use.

- **GENERATES MIXED WASTES**
  Is mixed waste generated? Mixed waste generation generally requires special permitting, disposal equipment, and operations. A system that generates an excessive amount of mixed waste may not be economical to use.

- **REMOTE OPERATION**
  Can the decontamination system in its current state of development be operated remotely? A system that can be operated remotely is desired for many applications.

- **STATE OF DEVELOPMENT**
  How far is the state of development? Particularly, has development work been performed to implement automation and remote operation? A system that has already had extensive development work to automate and remotely operate is desirable.

- **"ON SITE" UTILITIES**
  Can "On Site" utilities be utilized for system operations? Do special needs exist? A system that can be operated solely from "On Site" utilities is desirable.

- **SIMPLICITY**
  The simplicity of the set-up and operation of the decontamination system relative to other systems. A system that is simple to setup and operate is desirable.

- **PREVENTIVE MAINTENANCE**
  Is regular preventive maintenance required for steady operation? A system that requires little or no preventive maintenance is desirable.

- **SAFETY**
  Does operation of the equipment pose a threat to worker safety? Are special equipment and/or clothing required for operation of the system? A system that poses a minimal threat to worker safety and that requires minimal special safety gear is desirable.

- **APPLICATION(S)**
  How, where, and on what can a particular decontamination technology be used.

- **ADVANTAGES**
  General advantages of the method with respect to this application.

- **DISADVANTAGES**
  General disadvantages of the method with respect to this application.

- **COMMENTS**
  General comments on the method with respect to this application.

4.2 Evaluation Matrices

Table 2 summarizes the evaluation of the different decontamination techniques based on the chosen evaluation criteria. A detailed examination of each respective technique appears in Appendix A. The evaluation criteria appear vertically along the left side of the matrix, and the decontamination techniques appear horizontally across the top. Each evaluation criterion has been assigned a weight percentage that represents the relative importance of the criterion in the final decision. The sum of these weight factors totals 100 percent. The entries in the matrix are based on a rating scale from 0 to 10, representing the relative desirability of a submission for a particular entry. A rating of 0 represents the least desirable submission, while 10 represents the most desirable. For example, a technique that can remove all smearable contaminants will receive a rating of 10 (the most desirable submission for that particular evaluation criterion), but if it is incapable of removing smearable contaminants, it will receive a rating of 0 (the least desirable submission).

The weighting factors are used to calculate a rating that reflects the relative desirability of a particular technique when considered as a whole. This rating is labeled as TOTAL and appears horizontally across the bottom of the matrix.

Table 2. Decontamination technique evaluation matrix.

4.3 Comparison of Decontamination Technologies

An evaluation of the decontamination technologies reveals that most methods currently available are not compatible with remote or robotic applications. The two methods that best meet the requirements are CO_2 Pellet Blasting and Ice (H_2O) Blasting. This subsection compares these two technologies in more detail, in order to decide which one is best suited for use with this application.

Both CO_2 blasting and ice blasting have many qualities which are desirable to include in a decontamination system. They are both capable of removing smearable and fixed contaminants. Both techniques are nondestructive and will not harm sensitive equipment. Neither technique produces secondary solid or mixed waste. Both techniques can be remotely operated, are relatively simple to operate, and require a relatively small amount of preventive maintenance to operate effectively. There are, however, some important differences in the operation of the CO_2 blasting decontamination technique as compared to the ice blasting technique.

One advantage that ice blasting has over CO_2 blasting is that it produces no gaseous waste. This makes it slightly easier to use in confined areas because a dedicated ventilation system is not required for worker safety. Since CO_2 is heavier than air, it displaces air in confined spaces, thus reducing oxygen available for workers to breathe and resulting in a safety hazard. The primary use of the decontamination system is to clean the hardware in a remote or completely autonomous operation. Workers will not be exposed to this danger on a regular basis.

There are two clear advantages that CO_2 blasting has over ice blasting; it is nearly fully developed for this specific application (through work performed in conjunction with the development of the LDUA), and it produces no liquid wastes. The lessons learned in the development of the LDUA decontamination system will result in a shorter development time for future decontamination systems with fewer unknowns. The fact that it produces no liquid waste may seem inconsequential in lieu of the fact that any secondary waste generated during decontamination can potentially be exhausted back into the tank, but there are some real benefits to avoiding introduction of secondary waste into the tank, especially liquid waste that can be difficult to contain. Any secondary waste created, even if it is initially exhausted back into the tank, will eventually have to be treated in some way.

After taking a closer look at the issues involved in choosing a decontamination system for any remote applications, it is clear that the best choice is a CO_2-based cleaning system.

5.0 Ventilation

The INEL has been in charge of designing a decontamination system for the LDUA since 1991 and has invested significant resources into researching and investigating the various aspects of CO_2 decontamination techniques. Based on this experience, a ventilation system will be required to provide full-time ventilation to the decontamination system enclosure during CO_2 cleaning operations.

The primary function of the ventilation system is to ensure that the atmosphere within the cleaning enclosure (including the tank atmosphere) is adequately isolated from the earth's atmosphere at all times and to carry away and trap contaminated airborne particulate generated during the decontamination process. The ventilation system would likely be a skid mounted mobile unit built to specification and provide all the required equipment such as fans, motors, prefilters, HEPA filters, ducting, and exhaust stack. The sizing and configuration of the unit would depend on the ventilation scenario that is implemented.

6.0 Conclusions and Recommendations

This report has incorporated a review of the major decontamination systems and techniques that are available today. The techniques need to have the capability to be applied in a remote or robotic type application. Special emphasis was placed on underground storage tank operating scenarios. This information was incorporated with a comprehensive review of available decontamination techniques to arrive at a list of evaluation criteria. These criteria were used to evaluate the various decontamination techniques to determine the technique best suited for these applications. The CO_2 blasting decontamination technique was chosen as the best technique for immediate implementation.

The following list summarizes the benefits of the CO_2 blasting decontamination technique over other techniques:

- Removes smearable and most fixed contaminants.
- Nondestructive to sensitive equipment.
- Creates no secondary liquid, solid, or mixed wastes.
- Can be operated remotely.
- Extensive related development experience with the LDUA.
- Simple to operate and maintain.
- Extremely safe under normal operating conditions.

The CO_2 blasting decontamination technique has some additional benefits that make it an attractive cleaning technology. Media parameters (size, velocity, and quantity of CO_2 pellets), can be easily adjusted to safely clean a wide spectrum of surfaces and materials ranging from plastic films to steel structures. CO_2 cleaning is also cost-effective because liquid CO_2 is readily available and inexpensive. An additional advantage of this technology is the cost savings resulting from the elimination of the secondary waste generation. Existing CO_2 cleaning systems have also developed a local vacuum cleaning head that can provide 100% evacuation of all CO_2 gas and debris from the surface while hardware is being cleaned.

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APPENDIX A

Decontamination Technique Summary Sheets

INNOVATIVE APPROACHES TO IMPROVE DECONTAMINATION - THE TECHXTRACT™ TECHNOLOGY

Ronald E. Borah
Michael W. Bonem
EET, Inc. - Bellaire, Texas

Hazardous Materials Control Research Institute
Federal Environmental Restoration III Conference
New Orleans, Louisiana - April 1994

ABSTRACT

New technologies are one of the most important avenues for successfully and cost-effectively dealing with the challenges of environmental remediation and decontamination. This paper describes the TECHXTRACT™ process, a chemical technology used to extract PCBs, heavy metals, radionuclides, and other hazardous contaminants from concrete, steel, and similar solid materials. In many cases, this process is preferred over other decontamination alternatives because it is highly effective in the extraction of subsurface as well as surface contaminants. Furthermore, the extraction technology is non-destructive, the chemical formulations are nonflammable and nonexplosive, the process minimizes waste volumes, and the application does not pose additional health risks for remediation crews. This technology is fully commercialized and has been used by a number of private companies and governmental agencies, including the Department of Energy (DOE) Oak Ridge Y-12 Plant in Oak Ridge, Tennessee.

The specific projects described in this report were performed by EET, Inc., the owner of the technology, as a subcontractor to Martin Marietta Energy Systems (MMES), the primary contractor for operation of the Y-12 Plant. The primary goal of the projects was the cleanup of polychlorinated biphenyl (PCB) contamination from concrete floors, walls, and equipment in one of the manufacturing buildings. During the course of this project, EET was also successful in extracting radionuclides from the same contaminated surfaces. The successful conclusion of this project has led to a number of other opportunities within the DOE, including technology demonstrations for cesium, plutonium, technetium, and mercury.

DECONTAMINATION TECHNOLOGIES: CURRENT PRACTICES AND NEEDS

Due to the large number of contaminated buildings owned by various federal agencies, decontamination is one of the fastest growing segments of the environmental industry. The Federal Facilities Compliance Act (FFCA), Base Realignment and Closure (BRAC), and change in mission for the DOE are all significant drivers of this trend. Through initial investigations, the owners of these contaminated facilities have found their problems to be quite significant. PCB contamination is widespread due to the many different types of systems (hydraulic, coolant, electrical) that used PCB-based oils. Heavy metal and radionuclide contamination is found in many manufacturing and assembly facilities due to past materials handling and disposal practices.

For each category of contaminants, several additional factors exacerbate the clean-up challenge. First, regulatorily required clean-up levels are typically very low due to the health risks associated with PCBs, heavy metals, and radionuclides. Clean-up normally requires a surface standard of 10 micrograms (μg) per 100 cm.^{2} for PCBs and readings of under 5000 dpm per 100 cm.^{2} (total), 1000 dpm per 100 cm.^{2} (removable), or lower for radionuclides.

Standards for heavy metals are different for each. Many contaminants tend to become electrostatically bonded to the substrate material. Successful removal, therefore, requires some type of reaction to break these bonds. In the best circumstances, these standards are difficult to achieve, but the age of many federal facilities (and their contamination) further complicates the problem. Over time, contaminants will migrate deeper into the substrate through the pores in any material. This migration occurs naturally, with water from routine cleaning, or with pressure. The depth to which this migration will occur is dependent on many factors, including the porosity of the material, the mobility and solubility of the contaminants, the presence of coatings, and the existence of other drivers. Migration of one-half inch or more is common, and can exceed four inches in some cases. Since many of the issues now being addressed in the federal market are the results of incidents from twenty or more years ago, deep penetration of contaminants is a widespread concern.

Despite these challenges, most current decontamination techniques lack the sophistication needed in this market. Standard approaches include physical (destructive) methods and chemical cleaning with surfactants, solvents, or acids. Physical mechanisms can be effective if the contamination is not deep and if damage to the surface is allowable. Its primary limitations are the large volume of waste that is generated, the risk for workers (primarily from airborne contaminants) during the operation, potential shutdown costs, and ongoing liability for landfill disposal. It can also be very expensive in cases of deep contamination, especially for radionuclides, due to the high cost of disposal. Off-the-shelf chemicals address surface contamination, and are usually ineffective when subsurface migration has occurred. In addition, many of these solutions (i.e., strong acids, solvents) pose significant health and safety risks for remediation workers.

Many projects where significant contamination is encountered end in one of two ways. Either the owner appeals to the EPA and other environmental authorities for a variance due to their inability to meet regulatory clean-up standards. Or total demolition is selected as the "only known technology" for solving the problem. The TECHXTRACT™ technology from EET is one solution to bridge the gap between current problems and ultimate clean-up.

OVERVIEW OF THE TECHXTRACT™ PROCESS

The TECHXTRACT™ technology, a sequential chemical extraction process, is a highly effective process for the removal of PCBs, heavy metals, radionuclides, and other hazardous substances from solid materials such as concrete, brick, steel, and exotic metals. The process is most applicable in remediation or decontamination projects when one or more of the following conditions apply:

- The acceptable level for any residual contaminant is very low (i.e., 1 or 10 μg per 100 $cm.^2$ for PCBs, background for radiation),

- Simple surface cleaning is ineffective, due to the leaching of subsurface contaminants back to the surface,

- The removal and disposal of the entire contaminated surface (and subsurface) is undesirable, either because the volume and resulting disposal and replacement costs are too high or due to waste minimization objectives,

- Significant safety concerns - such as flammability, corrosivity, creation of airborne contaminant particles, fugitive emissions or generation of toxic fumes and/or explosive gases - are raised,

- Decontamination is to be performed on surfaces that are not flat and horizontal, such as equipment, walls, ceilings, structural beams, and internal piping,

- If very low residual contaminant levels are achieved, substantial economic benefits can be realized (i.e., resale of equipment, reclassification as non-hazardous, avoidance of disposal as hazardous, LLRW, or transuranic waste),

- All other options have failed to achieve the desired objectives.

Even when none of these conditions apply, the technology will still remove undesirable contaminants, but is less likely to be cost effective.

The TECHXTRACT™ technology is a proprietary process developed by EET. The process and the unique chemical blends that it incorporates were developed over a three-year period, and are currently patent pending. The initial research was done in response to a request by a steel industry customer who had serious PCB problems and faced several of the constraints listed above. After this initial research, the chemical formulations and the application techniques were continually modified to improve their effectiveness and to expand the range of situations in which they could be used.

While the technology will be described in more detail in the next section, a summary of the process is provided below:

- The extraction technology is a sequential chemical process, using a blend of specifically tailored chemicals to prepare and then remove contaminants from the affected surface.

- The actual application of the chemicals is a relatively straightforward scrubbing process, using either hand implements or larger floor scrubbing equipment.

- Due to the design of the chemical formulation, the effectiveness of the technology is not diminished by vertical or irregular surfaces.

- Success of the technology is measured by the percentage reduction in contaminants after each cycle. Reduction rates are typically 95 to 99 percent per cycle on PCB projects, and are slightly lower for heavy metals and radionuclides.

- Safety precautions and personal protective equipment are dictated by the contaminants in the surface, not by any property of the chemicals. On PCB projects, crews normally wear Tyvek™ or comparable suits, hoods, respirators, goggles, rubber gloves, and rubber boots.

TECHNICAL DISCUSSION

The extraction technology is a multistep process in which proprietary chemicals are applied to the contaminated surface, allowed to react with and extract contaminants, and then removed. While the specific chemicals and cleaning techniques are custom engineered for each project, the basic process remains the same. After cleaning any debris from the surface and applying a pre-flush solution, the first chemical blend (surface preparation) is applied. This first chemical cleans and prepares the surface to maximize the effectiveness of the extraction step. After this blend is rinsed and removed from the surface, a second chemical blend (extraction) is applied. This formula binds the contaminants in the solution, allowing them to be extracted as the surface and substrate are flushed. At the end of the application, the surface is again rinsed and the liquids are removed. This entire cycle takes one day, and may be repeated several times to achieve the desired levels of decontamination. Sampling is done at the end of any cycle to determine remaining contaminant levels. After the final cycle, a chemical fixation formula is applied to immobilize any remaining contaminants, lessen the chance of recontamination, and strengthen the substrate.

All of the chemicals used in the process are in a liquid state. To minimize the volume that is used (and the resultant waste), the chemicals are normally atomized and applied as a fine mist. Large volumes are not necessary for the extraction process to be successful. The process does require that the chemicals make good contact with all surfaces. To do this, the chemicals are either scrubbed onto the surface manually (i.e., with brushes) or with automated machinery (i.e., floor scrubbers) on larger areas.

The chemical blends used in the process are specially formulated to address the unique nature of each project, including the contaminants and the surface/substrate composition. The surface preparation formula is a complex blend of acids and other chemicals which cleans dirt, oil, grease, and other interferences from the surface. It also solubolizes inorganics and organics and prepares the substrate by establishing proper conditions for the extraction step. The extraction blend also uses advanced chemistry in the fields of microemulsification and chemical ion exchange, and is central to the overall technology. The extraction technique uses these blends which interact with contaminants at the molecular level. In essence, the extraction solution penetrates below the surface and binds itself to the contaminants, then pulls horizontally and vertically through the microscopic pores to the surface. Additional components of the formula encapsulate the contaminants to prevent them from recontacting and thereby recontaminating the surface, keeping them in suspension until they can be removed during the rinse step. Just as important as the chemistry, EET has developed specific application techniques that substantially improve job performance.

Y-12 CASE HISTORIES

EET has performed many different projects using the TECHXTRACT™ technology for the extraction of PCBs and other hazardous contaminants. One series of projects was performed at the Department of Energy (DOE) Y-12 Plant in Oak Ridge, Tennessee. This plant is operated for the DOE by Martin Marietta Energy Systems (MMES), EET's client on the project. The requirement of the initial project was the reduction of PCB contamination to below 10 μg per 100 cm.^{2} in approximately 20,000 sq. ft. of one manufacturing building. The building was equipped with a variety of lathes and other machinery and had a central hydraulic system. This system used PCB-oils (60% Aroclor 1248, 40% perchlorethylene) from 1964 until 1984, when the system was flushed and a PCB-free oil was introduced. Over the 30+ years that the building was in use, these fluids leaked or spilled in several places, contaminating floors, walls, and equipment with PCBs.

The existence of PCBs and MMES's inability to find a technology which could reduce contamination levels to the regulatory standards had brought a priority construction project to a halt. MMES personnel had tried several other methods for removing PCB contamination beginning in November 1991. The floor was scrubbed with different off-the-shelf solvents and/or surfactants, which did lower the PCB levels, but tended to plateau around 500 μg per 100 cm.^{2}. In one case, the floor was scabbled and jackhammered. Even this did not achieve the 10 μg standard, but it did result in a badly scarred concrete floor which became known as the "moon surface." As little as 1/4 inch and as much as 4 inches of concrete were removed from this area, with some holes punched nearly through to the ceiling below. While these or similar techniques had been used with some success in other applications at the Y-12 plant, the age and severity of the spill allowed significant penetration of the PCB-based oil into the subsurface and prevented these standard approaches from working. After these repeated attempts at achieving clean-up levels, MMES submitted a proposal to the EPA for sealing the PCB contamination in place due to the apparent lack of an adequate decontamination technology.

After this requested variance was submitted to the EPA, and with continuing pressure to restart the restoration project, MMES personnel identified the extraction technology offered by EET (operating as EnClean at the time) as a viable alternative. EET began work on Phase 1 of a fixed price contract on September 23, 1992, using a crew of four technicians plus a project manager. Work on this phase and the other two phases of the original contract, totaling approximately 20,000 sq. ft. of floors and ceilings, was completed on December 23, 1992. Each of these areas was sampled and determined to be clean according to MMES specifications of less than 10 μg per 100 cm.^{2}. Eighty-five percent (85%) of the final samples showed nondetectable levels of PCBs. Sampling was performed using smear samples and following the Midwest Research Institute's document, "Verification of PCB Spill Cleanup by Sampling and Analysis." All laboratory analysis was performed by TMA, an independent third party lab. Table 1 summarizes the before and after PCB levels.

In addition to the final clean-up results, MMES and the DOE received a secondary benefit from the low waste volume that was produced by this project. The total liquid waste, which includes all PCB-contaminated cleaning chemicals and rinse fluids, was less than 0.04 gal per sq. ft. The only other PCB wastes from the project were miscellaneous solid items, such as personal protective equipment and miscellaneous hand tools, which were placed in solid waste drums.

In a related project for MMES, EET was contracted to clean a metal machining lathe. This piece of equipment was contaminated with PCBs as well as uranium and related decay products. The equipment had been removed from service due to contamination, but disposal was limited because it was classified as a mixed waste. In-house personnel had already attempted to decontaminate the machine without success, and had ultimately painted it with several coats of lead-based paint to reduce radiation levels. As part of its decontamination process, EET removed the layers of paint so that the extraction chemicals could have direct access to the surface and pores of the metal. Third party monitoring documented the results of the radioactive decontamination after each cycle of the process. During the first two cycles, radiation levels actually increased as the lead paint was removed and the radionuclides were pulled to the surface. Ultimately, the machine was decontaminated to background levels for beta/gamma radiation (<424 dpm per 100 cm.^{2}), from a high of over 250,000 dpm per 100 cm.^{2}. No surface activity was measured, and as further validation of the process, analysis of the rinse solution showed high activity levels for uranium. All PCB clean-up standards were achieved early in the clean-up. Table 2 summarizes the results of the beta/gamma measurement, as performed by TMA/Eberline.

The extraction technology is higher in cost than other clean-up solutions, but only in those cases where these alternatives can succeed in their initial application. In many cases, the choice of an alternate approach results in significant expense, lost time, and waste generation without any meaningful reduction in contamination levels. For comparative purposes, the cost of the TECHXTRACT™ technology on the MMES projects ranged from $8 to $26 per sq. ft. cleaned. In EET's other experience, the cost of extraction projects has been as low as $5 per sq. ft. cleaned, with relatively small additional expenditures required for transportation and disposal. Cost ranges reflect many factors, including the size of the area to be cleaned, level of contamination, required level for decontamination, and types of contaminants.

CONCLUSION

In each of these cases and many others, EET's initial results have led to contract extensions for the decontamination of other "uncleanable" areas. The power of the TECHXTRACT™ process is its ability to penetrate into the substrate through the pores in the material so that PCBs, heavy metals, radionuclides, and other contaminants can be pulled into and held in solution and ultimately extracted. This technology offers significant benefits in reuse of previously contaminated buildings and equipment and avoided disposal costs.

EET continues to perform research to improve the TECHXTRACT™ process and broaden its applications. Demonstration projects are planned during the spring or summer of 1994 for a variety of other radioactive or heavy metal contaminants, including mercury, technetium, cesium, and plutonium. EET has also entered into an agreement with Idaho National Engineering Lab to test the TECHXTRACT™ blends for soil washing. Through these and other ongoing efforts, the role and effectiveness of the TECHXTRACT™ technology for the many needs of the decontamination market will be fully defined.

TABLE 1

PCB LEVELS BEFORE AND AFTER PROJECT BASED ON SURFACE WIPES/HEXANE PROTOCOL

AREA	PRIOR TO EXTRACTION PROCESS	AFTER EXTRACTION PROCESS*
Lathe test area	13-40 μg/100 cm.^{2}	<10 μg/100 cm.^{2}
Third Mill	35-110	<10
Circle shear	28-8900	<10
North side	1-2900	<10

* All final sample results showed PCBs at less than 10 μg per 100 cm.^{2} and 85% were nondetect.

TABLE 2

BETA/GAMMA SURVEY MEASUREMENTS FOR LATHE DECONTAMINATION PROJECT*

LOCATION NUMBER	BEGINNING	INTERMEDIATE	FINAL
1	190,252 dpm/100 cm.^{2}	278,678 dpm/100 cm.^{2}	<424 dpm/100 cm.^{2}
2	4,018	<262	<424
3	7,340	396	<424
4	1,782	535	<424
5	44,580	51,658	<424
6	600	364	<424
7	1,974	396	<424
8	4,305	3,845	<424
9	409	<262	<424
10	19,764	34,219	528
11	664	<262	<424
12	26,471	12,660	<424

* All surveys were taken and documented by TMA/Eberline; "less than" (<) results indicate readings at background levels.

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Kip E. Archibald

LOCKHEED MARTIN

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Idaho National Engineering Laboratory
Lockheed Martin Idaho Technologies Company, Inc.
Idaho Falls, Idaho 83415

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CO_2 Pellet Blasting Studies

1.0 INTRODUCTION

Initial tests with CO_2 pellet blasting as a decontamination technique were completed in 1993 at the Idaho Chemical Processing Plant (ICPP) at the Idaho National Engineering Laboratory (INEL).[1] During 1996, a number of additional CO_2 pellet blasting studies with Alpheus Cleaning Technologies, Oak Ridge National Laboratory, and Pennsylvania State University were conducted. After the testing with Alpheus was complete, an SDI-5 shaved CO_2 blasting unit was purchased by the ICPP to test and determine its capabilities before using in ICPP decontamination efforts. Results of the 1996 testing will be presented in this report.

2.0 OBJECTIVES

The objectives of these blasting studies included:

1. Determine the effectiveness of the CO_2 systems for decontamination.
2. Determine the effectiveness of different blasting guns.
3. Determine the effectiveness of pellets versus shaved CO_2.
4. Compare the removal rates of the portable units versus the large stand alone units.
5. Determine how effective the CO_2 units are at general cleaning, including paint removal from wood, concrete, stainless and carbon steel.

3.0 CO_2 SYSTEMS INVESTIGATION

Six different units have been tested including the system used during the 1993 CO_2 blasting demonstration at the ICPP.[1] The effectiveness of these systems were compared using stainless steel coupons with simulated contamination (SIMCON) dried on the surface to represent loose contamination (SIMCON I) or baked on the surface to represent fixed contamination (SIMCON II).[2]

3.1 Cold Jet

A Cold Jet system was used during the 1993 CO_2 demonstration at ICPP. This was a large stand alone system that had the capability of producing its own pellets. These results have been previously reported[1] and are summarized in Tables 1 & 2.

3.2 Alpheus

Alpheus also has a large stand alone system capable of producing its own pellets along with a portable unit which requires externally made pellets. Alpheus has just recently developed a portable system (SDI-5) that is capable of using either blocks of CO_2 or pellets.

The tests with Alpheus equipment were conducted by sending SIMCON I and II coupons to Alpheus Cleaning Technologies in Rancho Cucamonga, California. They blasted the SIMCON coupons using their Model 250 stand alone system and their portable units, SDI-5 and MLB-5, which are pneumatically operated. The model 250 produces its own pellets while the model MLB-5 has to have pellets made and transferred to the system. The model SDI-5 unit uses blocks of CO_2 which are shaved by blades and the particles of CO_2 are then blasted onto the surface being cleaned. The coupons were blasted with the same optimum pressures and time determined during the 1993 testing. These results are summarized in Tables 1 and 2.

The main differences between the Alpheus and Cold Jet systems are the pellet delivery systems and how the pellets are produced. The Alpheus systems have a two hose delivery system were the Cold Jet systems have a one hose delivery system. The two hose delivery system helps prevent freezing when blasting at low pressures and delivers the pellets to the nozzle with very little pellet degradation. The Alpheus system produces pellets by means of a roller die system where the Cold Jet systems uses a hydraulic press system. The Alpheus pellets are more uniform in size and density than the Cold Jet system.

3.3 Centrifugal CO_2 System

The CO_2 system tested at Oak Ridge National Laboratory was a Centrifugal CO_2 system. This system uses CO_2 pellets that are loaded onto an accelerator wheel which accelerates them along a curved path and delivers them to the surface being cleaned. The pellets have a velocity range from 0 to 500 m/s. This system is not as mobile as the commercially available CO_2 systems and at the present time the items that are being cleaned have to be placed under the system.

However, Oak Ridge personnel were looking at mounting this system on a robot for movement over surfaces.

When testing the centrifugal CO_2 system, only SIMCON II coupons were sent to Oak Ridge National Laboratory. During this test the operators of this equipment varied the pellet speed, feed rate, scan rate, and pellet dosage to optimize the cleaning rate. The cleaning results from this testing are in Table 3.

3.4 Supersonic Abrasive Ice-Blasting

Tests were also conducted with Pennsylvania State University using their recently developed supersonic abrasive ice-blasting system. This system projects a stream of cold compressed gas and ice micro-particles at high speeds against surfaces that need to be cleaned. When the ice micro-particles impact the surface, they wear away soft coatings and radioactive residues without damaging the surface. The system was still in its final development and testing phase when these tests were performed. The cleaning results from this test can be seen in Tables 1 and 2.

3.5 SDI-5 Testing

After receiving the results from the Alpheus SDI unit testing, a unit was purchased and tested at the INEL. This portable mini-blast SDI-5 system is a pneumatically operated CO_2 blasting system that uses blocks of CO_2 instead of pellets. The size of the unit is 24" wide X 36" long X 42" high and weighs 280 lbs dry. The system has an adjustable dry ice feed rate from 1.5-4.5 lbs/min and a blasting pressure from 50-300 psi. A minimum air supply of 80 psi @ 80 cfm is required. The hopper capacity is 120 lbs. Figure 1 shows the SDI-5 system.

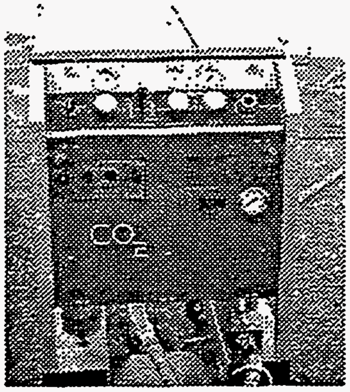

Figure 1 - SDI-5 System.

During the testing of the SDI-5 system at the INEL, a portable (150 psi/110cfm) compressor was used. This compressor limited the blasting pressure of the system during the testing to between 50 and 100 psi. Also, during this testing period an air dryer for the compressor could not be located. This caused some freezing problems around the nozzle stinger because of the moisture in the air line.

The testing of the SDI-5 CO_2 system was organized in four distinct phases. The first phase concentrated on varying the pressures, blast guns and time while cleaning SIMCON coupons. The second phase involved general cleaning which consisted of paint removal from concrete, wood, carbon and stainless steel along with removing tape, rust, and stains from the above mentioned substrates. The third phase consisted of testing a special heating unit which can be attached to the SDI-5 unit before the blasting gun. The heating unit is used to heat the blast air before it reaches the gun which helps reduce condensation on the item being blasted. The final phase of testing was to evaluate a new swivel fan gun that Alpheus has developed.

During the first phase of testing there was a learning period to determine how to operate the equipment correctly. This system is a fairly easy system to operate but does take time to understand how and when to adjust the ice rate and feeder pressure to obtain the proper blasting conditions. After learning how to operate the system, each of two guns (Duck, Anteater) were tested by blasting SIMCON coupons at different pressures and times to determine the cleaning efficiency of each gun. Figures 2 and 3 show the blasting guns that were used. During this phase of testing freezing problems were encountered when blasting continuously for 5 to 10 minutes. The moisture from the compressor was accumulating in the system and causing ice to build up around the nozzle stinger which in turned blocked the flow of CO_2 particles. The cleaning results from the first phase of testing can be seen in Table 4. Figure 4 shows the location of the stinger.

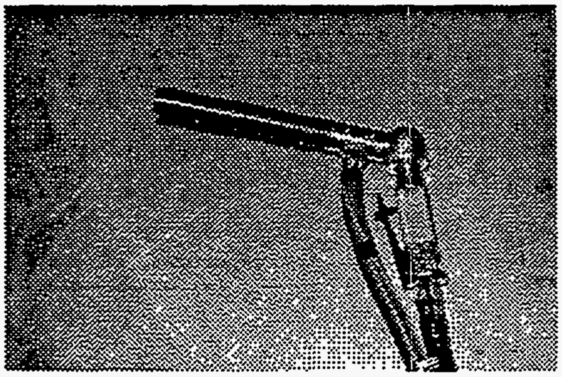

Figure 2 - Duck.

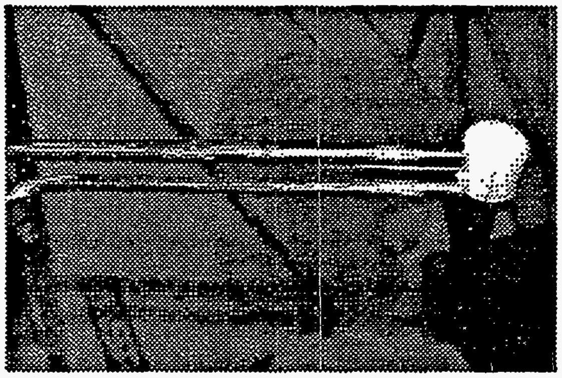

Figure 3 - Anteater.

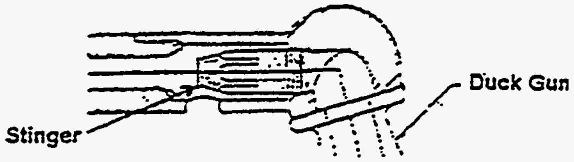

Figure 4 - Stinger Location.

The results from the second phase of testing indicated the SDI-5 system is very effective for general cleaning. The SDI-5 system removed rust, tape, stains and enamel paint from a variety of materials. The system was able to remove epoxy paints but at a slower rate than the enamel paints.

During the third phase of testing a 9KW,480V portable heater which was mounted on a hand cart was tested. The heater was attached to the blast hose on the air outlet side of SDI-5 system. The heater is used to reduce the amount of condensation that can accumulate on the material being blasted. During the heater tests, the off gas didn't seem to be as noticeable as when the heater wasn't used. This reduction in off gas would be very beneficial when working in glove boxes or confined spaces. The heater also helped eliminate the freezing problems that occurred during the first phase of testing. When the heater was used the blasting gun was warm to the touch and there was no sign of an ice build up on the stinger. The cleaning results from the testing with the heater can be seen in Table 4. Figure 5 shows the portable heater.

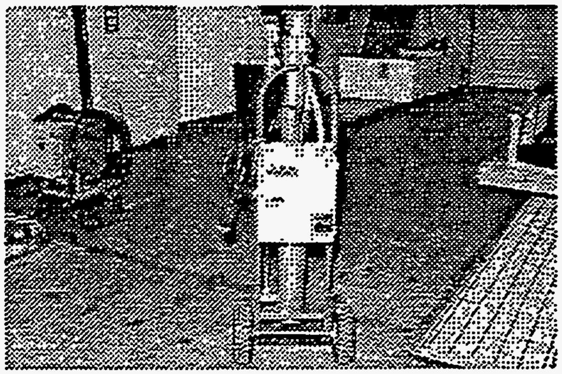

Figure 5 - Portable Heater.

In the final phase a new swivel fan gun developed by Alpheus was tested. This gun was approximately 16 inches long and had a fanning length of approximately 2.5 inches. The gun was tested using the heater and pressures of 50 to 100 psi. The gun was used to clean painted items (fencing, stainless steel, plastic, etc.). The gun was easy to handle and was able to remove paint on flat surfaces faster than either the Duck or Anteater guns. During this phase of testing, there were no freezing problems with the nozzle stinger or system. Figure 6 shows the swivel fan gun.

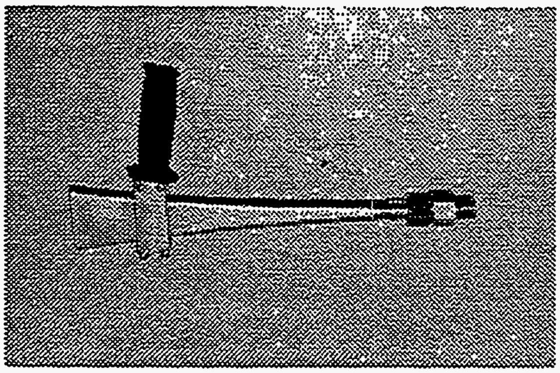

Figure 6 - Swivel Fan Gun.

4.0 RESULTS

After all the testing was complete, the results were compiled in the following tables (attached) to show the percent removal of Cs and Zr on SIMCON I & II coupons. The results indicate that the Alpheus systems were more effective at removing fixed contamination than the other systems. When comparing the removal of loose contamination the Alpheus systems were slightly more effective than the Cold Jet system used during the ICPP demonstration.

The coupons blasted by Alpheus with the SDI-5 system were cleaner than those done with the INEL SDI-5 system. However, once the INEL had some experience operating the SDI-5 system, results were obtained similar to those obtained by Alpheus.

The results also showed that the coupons blasted with the heater/CO_2 system were cleaner then those blasted without the heater. This could have been because the coupons that were blasted without the heater were the first coupons blasted prior to system operation optimization. The combination of the heater and guns showed that the system was faster and more effective at removing paint when the heater was used than when it wasn't used. The heater also eliminated the freezing problems encountered during the first phase of testing.

A videotape of the SDI-5 blaster and CO_2 demonstration at the ICPP is available.

Table 1

SIMCON 1 - Percent Removal

Alpheus Model 250

Time	:30 sec.	1:30 min.	2:00 min.
Constants: Pellet size (.125), Pressure (150 psi)	Cs-100% Zr-100%	Cs-100% Zr-100%	Cs-100% Zr-100%

Cold Jet

Time	:30 sec.	1:30 min.	2:00 min.
Constants: Pellet size (.125), Pressure (150 psi)	Cs-83% Zr-87%	Cs-91% Zr-92%	Cs-90% Zr-92%

Alpheus Model SDI-5 (Portable -Shaved)

Pressure	50 psi.	80 psi.	150 psi..
Time (1:00 min.)	Cs-100% Zr-99.7%	Cs-100% Zr-100%	Not Blasted
Time (1:30 min.)	Not Blasted	Not Blasted	Cs-100% Zr-100%

Alpheus Model MBL-5 (Portable-Pellets)

Pressure	50 psi.	80 psi.	125psi.
Time (1:00 min.)	Not Blasted	Cs-100% Zr-100%	Not Blasted

Supersonic Ice Blasting

Ice Pellet Size	Impact Speed	Cleaning Time	% Removed
70 um	230 m/s	8-12 sec.	Cs - 92.0 Zr - 93.2

Table 2

SIMCON 2 - Percent Removal

Alpheus Model 250

Time	:30 sec.	1:30 min.	2:00 min.
Constants: Pellet size (.125), Pressure (125 psi)	Cs-64.5% Zr-98.0%	Cs-81.3% Zr-100%	Cs-75.1% Zr-98.8%

Cold Jet

Time	:30 sec.	1:30 min.	2:00 min.
Constants: Pellet size (.125), Pressure (125 psi)	Cs-41% Zr-79%	Cs-63% Zr-78%	Cs-57% Zr-74%

Alpheus Model SDI-5 (Portable -Shaved)

Pressure	50 psi.	80 psi.	125psi.
Time (1:00 min.)	Cs-74.3% Zr-95.1%	Cs-66.5% Zr-97.2%	Not Blasted
Time (1:30 min.)	Not Blasted	Not Blasted	Cs-84.8% Zr-100%

Alpheus Model MBL-5 (Portable-Pellets)

Pressure	50 psi.	80 psi.	125psi.
Time (1:30 min.)	Not Blasted	Not Blasted	Cs-75.3% Zr-98.6%

Supersonic Ice Blasting

Ice Pellet Size	Impact Speed	Cleaning Time	% Removed
70 um	230 m/s	8-12 sec.	Cs - 3.6 Zr - 59.0

Table 3
SIMCON 2 - Percent Removal

Centrifugal CO_2 Results

Pellet Speed (m/s)	Pellet Feed Rate (kg/hr)	Scan Rate (mm/s)	Pellet Dosage (Kg/m^2)	% Removed
350	170	5	126	Cs - 55.0 Zr - 95.4
350	170	2	315	Cs - 83.4 Zr - 98.4
350	150	12	28	Cs - 4.4 Zr - 91.1
350	150	9	37	Cs - 27.1 Zr - 93.4
350	150	6	55	Cs - 28.0 Zr - 93.9
350	150	3	110	Cs - 27.0 Zr - 93.6
350	150	2	165	Cs - 43.0 Zr - 92.3
290	120	9	30	Cs - 60.0 Zr - 90.3
290	120	6	44	Cs - 79.2 Zr - 96.4
290	120	3	89	Cs - 59.3 Zr - 93.3
290	120	2	133	Cs - 46.0 Zr - 82.0

Table 4
SDI-5 TESTING

Test #1
Gun Type: Duck
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 100 psi

Feeder Pressure: 50 psi
Ice Rate: 70 psi
Coupons Turning at 100 rpm

Time (1:30 min.)	SIMCON 2 Coupons	Average % Removal Cs - 59 %, Zr - 87%
Time (3:00 min.)	SIMCON 2 Coupons	Average % Removal Cs - 64 %, Zr - 80%

Test #1
Gun Type: Anteater
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 90 psi

Feeder Pressure: 40 psi
Ice Rate: 60 psi
Coupons turning at 100 rpm.

Time (1:30 min.)	SIMCON 2 Coupons	Average % Removal Cs - 67 %, Zr - 86%
Time (3:00 min.)	SIMCON 2 Coupons	Average % Removal Cs - 68 %, Zr - 91%

Test #2
Gun Type: Duck
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 90 psi

Feeder Pressure: 50 psi
Ice Rate: 50 psi
Coupons Turning at 600 rpm

Time (:30 sec.)	SIMCON 1 Coupons	Average % Removal Cs - 94 %, Zr - 92%
Time (1:30 min.)	SIMCON 1 Coupons	Average % Removal Cs - 98 %, Zr - 97%

Table 4 (Cont.)
SDI-5 TESTING

Test #2
Gun Type: Duck
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 90 psi

Feeder Pressure: 50 psi
Ice Rate: 50 psi
Coupons Still on Plate (sweeping)

Time (:30 sec.)	SIMCON 1 Coupons	Average % Removal Cs - 98 %, Zr - 97%
Time (1:30 min.)	SIMCON 1 Coupons	Average % Removal Cs - 99 %, Zr - 98%

Test #2
Gun Type: Duck
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 100 psi

Feeder Pressure: 50 psi
Ice Rate: 50 psi
Coupons Turning at 600 rpm

Time (1:30 min.)	SIMCON 2 Coupons	Average % Removal Cs - 71 %, Zr - 87%
Time (3:00 min.)	SIMCON 2 Coupons	Average % Removal Cs - 49 %, Zr - 81%

Test #3 (Heater)
Gun Type: Duck
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 100 psi
Heater Temp. 145°F

Feeder Pressure: 60 psi
Ice Rate: 50 psi
Coupons not spinning
CO_2 Blocks had been in Box For 2 ½ Weeks

Time (:30 sec.)	SIMCON 1 Coupons	Average % Removal Cs - 99 %, Zr - 99%
Time (1:30 min.)	SIMCON 1 Coupons	Average % Removal Cs - 99 %, Zr - 99%

Table 4 (Cont.)
SDI-5 TESTING

Test #3 (Heater)
Gun Type: Duck/ Anteater
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 100 psi
Heater Temp. 145°F

Feeder Pressure: 60 psi
Ice Rate: 50 psi
Coupons Not Spinning
CO_2 Blocks had been in Box For 2½ Weeks

Time (:30 sec.)	SIMCON 2 Coupons	Average % Removal Cs - 63 %, Zr - 91%
Time (:30 sec.) Anteater	SIMCON 2 Coupons	Average % Removal Cs - 75 %, Zr - 95%
Time (1:30 min.)	SIMCON 2 Coupons	Average % Removal Cs - 93 %, Zr - 99%
Time (1:30 min.) Anteater	SIMCON 2 Coupons	Average % Removal Cs - 88 %, Zr - 100%
Time (3:00 min.)	SIMCON 2 Coupons	Average % Removal Cs - 93 %, Zr - 98%
Time (3:00 min.) Anteater	SIMCON 2 Coupons	Average % Removal Cs - 71 %, Zr - 98%

Test #3 (Heater)
Gun Type: Duck
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 100 psi
Heater Temp. 145°F

Feeder Pressure: 60 psi
Ice Rate: 50 psi
Coupons Spinning At 100 RPM
CO_2 Blocks had been in Box For 2½ Weeks

Time (3:00 min.)	SIMCON 2 Coupons	Average % Removal Cs - 71 %, Zr - 96%

Table 4 (Cont.)
SDI-5 TESTING

Test #3 (Heater)
Gun Type: Duck/ Anteater
Stinger: Green 85
Distance: 2 inches
Blast Pressure: 100 psi
Heater Temp. 145°F

Feeder Pressure: 60 psi
Ice Rate: 50 psi
Coupons Spinning at 100 RPM
CO_2 Blocks had been in Box For 2½ Weeks

Time (:30 sec.)	SIMCON 2 Coupons	Average % Removal Cs - 60 %, Zr - 91%
Time (:30 sec.) Anteater	SIMCON 2 Coupons	Average % Removal Cs - 50 %, Zr - 88%
Time (1:30 min.)	SIMCON 2 Coupons	Average % Removal Cs - 88 %, Zr - 94%
Time (1:30 min.) Anteater	SIMCON 2 Coupons	Average % Removal Cs - 61 %, Zr - 100%
Time (3:00 min.)	SIMCON 2 Coupons	Average % Removal Cs - 71 %, Zr - 98%

5.0 REFERENCES

[1] Archibald, E. K., "CO_2 Pellet Blasting Literature Search and Decontamination Scoping Tests Report", WINCO-1180, December 1993.

[2] Demmer, R. L., "Development of Simulated Contamination (SIMCON) And Miscellaneous Scoping Tests", WINCO-1188, January 1994

APPENDIX B

VENDOR MATERIAL

copyrighted
material
removed.

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ENGINEERING DESIGN FILE

Form L-0431.2#
(05-96-Rev.#02)

Project File Number	015720
EDF Serial Number	EDF-BSC-004
Functional File Number	CB-01

Project/Task	BIN SET CLOSURE STUDY
Sub task	Robot and Cost Description

Title: COMMERCIALLY AVAILABLE ROBOTS AND ASSOCIATED COSTS

SUMMARY

The purpose of this Engineering Design File (EDF) is to give information about commercially available robots and their associated costs. Cost information with respect to present applications are given in this EDF and was obtained via phone conversations with individual vendors, including Oak Ridge, INEEL, and Red Zone Robotics. The information was then used for Calcined Solids Storage Facility (CSSF) bin set RCRA closure cost estimates. Further research is necessary for better accuracy since cost is dependent upon ever changing subject matter such as associated risk, technology, environment, hardware, engineering and development.

During CSSF bin set RCRA closure it is proposed that the robotic arm be used to clean interior bin wall surfaces and the tractor robot be used to move calcine and clean the bin bottom.

Oak Ridge National Laboratory (ORNL) [from Dr. Berry Berks]

ORNL is a Department of Energy multiprogram laboratory located in Tennessee and managed by Lockheed Martin Energy Research Corporation. The ORNL at present is RCRA closing several underground gunnite storage tanks (40 foot diameter and 24 feet tall) that hold radioactive sludge. The providence Group lead by Dr. Berry Berks (lead engineer) [(423) 425-0524 or (423) 576-7350] was chosen for this project. The cleaning process uses a Light Duty Utility Arm (LDUA) (using a 36-foot deployment apparatus) and a tractor type robot inserted through 22-inch tank risers. The tractor robot was a Houdini class robot, which folds on itself to fit through a 24-inch riser. Once inside the tank, the tractor robot unfolds and begins working. Their cost for storage tank cleaning and removal was as follows (dollars):

	Commercially Available Model	With Research & Development
Tractor Robot (foldable, to fit through a 22-in riser)	$2.5 million	$3.5 million
LDUA (40' arm with a 17.5' reach)	$4.5 million	$6.5 million

(Continued)

Distribution: B.C. Spaulding, M.M. Dahlmeir, B.R. Helm, D.J. Harrell and project file (original +1)

Authors Department	Reviewed	Approved
K.D. McAllister 4130	Date 2/4/78	Date 2/4/98
Date 2/4/98		

Estimated Sub-contracted Calcine Removal Costs if Providence Group were hired to clean the CSSF Bin sets:

	Cost
Ancillary Equipment Cost (approximate robot cost (research and development) plus 50%)	$15 million
Operational Costs (Labor, Tank modification, software, deployment, regulatory compliance (readiness review & safety reviews) approximately 5 times Ancillary Equipment Cost)	$75 million
(prior to contingency) **Total**	$90 million

Robot duplication prices would be considerably less than what is shown.

Idaho National Engineering Laboratory (INEEL) [from Dave Willis and Cal Christensen]

INEEL is a Department of Energy laboratory located in west desert near Idaho Falls, Idaho and managed by Lockheed Martin Corporation. The INEEL use LDUA's (robotic arms), inserted through 18-inch tank risers, to inspect underground, radiation contaminated stainless steel storage tanks (50 feet in diameter and 30 feet high). The tractor robot is used to ground carry radioactive material from one point to another. The pipe crawler robots are typically used for pipe inspection only (pipe crawling robots for piping less than 3 inches are still under development). The estimated costs for these robots are as follows:

	Commercially Available Model	Equipped Model*
Pipe Crawler Robot**	$200-300 thousand	$400 thousand
Tractor Robot (non-foldable, available in stock)	$40 thousand to 1.3 million	$60 to 1.5 million
Robotic Arm (54' arm with a 13.5' reach)	$2.5 million	$5.0 million
End-Effectors (typical clamping/grabbing devices)	$150-500 thousand per system	

*Equipped is defined as controllers, cables, computers, monitoring systems and tools to do the job.

**Since research and development is necessary for a 3-inch pipe crawler robot it was suggested by Cal Christensen that the cost for such a robot be estimated to be between 1 to 5 million (this estimate was received recently and not used in the Bin Set Closure cost estimate).

Red Zone Robotics 2425 Liberty Ave., Pittsburgh PA 15222 [from David White 412-765-3064]

Red Zone Robotics, maker of the Houdini class robots used in Oak Ridge, can design and develop a foldable tractor robot that will fit through an 18 inch riser for $1 million dollars (500 thousand for the robot (includes vacuum attachment and push blade) and 500 thousand for the deployment system (attaches to riser top, allows for shielded robot deployment, maintenance and decontamination). Duplicate robots (estimated one per CSSF bin) and deployment apparatus (estimated one per CSSF bin set) would be $150 to $200 thousand dollars each and $350 to $400 thousand dollars each respectively. These prices include controllers, cables, computers, monitoring systems and tools to do the job. The Houdini robot is designed for a total dose rate of 10^6 R, with a 900 lb plow force.

INEL

ENGINEERING DESIGN FILE

Form L-0431.2#
(05-96-Rev.#02)

Project File Number	015720
EDF Serial Number	EDF-BSC-005
Functional File Number	BC-04

Project/Task	BIN SET CLOSURE STUDY
Sub task	Starting Conditions Defined

Title: BIN SET CLOSURE STARTING CONDITIONS

SUMMARY

This document defines the starting conditions and boundaries for the Bin Set Closure project. The required interfaces between the Calcine Retrieval and Transportation project (EDF-WTS-002) and Bin Set Closure project are introduced along with retrieval scheduling dates. The interfaces are presented for the following areas of the Calcine Solids Storage Facility (CSSF):

1. Vaults
2. Bins
3. Piping
4. Equipment
5. Shielding
6. Scheduling
7. Miscellaneous

For more information on Bin Sets see the following documentation:

1. Safety Analysis Report for the ICPP High-Level Solid Radioactive Waste Storage Facilities, G.E. Lohse, Jan. 1972, ICP-1005.
2. Final Safety Analysis Report of the Fourth Calcined Solids Storage Facility, Feb. 1980, ENICO-1031.
3. Final Safety Analysis Report for the Fifth Calcined Solids Storage Facility, Feg. 1984, ENICO-1068.
4. Preliminary Safety Analysis Report for the ICPP Sixth Calcined Solids Storage Facility, June 1981, ENI-142
5. Preliminary Safety Analysis Report for the ICPP Seventh Calcined solids Storage Facility, J.M. Siemer, R.A. Suckel, Aug. 1987, WIN-174.
6. Calcine Retrieval and Transportation, S.E. Gifford, EDF-WTS-002.

Distribution: B.C. Spaulding, M.M. Dahlmeir, B.R. Helm, D.J. Harrell and project file (original +1)

Authors Department	Reviewed	Approved
K.D. McAllister 4130	Sara Gifford	
Date 2-2-98	Date 2 February 1998	Date 2/2/98

BIN SET CLOSURE
STARTING CONDITIONS
(11/19/97)

Introduction:
After the bin set calcine retrieval and transportation process (EDF-WTS-002) is complete (cease use, as defined for the Bin Set Closure Study, has been achieved), it is necessary to define the starting conditions for the Bin Set Closure project. The boundaries are defined for the Bin Set Closure Study. Specifically the processes, activities and responsibilities to be accomplished under the Calcine Retrieval and Transportation project and Bin Set Closure project are defined in regards to the Vaults, Bins, Piping, Equipment, Shielding and Miscellaneous subjects.

Vaults:
The Calcine Retrieval and Transportation project will remove the bin set super structure of CSSF 1 through 4 (the rooms or buildings above the bin containment area, i.e. cyclone room, off gas filtration room, etc.). A self-supporting concrete slab (21 to 18 inches thick) will then be poured on top of the bin vault roof (CSSF 1-4 only) to increase radioactive shielding and allow a smooth, level working foundation. The bin vault roof load limit has not been defined at this time. The concrete slab will surround, but not cover, cut and capped process piping. The CSSF 5 through 7 superstructures will be decontaminated and left in place by the Calcine Retrieval and Transportation project.

Retrieval (8-inch) and D & D (18-inch) risers will be inserted as needed through the concrete slab (CSSF 1-4) or inserted through the superstructure roof and floor (CSSF 5-7) by the Calcine Retrieval and Transportation project.

Bins:
A maximum of 5% of the total bin volume calcine will be left in the bin by the Calcine Retrieval and Transportation process.

Bin wall and heel contamination will be present.

In addition to existing bin retrieval risers the Calcine Retrieval and Transportation project will install 8-inch risers for use during retrieval process and 18-inch risers for use during the closure process. The following is the number of risers that will be installed for each bin set:

Bin Set #1
    24—8 inch schedule 40 risers attached (welded to the bin)
    20—18 inch D & D risers attached (welded to the bin)
Bin Set #2
    8—8 inch schedule 40 risers attached (welded to the bin)
    7—18 inch D & D risers attached (welded to the bin)
Bin Set #3
    7—8 inch schedule 40 risers attached (welded to the bin)
    7—18 inch D & D risers attached (welded to the bin)
Bin Set #4
    3—18 inch D & D risers attached (welded to the bin)
Bin Set #5
    14—18 inch D & D risers attached (welded to the bin)
Bin Set #6
    14—18 inch D & D risers attached (welded to the bin)
Bin Set #7
    14—18 inch D & D risers attached (welded to the bin)

The Calcine Retrieval and Transportation project will weld the 8-inch and 18-inch risers to the bin outside surface by inserting a remote welder down through each the riser. A remote test, not yet developed, will confirm a proper secure attaching weld. A metal wall cutter will be inserted down through all 8-inch retrieval risers to gain access throughways into the bins. The 18-inch risers will be attached to the bin surface by the Calcine Retrieval and Transportation project. The Bin Set Closure study project will cut all the 18-inch riser throughways.

Piping:
All bin sets will be isolated by cutting process piping (except for necessary utility and instrumentation lines) within the confinement enclosure by the Calcine Retrieval and Transportation project. At the cut point, process piping leading into the bin set will be capped and pipes leading away from bin sets will be cleaned, decontaminated and grouted as outlined by EDF-WTS-002 (Calcine Retrieval and Transportation project). Calcine retrieval and new HVAC pipelines (original HVAC pipelines will have been dismantled, decontaminated and replaced by the Calcine Retrieval and Transportation project) will not be cut, but left in place. The pipelines leading from the confinement enclosure to the bin vault at the cut point will be the responsibility of the Bin Set Closure group (see Figure 2-2). Pipelines leading from the cut point away from the bin set will be the responsibility of the Calcine Retrieval and Transportation project.

All retrieval lines installed during the Calcine Retrieval and Transportation project will be available for used during the Bin Set Closure project.

Equipment:
The Calcine Retrieval and Transportation project will ensure equipment is decontaminated, in good working order and ready to use by the Bin Set Closure project. Interfacing between the Calcine Retrieval and Transportation project, Bin Set Closure project and Waste Treatment Facility program will be required to ensure that the equipment and project scheduling is compatible between the three groups.

The CRT will transfer the following equipment to BSC[1]:

1. Heating, Ventilation, and Air-conditioning equipment will be installed on each CSSF vault as per EDF-WTS-002 to ventilate bin vault, confinement enclosure and ventilation instrumentation and control buildings. This equipment will be both sufficient and available for use during the Bin Set Closure project. [Filters and ductwork will be contaminated]
2. Retrieval equipment (to allow continued calcine retrieval) [will be contaminated]
3. Bridge crane (7 total (1 per bin set), to allow for drill platform placement, heavy load lifting, relocation of vertical deployment apparatus, bin set closure work) [minimal/no contamination]
4. Remote Core-drilling Platform (1 only, to drill through vault roof if needed) [designed to be relocated after decontamination minimal contamination but cleanable]
   a. Plug removal Hoist
   b. Drill Motor
   c. Drill Bit Turret
   d. Remote Operating Station
5. Portable Drilling Dust Collector (1 only, to prevent contamination from spreading) [designed to be relocated after decontamination minimal contamination but cleanable]
6. Exhaust Fan (3 exhaust fans: one for the bin vault, one for the confinement enclosure, one for the ventilation instrumentation and control building)
7. Riser Plugs (100 retrieval and 79 D & D plugs, to seal risers to prevent contamination from spreading) [contaminated]
8. CO_2 Decontamination System (2 only, used to decontaminate equipment, containment rooms, shielding, and bins. [minimal contamination—not a significant part of retrieval system.]

---

[1] Calcine Retrieval and Transportation, S.E. Gifford, Dec. 1997, EDF-WTS-002

9. CCTV (closed circuit television) Equipment (to view inside bins, risers and vaults to ensure proper remote operation, verify cleanliness etc.) [contaminated due to bin entry]
    a. Camera and lighting (2 per bin, 100 total)
    b. Video workstation
    c. Switching Panel, 2 monitors, lighting Control
    d. TPZ Head Control Drive Interface Patch Panel
10. AHU (auxiliary heating unit) with heating and cooling coils, filters, dampers (320 cfm) (7 total, 1 per bin set, to heat and cool ventilation and instrumentation control building with separate units) [Should not be contaminated]
11. Vertical Deployment Apparatus (7 total, 1 per bin set, to deploy extension pipe for retrieval risers) [designed to be relocated after decontamination minimal contamination but cleanable]
    a. Plug removal hoist
    b. Rotation drive
    c. Extension tube carousel/turret
    d. Air supply hose reel
    e. Confinement casting
    f. External ladder and platforms
    g. External drives
    h. Telescoping line with lower seal
    i. Vertical position indicator
12. Retrieval Line Jumpers (1 per bin, 4-5 feet long sections, 500 feet total, to connect retrieval system to permanent calcine transport piping system) [designed to be relocated after decontamination minimal contamination but cleanable]
13. Pipe Cutting Device for 8-18 inch pipes (1 only, to cut riser piping as needed for bin set closure required) [should be decontaminated and removed from bin sets]
14. Control Consoles (1 only, for vertical deployment apparatus, remote viewing and process instrumentation located in the ventilation controls and instrumentation building) [no contamination]
15. Remote Welding and Inspection Equipment (1 only, weld inspection, testing unit and cutting devices) [minimal contamination]
16. Retrieval Lines (2 per bin, 100 total, removes calcine from bin bottom using air and vacuum) [contaminated due to bin entry]
17. Ventilation, Instrumentation, and Control building (VIC) (1 per bin set, 7 total, pre-manufactured steel building placed on the side of each bin set) [minimal contamination]
18. Confinement Enclosure (1 per bin set, 7 total, pre-manufactured steel building placed on top of each bin set) [minimal contamination]

The Bin Set Closure project will receive a detailed list of contaminated equipment (equipment that has come in contact with waste) from the Calcine Retrieval and Transportation project. It is assumed that all equipment, which comes in contact with waste, will be disposed of upon completion of the Bin Set Closure project. Equipment that has come in contact with waste will be managed in accordance with RCRA. This requires appropriate waste treatment, storage and disposal.

Shielding:
The following shielding will be present after retrieval is complete

1. Confinement enclosure above bin vault roof [minimal contamination—previously decontaminated 3-4 times]
2. Portable shielding for vault penetrations
3. Any other required and necessary shielding (i.e. double containment where needed, equipment shielding etc.)

Scheduling (from Calcine Retrieval and Transportation, S.E. Gifford, EDF-WTS-002) The Calcine Retrieval and Transportation project and Bin Set Closure project must coordinate with the Waste Treatment Options in order to support the following schedule:

1. Retrieval will occur 4 hours/week.
2. Waste Treatment Facility is expected to be operating 29 weeks/year.
3. Calcine will be retrieved 29 weeks/year.
4. Calcine retrieval will begin 1/1/13.
5. It is expected to take 20 years to process all calcine from the CSSFs.
6. Two transportation systems are available to transport the calcine from the CSSFs to the Waste Treatment Facility. This allows 2 CSSFs to be retrieved at one time. The transport system provides the air jet and suction necessary to retrieve the calcine. The transportation systems are referred to as A and B.
7. The volumes of calcine used in these calculations were calculated by Steve Swenson, Calcine Solids Storage Facility—Volume Calculation, EDF-BSC-001 and do not represent the calcine volume expected to be processed by the processing facility (calcine volumes should be less).
8. It is likely that volumes presented are larger than the actual calcine volume contained in each CSSF bin.
9. The scheduling calculations do not allow any extra time for switching between CSSFs because there is ample time in the schedule to accommodate switching activities.

CSSF	Total Voume of CSSF Bins (feet^3)	Time Required for Retrieval (year)	Transport System	Start Dates	Ending Dates
1	7844	1.0	A	1/1/13	1/1/14
7	64,778	8.2	A	1/1/14	3/1/22
3	40,686	5.2	A	3/1/22	5/1/27
4	17,895	2.3	A	5/1/27	9/1/29
5	36,544	4.6	B	1/1/13	8/1/17
6	56,649	7.2	B	8/1/17	10/1/24
2	31,542	4.0	B	10/1/24	10/1/28

Miscellaneous:

1. The CSSF shall be RCRA closed by the Bin Set Closure project
2. Hazardous waste determination shall be conducted on all newly generated waste by the respective waste generating projects (Calcine Retrieval and Transportation and Bin Set Closure projects).
3. The Calcine Retrieval and Transportation project will provide any air permitting (CAA and NESHAPS) required during retrieval activities. Bin Set Closure project will be included under this permitting.
4. Calcine Retrieval and Transportation project will require bin mock-ups prior to initiating calcine retrieval. These mock-ups will be available for Bin Set Closure project use. However, Bin Set Closure mockups are not included in the Calcine Retrieval and Transportation cost estimates.

INEL

ENGINEERING DESIGN FILE

Form L-0431.2#
(05-96-Rev.#02)

Project File Number 015720
EDF Serial Number EDF-BSC-006
Functional File Number BC- 02

Project/Task Bin Set Closure Study
Sub task Meeting Minutes

TITLE: Bin Set Closure Scoping Meeting Minutes (November 6, 1997)

SUMMARY

A scoping/kick off meeting was held to come up with different methodologies to close the ICPP Bin Sets. The meeting attendees included Bryan Spaulding, Michelle Dahlmeir, Jim Bosley, Lee Tuott, Dave McAllister, Steve Swanson, Craig DeCoria, and Rick Gavalya.

It was decided that two basic closure methods should be pursued further: Risk Based Clean Closure, and Closure to RCRA Landfill Standards.

The major tasks to be accomplished under each closure method were defined as follows:

Risk Based Clean Closure:

1. Remove the Residue from the bins
2. Decontaminate the vessels (bins)
3. Decontaminate the pipelines

Closure to RCRA Landfill Standards:

1. Grout bin and vault
2. Grout Vault void
3. Monitoring
4. Piping – fill at same time as bin voids

Several methods of accomplishing these tasks were discussed and are included in this EDF.

Due to the nature of this study and the limited time available, the attached meeting minutes are in a rough draft form. The information is correct.

Distribution: B. C. Spaulding, MS 3765; B. R. Helm, MS 3765; D. J. Harrell, MS 3211; M. M. Dahlmeir, MS 3765; Project File (Original + 1)

Authors	Department	Reviewed	Approved
MM Dahlmeir	11-20-97		
M. M. Dahlmeir	**MC&IE/4130**	Date 11/20/97	Date 11/20/97

Bin Set Closure Meeting
November 6, 1997
EROB Conf. Room 202

Attendees: Bryan Spaulding, Michelle Dahlmeir, Jim Bosley, Lee Tuott, Dave McAllister, Steve Swanson, Craig DeCoria, and Rick Gavalya

In order for Risk Based Clean Closure to be accomplished, the following items would have to be addressed: (Items 1-10 for Risk Based Clean Closure, Items 11-12 is for subsequent use)

1. Cleanliness Level - below $1x10^{-6}$
   (No further evaluation for cumulative release risk.) Release risk under CERCLA.
2. Remove as much waste and residue as practical
3. Cease use is the point where all waste has been removed that can be removed using existing calcine retrieval equipment - This is an assumption, as the trigger to go to risk based clean closure is that all of the contamination cannot be removed
4. Acceptable Health Risk is related to contamination, not the calcine removed (tied to #1)
5. Define the extent of system
   - ancillary equipment to bins
   - prev. capped piping coming from WCF to bins 1,2,3 is included
   - VOG lines for WCR are still in service for Bin Sets 1, 2, and 3 – verify the boundaries
   - talk with Bill Landman to verify system boundaries
6. Assume there is a tank to transfer the residue into, and a treatment for the residue, as the residue will be High level waste
7. What type of waste stream are we generating by the decontamination method we choose; HLW - dry; LLW-washings
8. Attempt to remove it and remove the waste - we will have LLW waste after attempt to remove per Handford case.
9. Must comply with NESHAPS and Clean Air Act. Provide constant air monitoring of potential releases - coordinate with the retrieval group. (They should have air permit - make sure were tied to it).
10. All HLW must be road ready by 2035 -coordinate with retrieval group.
11. Fill void with clean material - clean closure - filling is not required by RCRA.
12. Bin voids may be used for LLW disposal - NRC licensed.
13. Need a risk assessment for what's left - have risk assessment for what is existing.

Will close as a landfill if RBCC cannot be met!

In order for Closure to RCRA Landfill Standards to be accomplished, the following items would have to be addressed:

1. Must demonstrate the impracticality of removing waste.
2. Demonstrate the ability to contain the waste your leaving - minimize release of contaminants
3. must demonstrate that releases are below cumulative release criteria for the ICCP; $1x10^{-4}$ at fence (ground water and air emissions)
4. Prevent subsidence management

5. Construct a cap – prove equivalency if the vault voids are filled with grout
6. Must perform long term monitoring and maintenance
7. Monitoring Plan
8. Coordinate with CERCLA

Conditions at Take Over:

1. Second level removed
2. Covered with a concrete slab

To get Risk Based Clean Closure

a) Define starting conditions (assumptions)
b) Will have 5% residual waste in tanks.
c) May need separate HVAC.
d) Bins have 6-8" pipes - except for bin 2.
e) Cyclone cell has been decontaminated and removed.
f) Vault superstructure has been removed.
g) Pre-fabbed containment building on the of vaults to hold a negative pressure on the vault and the containment building. Some of the HVAC equipment will be housed in a separate building and piped in (already there)
h) All bin lines to and from bins will already be cut and capped.

Major Activites-
5. Removal of waste
6. Decon of vessels
7. Decon of pipelines

Group Discussions:

Starting Conditions: Assumption must be that all the calcine can be retrieved by using a fluidize method. Mock-ups show they can retrieve 95% easily. But there is no guarantee how well the mock-ups actually represent the conditions of the system.

Why a concrete pad over the top? That's what they are doing for bin set 1 - to reduce exposure.

If they are going to be removing all the existing equipment before pouring the concrete pad what are you doing with the pipes? They will be cut off at the level of the current roof and capped.

First Step - we're going to have to find some kind of method to get into these bins.

> They actually have two layers - 1st layer where the penthouse and HVAC system are and then you have the control room, which is separated by thirds with a ventilation system in the middle. So you have the roof, that layer, and then the bin start. Looks like you can pop the cover on the roof, go through the control center and pop the cover off that and be able to access the piping that way.

Is all the housing going to be removed down to the last floor? The center is the cyclone cell. You have your instrument room and then your cyclone cell in the center and a fan room off to the side. So, they will not remove below the cyclone cell.

All bin lines will be cut and capped that come up through the superstructure.

In order to get access we'll have to decon it down to the bin. Assume the Cyclone cell has been decontaminated. Now, are we ready to go into the bins? (See Major Activities Above)

How are we going to get the waste out??

Waste Removal

One of the overlying assumptions is that Sarah can actually get the waste out down to where we can consider cease use. What we have done is defined cease use as the point when all waste has been removed that can be removed with the use of existing calcine removal equipment.

Methods to remove as much waste as practical:

- Dissolution with Nitric Acid
- Carbon dioxide blasting
- Air Jets - High pressure air
- Wash (Water wash, decontamination agents)
- Flush with water and skim top
- Float tanks and remove
- Steam methods

Assumption - all waste that can be removed is removed

Vessel Decontamination

To what level? Risked Based Level

No way to guarantee you've got everything clean, all you can do is make an attempt to wash the walls and deal with what's in the bottom. Maybe use carbon dioxide on the walls and water on the bottom. Maybe no water at all!

Is there any chance of going inside the vault and access the bin from the outside to get better access to the bottom of the bin?
Do we have a manipulator or can we design one to go 60' in??

Methods to decontaminate the vessel to debris standards:

- Dissolution with Nitric Acid
- Carbon dioxide blasting
- Air Jets - High pressure air
- Wash (Water wash, decontamination agents)
- Flush with water and skim top

- Float tanks and remove
- Steam methods
- Bead blasting
- Microbes
- Biological destruction
- Heating
- Evaporation

RCRA has retrieval strategies.

Abrasive blasting
Extraction technologies
Thermal treatments
Physical technologies
High pressure water sprays

Piping Decontamination:

Assume the instrumentation and utility lines have already been isolated from the vault by the Retrieval Project.

The transfer lines and ventilation lines to the bins must be decontaminated to Risk Based Clean Closure levels.

Sarah, from your standpoint is the piping that your capping are you doing anything with the piping outside of the building? Nope, just cutting where it comes in and capping it there.

So, part of the decontamination would be the piping outside of the building? I think so.

So we still have piping inside? The piping inside for the most part should be going through the distributor into the vents.

Assume non-waste piping has already been removed.

Issue – the bin lines will be cut and capped and grouted over by the retrieval project. We need to make sure this doesn't happen – we need access or they should decon the pipes.

Assume the lines outside of the vaults will be decontaminated during the retrieval project. We won't deal with them.

Assumption: Decontaminate the distributor and associated piping prior to decontaminating the bins.

Distributors are not controlled – hope the pig goes through one feeder pipe and stops before goes through to bins.

Need some kind of resolution with respect to the decon because there is potentially some ability to flush back into NWCF where you can then transfer out to someplace. But there isn't that capability inside the bin set to transfer liquids.

If the pipes are cut and capped and we are doing it then there is a method of deconing it back to the system. Or if someone else is doing the cutting and capping then it's handed to us as a decontaminated system.

You have a distributor right underneath the floor it. It feeds to all the bins and above that is a cyclone that brings the stuff in and the return air that goes back. So really what's below that floor your going to use one of your deconning methods to decon. The issue is that they have come back and laid 2' of concrete on top of your cap. That's what they are planning on doing and if they do that we have a problem. We can't physically get into them anymore. Is there anyway they can blow that distributor with air before they do that? The almost have to do something - either that or allow an access way.

From the Bins to the Vault roof can be about 30'. In reality we may be able to snake an extra line down there that has some sort of a rotating CO_2 type apparatus.

MAJOR ISSUE: The bin lines are going to be cut, capped, and grouted over - we need to make sure that doesn't happen. Do what needs to be done to seal them off, but leave access for us to come in and deal with the deconning.

Methods to decontaminate piping:

- Robotic cleansing
- Water or liquid
- Carbon Dioxide blasting
- Mechanical cleaning – abrasive or wire brush
- High Pressure steam/air
- Use an abrasive Pig

If we do our best shot at decontamination is that going to be adequate for Risk Based Clean Closure? If you do your best and then come back and characterize it and do estimates and it comes out to the levels, you'll be OK.

RBCC will be the most expensive. We'll have to go to great expense to get the pipes cleaned.

To Get to Landfill

Assume no additional material needs to be removed after cease use. Why?? Cost and dose to workers!

- Will they (regulators, State of Idaho) buy into us leaving 5% of the tanks?
  - They should due to expense.

How are we going to minimize release of these contaminants?

- Grout bin and vault
- Grout Vault void
- Monitoring
- Piping – fill at same time as bin voids

Make a best attempt to disperse calcine in grout so no longer have HLW. Volume has to be reduced – increase volume, decrease concentration – need a complete discussion on why that will no longer be HLW.

Assume that the volume of waste left in the landfill is no longer considered HLW.

Assume that the waste will meet CERCLA ICPP Total Risk Criteria

- Hazardous waste landfill - because we cannot remove all waste. No waste will be added.
- Ground Water Monitoring - more than enough out there now
- Fill all the bins but one and on the last one force the grout through the piping system - distributor.
- Coordinate everything with CERCLA

Do not de-list, leave RCRA in place – can close as landfill because waste is already there, can't clean – not bringing things in to make it a landfill.

Assume that monitoring at the bin sets will only be required for NRC. We will place monitoring capability for others as Best Management Practice.

Bosley will check with Brent to see if landfill is part of our scope of work.

Assume: Concrete cover Sara puts on the vault is our cap.

So, we do not have to tear down what is sticking out of the ground on these vaults? - No. CERCLA is responsible for the ultimate caps.

Discussed in situ vitrification rather than grout – could also use any other materials mentioned in TFF.

Bin Set 1 in not statically stable – does not meet seismic criteria based on design basis earthquake (per Sara Gifford).

1. Needs:
    - Outline
    - Requirements and assumptions is where most time will be spent
    - Methodology
    - Different ways of doing things
    - Picking which way we think is best and why we think it's best

2. Where to Start: Risk Based Clean Closure
3. Need to show why total removal is not possible - Michelle can take care of that Start looking at Risk Based Clean Closure criteria and the different methods for meeting the remaining tasks that are involved. Selecting one of those methodologies for doing that task.

INEL

ENGINEERING DESIGN FILE

Form L-0431.2#
(05-96-Rev.#02)

Project File Number 015720
EDF Serial Number EDF-BSC-007
Functional File Number ED-02

Project/Task BIN SET CLOSURE STUDY
Sub task Bin Set Description

Title: BIN SET DESCRIPTION

SUMMARY

The purpose of this Engineering Design File (EDF) is to provide a central location for information pertaining to the Calcined Solids Storage Facility (CSSF) (see attached Figure). The information such as physical description, dimensions and design parameters etc. is in matrix form. This matrix is divided into three sections, CSSF Bin Vault, CSSF Bin and Retrieval Risers. A summary of topics represented by these sections are as follows:

Bin Vault

- Vault Identification Number
- Inside Vault Height
- Outside Vault Height
- Bin Set Height
- Depth Buried in Ground
- Inside Diameter
- Outside Diameter
- Number of Pre-Cast Roof Beams in Super Structure

Bins

- Number of Bins per Vault
- Bin Set Capacity
- Approximate Volume of Stored Calcine
- Total Estimated Volume Stored Calcine
- Bin Construction Stainless Steel
- Bin Style
- Inner Annular Diameter
- Distance from Vault Floor to Bin Top
- Bin Anchored to Vault Floor
- Inside Obstructions
- Bin Outside Diameter
- Bin Length
- Bin Wall Thickness
- Bin Bottom Shape
- Design Pressure
- Design Temperature
- Design Decay Heat
- Corrosion Allowance

Retrieval Risers

- Currently Existing Retrieval Risers per Bin
- 8" Retrieval Risers per Bin
- 18" Retrieval Risers per Bin

(Continued)

Distribution: B.C. Spaulding, M.M. Dahlmeir, B.R. Helm, D.J. Harrell and Project File (original +1)

Authors	Department	Reviewed	Approved
K.D. McAllister	4130	Date 2/3/98	Date 2/3/98
K.C DeCoria	4130		
Date 2/3/98			

The information presented in the array has been verified to the extent possible through drawings or other reliable sources (see References). These values are close approximations and preliminary in nature. Additional work and further study is needed to obtain better accuracy.

Following a search within our library archives and appealing to experts, CSSF bin set loading restrictions could only be found for bin set 6, where in, "vault and access cell will be designed to support 32,000 kg distributed over the central 1.5 m^2 of the vault roof and 50,000 kg distributed over 0.74 m^2 of the circumference located 0.3 m from the edge of the vault roof"[1]. Bin set 7 may have the same loading restrictions as bin set 6 since the two bin sets have similar construction.

It is important to note that all CSSF Bin Set bins are designed, fabricated, and tested in accordance with the following ASME Boiler and Pressure Vessel Codes:

1. Bin Set #1 Bins: Conforms to ASME Boiler and Pressure Vessel Code, Section VIII – 1965 including all 1956, 1957, and 1958 addenda[2].
2. Bin Set #2 Bins: Conforms to ASME Boiler and Pressure Vessel Code Subsection B, Part UW in Section VIII[3].
3. Bin Set #3 Bins: Conforms to ASME Boiler and Pressure Vessel Code Subsection B, Part UW in Section VIII[4].
4. Bin Set #4 Bins: Conforms to ASME Boiler and Pressure Vessel Code, Section VIII, Division 2 and section IX[5].
5. Bin Set #5 Bins: Conforms to ASME Boiler and Pressure Vessel Code, Section VIII, Division 2[6].
6. Bin Set #6 Bins: Conforms to ASME Boiler and Pressure Vessel Code, Section VIII, Division 2 and section IX[7].
7. Bin Set #7 Bins: Conforms to ASME Boiler and Pressure Vessel Code, Section VIII, Division 2[8].

References:

1. Preliminary Safety Analysis Report for the ICPP Sixth Calcined Solids Storage Facility, ENI-142, June 1981: p 5-7.
2. Solids Storage Bins Specification No. 5775-CPP-P10, U.S. Atomic Energy Commission, Idaho Operations Office, Idaho Falls, Idaho, AEC Contract AT(10-1)-890.
3. Solids Storage Bins Specification No. P-7, CPP – Additional Calcined Waste Storage Facilities, Atomic Energy Commission, Idaho Operations Office, Idaho Falls, Idaho, AEC Contract AT(10-1)-1180.
4. Conforms to the same ASME Boiler and Pressure Vessel Code because the bins are similar except the bins are taller. See Safety Analysis Report of the ICPP High-Level Solid Radioactive Waste Storage Facilities, G.E. Lohse, ICP-1005, TID-4500 (Waste Disposal and Processing).
5. Final Safety Analysis Report of the Fourth Calcined Solids Storage Facility, February 1980, ENICO-1031, UC-70.
6. Final Safety Analysis Report for the Fifth Calcined Solids Storage Facility, February 1984, ENICO-1068, UC-70, Rev. 1.
7. Final Safety Analysis Report for the ICPP Sixth Calcined Solids Storage Facility, December 1992, WIN-107-8.3E, Rev. 1.
8. Project Design Criteria for the ICPP Seventh Calcined Solids Storage Facility, R.F. Mozes, September 1984, WIN-157

Matrix References:

[a] Drawing 106585
[b] Drawing 118877
[c] Drawing 153242
[d] Drawing 157778
[e] Drawing 158462
[f] Drawing 161360
[g] Drawing 168110
[h] Drawing 118865
[i] Drawing 154139
[j] Drawing 157774
[k] Drawing 153241
[l] Drawing 157802
[m] Drawing 158517

[n] Drawing 106583
[o] Drawing 154148
[p] Drawing 158469
[q] Drawing 161373
[r] Drawing 168116
[s] Waste Inventories/Characterization Study, R.S. Garcia, Sept. 1997, INEL/EXT-97-00600.
[t] Drawing 158510
[u] Drawing 106577
[v] Drawing 118871
[w] Drawing 153510
[x] Drawing 155750
[y] Drawing 168198
[z] Drawing 168199
[aa] Drawing 165772
[bb] Drawing 153513
[cc] Drawing 1375-CPP-760-M1 (serial number not available)
[dd] Drawing CW45314-1,2 (Capital Westward Drawing) [ICPP drawings were unable to show information needed]
[ee] Drawing 118872
[ff] Drawing 158522
[gg] Drawing 106588
[hh] Final Safety Analysis Report for the Fifth Calcined Solids Storage Facility, Feb. 1984, ENICO-1068, UC-70: pp 32-34
[ii] Preliminary Safety Analysis Report (PSAR) for the ICPP Seventh Calcined Solids Storage Facility, Aug. 1987, J.M. Siemer & R.A. Suckel, WIN-174: p 4-6
[jj] Final Safety Analysis Report for the Fifth Calcined Solids Storage Facility, Feb. 1984, ENICO-1068, UC-70: p 32
[kk] Final Safety Analysis Report for the fourth Calcined Solids Storage Facility, Feb. 1990, ENICO-1031, UC-70: p 22
[ll] Preliminary Safety Analysis Report for the ICPP Sixth Calcined Solids Storage Facility, Jun. 1981, ENI-142
[mm] Drawing 160283
[nn] Drawing CW06358 Sheet 1 of 6 (Capital Westward Drawing) [ICPP drawings were unable to show information needed]
[oo] Data gathered by Mike Swenson, 526-3576
[pp] Drawing 153511
[qq] Drawing 155750
[rr] Drawing 160284
[ss] Drawing 165773
[tt] Calcined Solids Storage Facilities – Volume Calculations, PFN-015720, EDF-BSC-001, FFN-C-01
[uu] Review of Calcined High-Level Waste Stored at the ICPP, M.D. Staiger, May 1995, Draft, UC-70
[vv] Drawing 158493
[ww] Capital Westward Drawing CW-06358
[xx] Drawing 106578

Definitions for the Purposes of This Study

Bin Vault:
Bin vaults are defined as cylindrical or square reinforced concrete buildings with various dimensions (given in the following matrix) set on bedrock and partially or fully buried. Each bin vault contains 3, 4 or 7 storage bins. To protect the storage bins the vaults have been designed to withstand provisions for tornado, earthquake, missile, fire, flood and explosion effects.

Bins:
Bins are defined as stainless steel, vertical cylindrically shaped vessels and pan shaped on either end (except for Bin Set 1 where the bins are flat at either end). These bins were design to hold processed calcine for long-term storage.

Retrieval Risers:
Retrieval risers are defined as 8 and 18-inch diameter pipe that runs vertically from the bin surface through the bin vault roof, allowing access into the bin. Retrieval riser installation occurs during the Calcine Retrieval and Transportation project (EDF-BSC-005).

Bin Set Description Matrix

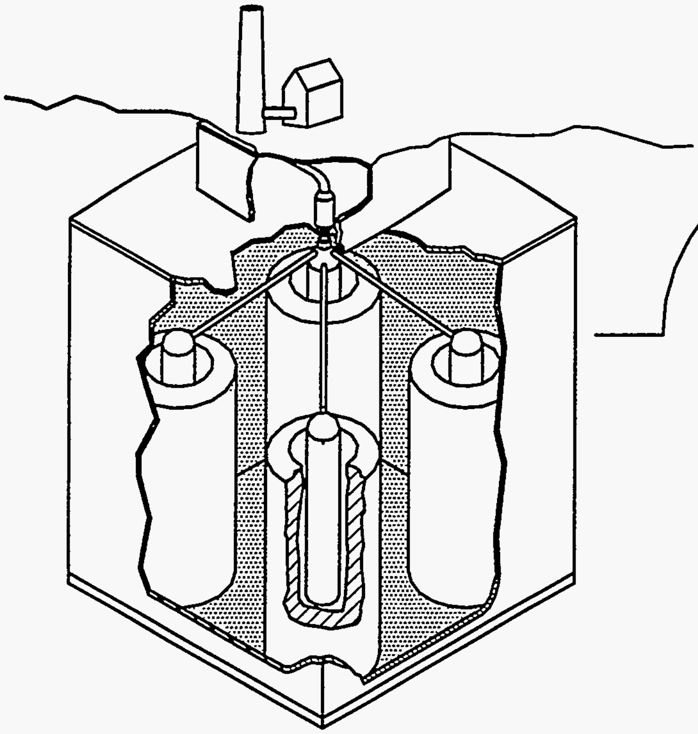
	Bin Set #1	Bin Set #2	Bin Set #3	Bin Set #4	Bin Set #5	Bin Set #6	Bin Set #7
Bin Vault							
Vault Identification Number	CPP-729	CPP-742	CPP-746	CPP-760	CPP-765	CPP-791	CPP-795
Inside Vault Height[1]	[a]39.33'	[b]61.83' to 64.83'	[c]67.21' to 70.21'	[d]64.71' to 67.21'	[e]73.25' to 76.92'	[f]88.5'	[g]88.5'
Outside Vault Height	[a]45.083'	[h]72.67'	[i,j]68.2'	[j]74.83'	[e]85.083'	[f]100.25'	[g]100.25'
Bin Set Height[2]	[a]54.83'	[h]83'	[c,j,k]78.5'	[i,j]78.583'	[e]97.167'	[f]111.75'	[g]111.75'
Depth Buried in Ground[3]	[a]54.83'	[h]50'	[c,j]45.5'	[j]48.5'	[j,m]49'	[f,j]36'	[g]36'
Inside Diameter[4]	[n]25.5' square	[b]46'	[o]46'	[d]36'	[p]47'	[q]52.33'	[r]52.33'
Outside Diameter[5]	[n]30.5' square	[b]50'	[o]50'	[d]42'	[p]55'	[q]60.83'	[r]60.83'
Number of Pre-Cast Roof Beams in Super Structure	[a]2	[b]8	[c]8	[d]6	[e]6	[f]2	[g]2
Bins							
Number of Bins per Vault	4 (with 12 internal bins)	7	7	3	7	7	7
[u]Bin Set Capacity (cubic feet)	7,844	31,542	40,686	17,895	36,544	56,649	64,778
[s]Approximate Volume of Stored Calcine (cubic feet)	373 'cold' alumina	900 dolomite & 'cold' alumina	3,950 'cold' alumina	910 'cold' alumina & dolomite	3,670 'cold' alumina & dolomite	730 'cold' alumina & dolomite	0
	7,292 'hot' alumina	10,754 'hot' alumina	1,860 dolomite & flourapatite	110 'hot' alumina-zirconia blend	50 developmental Calcine	5,010 'hot' alumina, zirconia-alumina-sodium blend	-
	-	18,582 'hot' zirconia	2,250 'hot' alumina	5,210 zirconia	31,303 'hot' alumina, zirconium, ROVER, & sodium blend	-	-
	-	-	24,844 zirconia	11,020 zirconia-sodium blend	-	-	-
	-	-	5,580 zirconia-sodium blend	-	-	-	-
	-	-	50 stainless steel	-	-	-	-
Total Estimated Volume of Stored Calcine[6] (cubic feet)	7,665	30,263	38,534	17,250	35,023	5,740	0
Bin Construction Stainless Steel	[oo]405	[oo]304	[oo]304	[oo]304L	[hh]304L	[oo]304L	[oo]304L
[oo]Bin Style	Concentric[8]	Cylindrical[9]	Cylindrical[9]	Cylindrical[9]	Annular[10]	Annular[10]	Annular[10]
Inner Annulus Hole Diameter	n/a	n/a	n/a	n/a	[t]4'	[mm]5.0'	[aa]1'
Distance from Vault Floor to Bin Top	[u]center bins 24.42' [u]outer bins 20' [u]Bin 4, center bin 26.75'	[v]42.5'	[w]outer 53' [w]center 61'	[x]55.33'	[t]55'	[mm]68'	[y,z]68.8'
Bins Anchored to Vault Floor	No	Yes	Yes	Yes	Yes	Yes	Yes
Inside Obstructions	[xx]Yes	[b]Yes	[w]Yes	[x]Yes	[cc,ff]Yes	[mm]Yes	[aa]Yes
Number of Inside Wall Stiffeners per Bin	[xx]2-all inner bin edges [xx]4-outer bin outer edge	[v]2	[w]3	[x]4	[t]0	[mm]0	[aa]0
Number of Thermowell Lances[7] per Bin	[xx]1	[v]1	[w]1	[x]1	[ww]1	[mm]1	[aa]1
Number of Horizontal Thermowell Lance Supports per bin	[xx]2	[v]2	[w]2	[x]2	[ww]2	[mm]3	[aa]3
Number of Thermowell Tripod Supports per Bin	[xx]0	[v]1	[w]1	[x]1	[ww]1	[mm]1	[aa]1
Corrosion Coupon Sample Hangers per Bin	[xx]0	[v]0	[w]0	[x]5	[t]5	[mm]0	[aa]0

Bins (continued)	Bin Set #1	Bin Set #2	Bin Set #3	Bin Set #4	Bin Set #5	Bin Set #6	Bin Set #7
Bin Outside Diameter	[u]center bins 3' [u]middle bins 7.5' [w]outer bins 12.1'	[v]12'	[w]12'	[x]12'	[t]12'	[mm]13.5'	[y]13.5'
Bin Length	[u]center bins 24.42' [u]outer bins 20' [u]#4 center bin 26.75'	[v]42.167'	[w]outer bins 52.67' [w]center bin 58.67'	[x]55'	[t]54.67'	[mm]67.5'	[aa]67.5'
Bin Wall Thickness[11]	[u]center Bin 1/8" [u]middle Bin[16] 1/8" inside 3/16" outside [u]outer most bin 3/16" [u]bin top ¼" [u]bin bottom 5/16"	[v]walls1/4" [v]dome 7/16" [ee]bin bottom 7/16"	[bb]walls 7/16" [w]dome 7/16" [w]bin bottom 9/16"	[cc,dd]walls 3/8" [cc]dome 1/2" [cc,dd]bin bottom 5/8"	[nn]dome 3/8" [nn]upper wall[12] 3/8" [nn]middle wall[12] 1/2" [nn]lower wall[12] 5/8" [nn]bin bottom 5/8"	[mm]dome 11/16" [mm]upper wall[12] 1/2" [mm]upper middle wall[12] 5/8" [mm]midsection middle wall[12] 3/4" [mm]lower middle wall[12] 7/8" [mm]bin bottom 1"	[aa]dome 11/16" [aa]upper wall[12] 1/2" [aa]upper middle wall[12] 5/8" [aa]midsection middle wall[12] ¾" [aa]lower middle wall[12] 7/8" [aa]bin bottom 1"
Bin Bottom Shape	[u]flat	[v]bowl shaped	[w]bowl shaped	[qq]bowl shaped	[t]bowl shaped	[mm]bowl shaped	[aa]bowl shaped
Design Pressure	[oo]3.75 to –3.75 psig	[oo]3.75 to –3.75 psig	[oo]3.75 to –3.75 psig	[kk]3.75 to –3.75 psig	[ll]3.8 to -4.4 psig	[ll]8 to –6 psig	[ll]8.5 to –6.5 psig
Design Temperature	[oo]343 deg. C	[oo]288 deg. C	[oo]288 deg. C	[kk]121 deg. C	[ll]205 deg. C	[ll]260 deg. C	[oo]260 deg. C
[oo]Design Decay Heat	1475 W/cu. m	175 W/cu. m	175 W/cu. m	175 W/cu. m	465 W/cu. m	410 W/cu. m	170 W/cu. m
[oo]Corrosion Allowance[13]	0.125"	0.125"	0.125"	0.016"	0.02"	0.02"	0.02"
Retrieval Risers							
Currently existing retrieval Risers per Bin	[u]0	[v]one 6" retrieval line	[w,pp]one 6" retrieval line	[qq]two 8" retrieval lines	[t]four 6" retrieval lines	[mm,rr]four 8" retrieval lines	[aa,ss]four 8" retrieval lines
8" Retrieval Risers per Bin[14,15]	2	outer bins 1, center bin 2	1	0	0	0	0
18" Retrieval Risers per Bin[14]	outer bins 2, center bins 1	1	1	1	2	2	2
Total 8" per 18" Risers per Bin Set	24/20	8/7	7/7	0/3	0/14	0/14	0/14

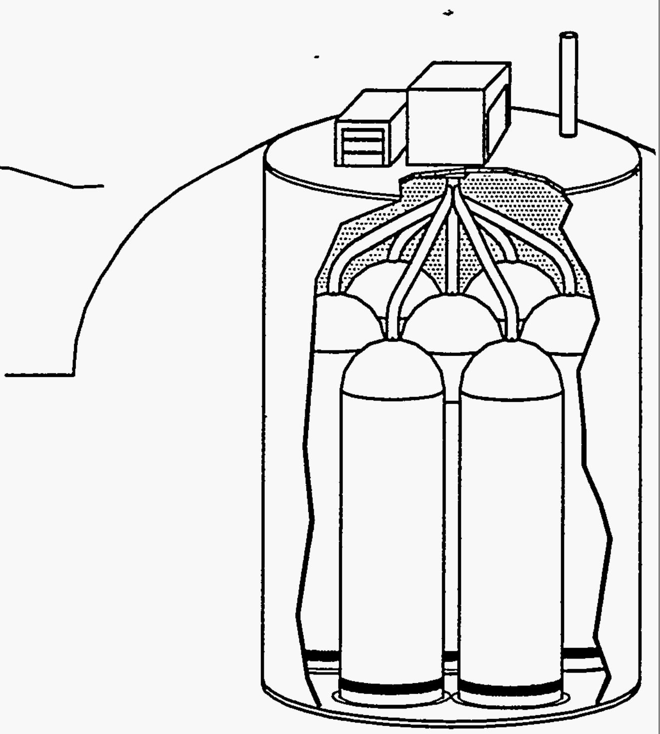
Explanation:

1 If pre-cast beams protrude into the vault significantly, two measurements are provided. The first number is from the floor to the beam and the second number is to the vault ceiling past the beam.
2 Measurement from the outside bottom vault edge to the top of the cyclone room roof.
3 Bin Set depth underground.
4 Square signifies a square vault.
5 Square signifies a square vault.
6 Volume of calcine currently stored in the bins as of 1995[uu].
7 Measures the calcine depth.
8 Flat bottom bins with the outer bin surrounding the middle bin, which in turn surrounds the central bin.
9 Cylindrical bins are shaped like a cylindrical pressure vessel.
10 Annular bins are shaped like a cylindrical pressure vessel with a hole formed length wise through the bin to allow for heat dissipation.
11 Risers initially attached to the dome portion of bin may add to the dome thickness in some areas.
12 Wall thickness varies over length.
13 Amount of corrosion allowable in 500 years.
14 Installed by the Calcine Retrieval and Transportation project.
15 A zero indicates that existing retrieval risers are assumed to be adequate for calcine retrieval purpose.
16 The first number given is the wall thickness of the inner bin wall, and the second number is the wall thickness of the outer bin wall.

D



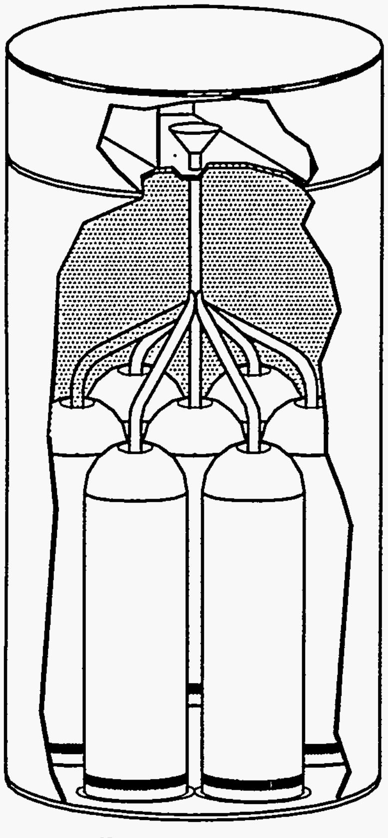
Bin Set 1



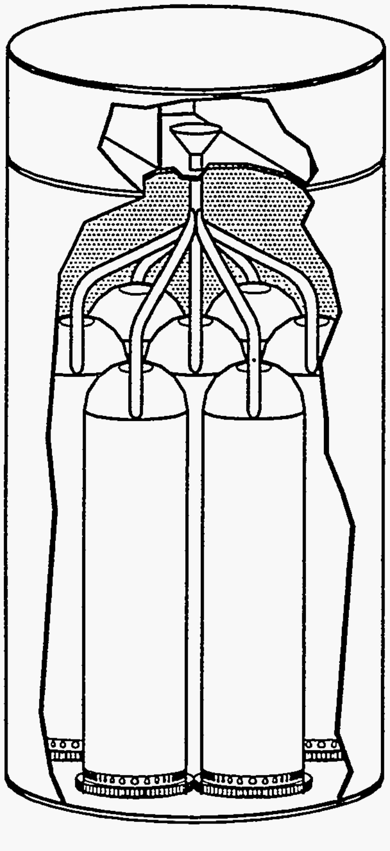
Bin Set 2

C

B



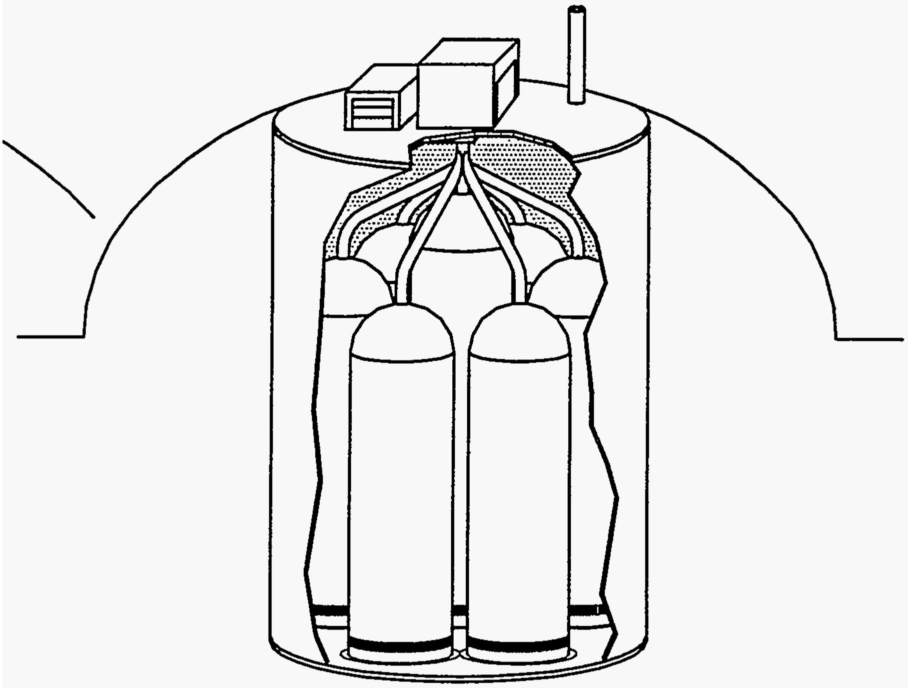
Bin Set 5



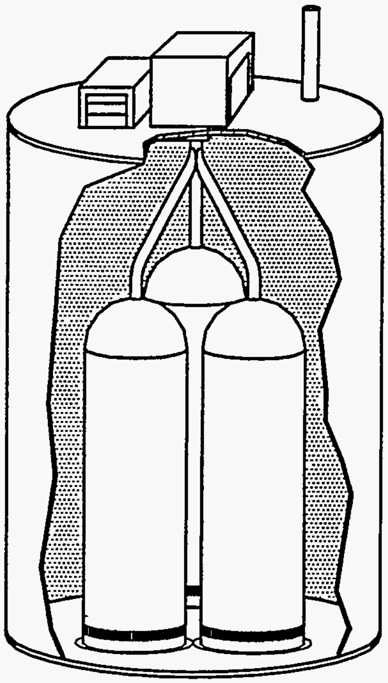
Bin Set 6

A

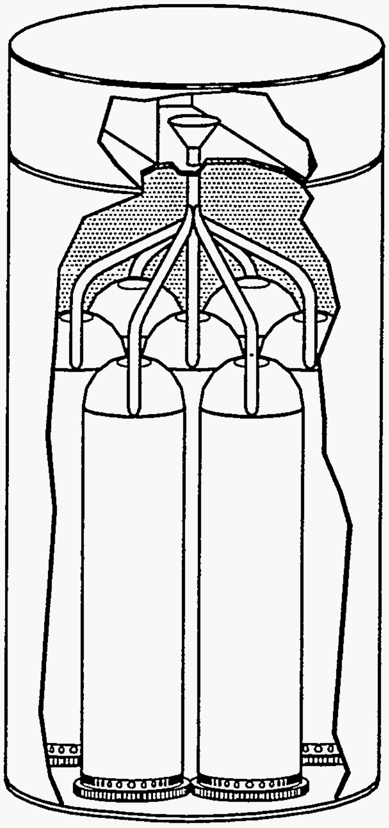
REVISIONS		
REV	DESCRIPTION	EFFECTIVE DATE:



Bin Set 3



Bin Set 4



Bin Set 7

FOR DRAWING INDEX SEE SUBDRAWING NO.
REQUESTER:
DESIGN:
DRAWN: W. HOWARD
SCALE: 1/4" = 1'-0"
PROJECT NO.
SPEC CODE
FOR REVIEW/APPROVAL SIGNATURES SEE DAR NO.
DESIGN PHASE:
QUALITY LEVEL:
EFFECTIVE DATE:

LOCKHEED MARTIN

PICTORIAL REPRESENTATION FOR EACH
OF THE SEVEN BIN SETS
FIGURE 2-1

SIZE	CAGE CODE	INDEX CODE NUMBER AREA	TYPE	CL	ORG	DWG-	REV
D	01MF3				530		

SCALE: NONE
SHEET 1 OF 1

431.02#
06/17/97
Rev. #04

ENGINEERING DESIGN FILE

Function File Number - SPR-01
EDF Serial Number - EDF-BSC-008

Project File Number 015720

Project/Task Bin Set Closure Evaluations

Subtask Estimates of Activity in Bin Sets Filled with Grout

Title: Class C and Class A Assessment

Summary: Of the options being considered for processing ICPP calcine and sodium-bearing waste (SBW), several options result in large volumes of grouted waste. One disposal option being considered for this grout is to place it in the emptied Bin Sets of the Calcine Solids Storage Facility (CSSF). The Full Separations Option and the TRU Separations / Class A Option result in a Class A grout, while the TRU Separations / Class C Option results in a Class C grout. The purpose of this EDF is to estimate the average activities of grout that is placed in the different Bin Sets, and determine if the resulting activity levels change the classification of the grout. These activities were estimated by adding activities of the grout to activities of the residual amounts of calcine estimated to remain on the bin walls, floor, supports and piping after calcine retrieval and closure activities. Two sets of data for residual calcine volumes were used, one based on a risk-based closure, the other on landfill closure. For each Bin Set, grout compositions were used for three cases – grout from processing SBW, grout from processing alumina calcine and grout from processing zirconia calcine. The calculations show that if Class A grout, or even clean grout, is placed in the Bin Sets, Class A limits are exceeded because of the activity of the residual calcine. The resulting waste would meet limits for Class C, but not Class A, for all of the Bin Sets. If Class C grout is placed in the Bin Sets, the resulting mixture does not exceed Class C limits, with the exception of placing grout from processing calcine into Bin Set 4 that contains the landfill-based residual calcine volume.

A second purpose of the EDF was to calculate the height of a lift of clean grout that would be needed in each Bin Set to produce a "heel" with activities meeting Class C limits. For risk-based residual calcine volumes, the height of grout varies from 2 feet for Bin Sets 1 and 7 to 19 feet for Bin Set 4. For landfill residual calcine volumes, the height varies from 3 feet for Bin Set 7 to 24 feet for Bin Set 4.

Distribution (complete package): M. M. Dahlmeir, K. C. Decoria, B. R. Helm, D. J. Harrell, B. C. Spaulding
Distribution (summary package only): J. J. McCarthy

Author C. M Barnes	Dept. 4170	Reviewed	Date 1/29/98	Approved	Date 1/29/98
CMBarnes	1/29/98	LMITCO Review	Date	LMITCO Approval	Date

INTRODUCTION AND BASIS FOR THE ASSESSMENT

After retrieval of calcine from the bins in the Calcine Solids Storage Facility (CSSF), small amounts of calcine will remain on the bin walls, floor, supports, and internal and external piping.

Estimates of the total residual calcine volumes in the Bin Sets are as follows:[1]

	Risk-Based Closure	Landfill Closure
Bin Set 1	31.2 ft^3	69.6 ft^3
Bin Set 2	88.1 ft^3	120.8 ft^3
Bin Set 3	149.4 ft^3	303.9 ft^3
Bin Set 4	49.7 ft^3	67.1 ft^3
Bin Set 5	106.5 ft^3	158.2 ft^3
Bin Set 6	162.9 ft^3	233.9 ft^3
Bin Set 7	178.4 ft^3	233.9 ft^3.

In terms of percentage of the original calcine volume, the residual calcine amounts to the following:

	Risk-Based Closure	Landfill Closure
Bin Set 1	0.40%	0.89%
Bin Set 2	0.28%	0.38%
Bin Set 3	0.37%	0.74%
Bin Set 4	0.28%	0.37%
Bin Set 5	0.29%	0.43%
Bin Set 6	0.29%	0.41%
Bin Set 7	0.28%	0.36%

NRC classification limits for waste are shown in Table 1. 10 CFR 61.55 also contains limits for ^3H, ^{63}Ni, ^{60}Co and ^{14}C, however, these radionuclides are not expected to be contained in the grout in any significant quantity.

The Full Separations Option and the TRU Separations / Class A includes process operations that remove cesium, strontium and actinides, which include transuranic radionuclides, from either sodium bearing waste (SBW) or dissolved calcine. Low activity effluents from these options are concentrated by evaporation, denitrated and then grouted into a waste that meets Class A limits.

The TRU Separations / Class C Option includes process operations that remove only actinides from the SBW and dissolved calcine. Cesium and strontium isotopes remain in the effluent streams that are grouted into a Class C waste.

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[1] Data received from S. Swanson, January 14, 1998.

Table 1. Radionuclide Concentrations Limits for Different Waste Classes.[2]

	Concentration Limit		
	Class C	**Class B**	**Class A**
	Ci/m3	Ci/m3	Ci/m3
^{137}Cs	4,600	44	1
^{90}Sr	7,000	150	0.04
^{99}Tc	3	0.3	0.3
^{129}I	0.08	0.008	0.008
	nCi/g	nCi/g	nCi/g
^{241}Pu	3500	350	350
^{242}Cm	20,000	2,000	2,000
Total Alpha	100	10	10

Material balances were produced as part of the TRU Separations Scoping Studies[4] for three cases – processing SBW, processing alumina calcine and processing zirconia calcine. The intent of these cases was to cover the compositional range of waste feeds, although in actual operation, calcine types may be blended. Also, many of the Bin Sets contain layers of several types of calcine, including calcine from blending different types of liquid wastes.

The volume of grout assumed to fill the Bin Sets is as follows:

Bin Set	**Grout Volume, ft^3**
1	7849
2	35749
3	42864
4	18661
5	38704
6	58356
7	67262

Table 2 shows the amount of activity, in Curies, present in the residual calcine of Bin Sets 1, 4 and 6. The activities shown in Table 2 for Bin Set 1 were based on activities for alumina calcine,[3] for Bin Set 4 on activities for zirconia calcine,[4] and

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[2] From 10 CFR 61.55

[3] D. R. Wenzel, *Evaluation of Radionuclide Inventory for Al Calcine*, Engineering Design File CPP-97067, EDF-FDO-004, October 14, 1997.

[4] D. R. Wenzel, *Evaluation of Radionuclide Inventory for Zr Calcine*, Engineering Design File CPP-97068, EDF-FDO-003, October 14, 1997.

for Bin Set 6 on activities for calcine from sodium-bearing waste.[5] Assuming all sodium-bearing waste is calcined, it will occupy about 70% of the volume of Bin Set 6. All activities in Table 2 are decayed to January, 2016. Radionuclides other than those shown in Table 2 are present in calcine; Table 2 shows only those radionuclides with NRC limits.

Table 2. Curie Content of Residual Calcine Volumes in Bin Sets.

	Risk-Based Residual Calcine			Landfill Residual Calcine		
	Bin Set 1	Bin Set 4	Bin Set 6	Bin Set 1	Bin Set 4	Bin Set 6
	Ci	Ci	Ci	Ci	Ci	Ci
Cs-137	3.4E+03	2.2E+03	1.2E+03	7.6E+03	3.0E+03	1.7E+03
Sr-90	3.1E+03	2.9E+03	1.2E+03	6.9E+03	4.0E+03	1.8E+03
Tc-99	1.7E+00	7.0E-01	3.1E-01	3.9E+00	9.4E-01	4.5E-01
I-129	2.9E-03	1.1E-03	2.6E-01	6.5E-03	1.5E-03	3.7E-01
Pu-241	8.1E-01	1.6E+01	4.4E+00	1.8E+00	2.1E+01	6.3E+00
Total alpha	3.5E+00	5.4E+01	1.9E+01	7.8E+00	7.3E+01	2.8E+01
Cm-242	1.4E-05	8.3E-07	3.9E-04	3.2E-05	1.1E-06	5.6E-04

CLASS A GROUT ASSESSMENT

As a first step in assessing whether Class A grout placed in Bin Sets would retain the Class A classification, average radionuclide concentrations were calculated based on adding clean grout, containing no radioactivity, to the Bin Sets. Table 3 shows average radionuclide concentrations that would be present in the Bin Sets if clean grout were used to fill the Bin Sets.

Table 3. Specific Activity of Clean Grout/Residual Calcine.

	Risk-Based Residual Calcine			Landfill Residual Calcine		
	Bin Set 1	Bin Set 4	Bin Set 6	Bin Set 1	Bin Set 4	Bin Set 6
	Ci/m3	Ci/m3	Ci/m3	Ci/m3	Ci/m3	Ci/m3
Cs-137	15	4	0.7	34	6	1.0
Sr-90	14	6	0.7	31	7	1.1
Tc-99	7.8E-03	1.3E-03	1.9E-04	1.7E-02	1.8E-03	2.7E-04
I-129	1.3E-05	2.2E-06	1.6E-04	2.9E-05	2.9E-06	2.3E-04
	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g
Pu-241	2.0	16.6	1.5	4.5	22.4	2.1
Tot alpha	8.7	57.3	6.5	19.5	77.2	9.3
Cm-242	3.6E-05	8.8E-07	1.3E-04	8.1E-05	1.2E-06	1.9E-04

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[5] D. R. Wenzel, *Evaluation of Radionuclide Inventory for Sodium Bearing Waste*, Engineering Design File CPP-97080, EDF-FDO-006, November 26, 1997.

Dividing the values in Table 3 by the waste concentration limits for Class A waste (see Table 1), gives the activity that would be in the bin sets as a fraction of the Class A limit. These "fractions" are shown in Table 4. To determine if a waste meets a particular waste class, fractions of all radionuclides are added together, and if the sum is less than 1, the waste meets the limits for that class. Table 3 shows that even if clean fill material were added to the residual calcine in the bin sets, the resulting waste would exceed limits for Class A waste. If filling the bin sets with clean grout results in material exceeding Class A limits, filling the bin sets with Class A grout from the separations facilities would also result in material exceeding Class A limits.

Table 4. Radionuclide Concentrations as Fractions of Class A Limits Assuming Bins Filled with Clean Grout.

	Risk-Based Residual Calcine			Landfill Residual Calcine		
	Bin Set 1	Bin Set 4	Bin Set 6	Bin Set 1	Bin Set 4	Bin Set 6
Cs-137	15	4	1	34	6	1
Sr-90	347	139	18	777	187	27
Tc-99	0.0260	0.0044	0.0006	0.0583	0.0059	0.0009
I-129	0.0016	0.0003	0.0197	0.0036	0.0004	0.0282
Pu-241	0.006	0.047	0.004	0.013	0.064	0.006
Tot alpha	0.9	5.7	0.6	2.0	7.7	0.9
Cm-242	1.8E-08	4.4E-10	6.6E-08	4.0E-08	5.9E-10	9.4E-08
Sum of the fractions	363	149	20	813	200	29

Conceivably, additional calcine could be removed from the Bin Sets in order to meet the Class A limits. Table 5 shows the estimated amounts of residual calcine that could be left in Bin Sets, which, if filled with clean grout, would meet Class A limits. The amounts shown in Table 5 are of such small magnitude that it does not appear feasible to achieve Bin Set closure with waste that meets Class A limits.

Table 5. Estimated Allowable Volumes of Residual Calcine in Bin Sets for Class A Waste Using Clean Grout as Fill.

Bin Set	Residual Calcine Volume, ft^3	Residual Volume as a Percent of the Original Calcine Volume
1	0.086	0.001
4	0.33	0.002
6	8.2	0.014

The above assessment was performed only for three of the seven bin sets, primarily because the most complete and consistent activity data was available for these bin sets. Table 6 shows activites for radionuclides in Bin Sets 1-6. Activities shown in Table 6 were calculated from data on the INEEL High Level Waste Systems Engineering home pages, updated November 14, 1997, and accessible from http://wcb08/~nichtt.wcb.inel/hlwhome.htm.

These activites shown in Table 6 are decayed to January 1, 2000, and do not contain daughter products, but provide a means of comparison activities in the six bin sets.

Table 6. Selected Calcine Activities by Bin Set.

Bin Set	**1**	**2**	**3**	**4**	**5**	**6**
	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg
Total alpha	9.29E-04	3.08E-03	6.08E-04	1.31E-02	8.35E-03	4.38E-03
Pu-241	3.08E-04	1.67E-03	4.84E-03		4.16E-04	1.10E-03
Cs-137	5.00E+00	2.34E+00	1.66E+00	2.20E+00	2.38E+00	1.39E+00
Sr-90	4.36E+00	2.17E+00	1.48E+00	2.15E+00	2.16E+00	1.36E+00

Table 6 indicates that calcine in Bin Set 1 has the highest ^{137}Cs and ^{90}Sr activites of any of the Bin Sets, calcine in Bin Set 6 has the lowest ^{137}Cs and ^{90}Sr activites, and calcine in Bin Set 4 has the highest total alpha-emitting radionuclide activities. Thus it can be assumed that the calculations in this assessment performed for Bin Sets 1, 4 and 6 reasonably bound all of the bin sets.

CLASS C ASSESSMENT

If the Bin Sets were filled with Class C grout, radioactivity in the Bin Sets would be the sum of radioactivity in the grout added to the Bin Sets and in the residual calcine left in the Bin Sets following all retrieval and closure activities. Table 7 shows the activity present in the Class C grout only, expressed as a fraction of the allowable Class C limit. The numbers in Table 7 show that residual calcine can contain activity amounting to about 64% of the Class C limit for bins filled with grout from processing alumina calcine, 75% of the Class C limit for bins filled with grout from processing zirconia calcine, and 96% of the Class C limit for bins filled with grout from processing SBW, and the resulting waste will meet Class C limits.

Table 7. Activity in Class C Grout As Fraction of Class C Limits.

	Class C limit	Grout from Alumina Calcine	Grout from Zirconia calcine	Grout from SBW calcine
	Ci/m^3			
Cs-137	4600	0.1476	0.0850	0.0119
Sr-90	7000	0.0887	0.0734	0.0074
Tc-99	3	0.1101	0.0386	0.0069
I-129	0.08	0.0034	0.0012	0.0290
	nCi/g			
Pu-241	3500	0.0000	0.0000	0.0000
Total alpha	100	0.0078	0.0465	0.0000
Cm-242	20000	0.0000	0.0000	0.0000
Sum of the Fractions		0.3575	0.2447	0.0553

Table 8 shows the total Curies that would be present in Bin Sets 1, 4 and 6 if they were filled with Class C grout. Table 9 shows the same data expressed as fractions of the Class C limit.

Table 8. Total Curies in Bin Sets Filled with Class C Grout.

	Risk-Based Residual Calcine Volumes			Landfill-Based Residual Calcine Volumes		
	Bin Set 1	Bin Set 4	Bin Set 6	Bin Set 1	Bin Set 4	Bin Set 6
			Filled with Grout from processing SBW			
Cs-137	1.6E+04	3.1E+04	9.2E+04	2.0E+04	3.2E+04	9.2E+04
Sr-90	1.5E+04	3.0E+04	8.7E+04	1.8E+04	3.1E+04	8.8E+04
Tc-99	6.4E+00	1.2E+01	3.5E+01	8.5E+00	1.2E+01	3.5E+01
I-129	5.2E-01	1.2E+00	4.1E+00	5.2E-01	1.2E+00	4.2E+00
Pu-241	8.1E-01	1.6E+01	4.4E+00	1.8E+00	2.1E+01	6.3E+00
Total alpha	3.5E+00	5.4E+01	1.9E+01	7.8E+00	7.3E+01	2.8E+01
Cm-242	1.4E-05	8.3E-07	3.9E-04	3.2E-05	1.1E-06	5.6E-04

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Table 8 (Continued)

	Risk-Based Residual Calcine Volumes			Landfill-Based Residual Calcine Volumes		
	Bin Set 1	**Bin Set 4**	**Bin Set 6**	**Bin Set 1**	**Bin Set 4**	**Bin Set 6**
	Filled with Grout from Processing Alumina Calcine					
Cs-137	1.5E+05	3.6E+05	1.1E+06	1.6E+05	3.6E+05	1.1E+06
Sr-90	1.4E+05	3.3E+05	1.0E+06	1.4E+05	3.3E+05	1.0E+06
Tc-99	7.5E+01	1.8E+02	5.5E+02	7.7E+01	1.8E+02	5.5E+02
I-129	6.3E-02	1.4E-01	7.1E-01	6.6E-02	1.4E-01	8.2E-01
Pu-241	8.1E-01	1.6E+01	4.4E+00	1.8E+00	2.1E+01	6.3E+00
Total alpha	3.8E+00	5.5E+01	2.2E+01	8.1E+00	7.4E+01	3.0E+01
Cm-242	2.2E-05	2.0E-05	4.5E-04	4.0E-05	2.0E-05	6.2E-04
	Filled with Grout from Processing Zirconia Calcine					
Cs-137	9.0E+04	2.1E+05	6.5E+05	9.5E+04	2.1E+05	6.5E+05
Sr-90	1.2E+05	2.7E+05	8.5E+05	1.2E+05	2.8E+05	8.5E+05
Tc-99	2.7E+01	6.2E+01	1.9E+02	3.0E+01	6.2E+01	1.9E+02
I-129	2.4E-02	5.0E-02	4.1E-01	2.7E-02	5.1E-02	5.3E-01
Pu-241	8.1E-01	1.6E+01	4.4E+00	1.8E+00	2.1E+01	6.3E+00
Total alpha	5.3E+00	5.9E+01	3.3E+01	9.7E+00	7.8E+01	4.2E+01
Cm-242	1.5E-05	1.8E-06	3.9E-04	3.3E-05	2.1E-06	5.6E-04

Table 9. Activity in Bin Sets Filled with Class C Grout Expressed as Fraction of Class C Waste Limit.

	Risk-Based Residual Calcine Volumes			Landfill-Based Residual Calcine Volumes		
	Bin Set 1	**Bin Set 4**	**Bin Set 6**	**Bin Set 1**	**Bin Set 4**	**Bin Set 6**
	Filled with Grout from processing SBW					
Cs-137	0.015	0.013	0.012	0.019	0.013	0.012
Sr-90	0.009	0.008	0.008	0.012	0.009	0.008
Tc-99	0.010	0.007	0.007	0.013	0.008	0.007
I-129	0.029	0.029	0.031	0.029	0.029	0.032
Pu-241	0.001	0.005	0.000	0.001	0.006	0.001
Total alpha	0.087	0.573	0.065	0.195	0.772	0.093
Cm-242	0.000	0.000	0.000	0.000	0.000	0.000
Sum of the fractions	0.151	0.635	0.123	0.270	0.837	0.152

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Table 9 (Continued)

	Risk-Based Residual Calcine Volumes			Landfill-Based Residual Calcine Volumes		
	Bin Set 1	**Bin Set 4**	**Bin Set 6**	**Bin Set 1**	**Bin Set 4**	**Bin Set 6**
	Filled with Grout from Processing Alumina Calcine					
Cs-137	0.151	0.149	0.148	0.155	0.149	0.148
Sr-90	0.091	0.089	0.089	0.093	0.090	0.089
Tc-99	0.113	0.111	0.110	0.116	0.111	0.110
I-129	0.004	0.003	0.005	0.004	0.003	0.006
Pu-241	0.001	0.005	0.000	0.001	0.006	0.001
Total alpha	0.095	0.580	0.073	0.203	0.780	0.101
Cm-242	0.000	0.000	0.000	0.000	0.000	0.000
Sum of the fractions	0.453	0.937	0.425	0.572	**1.139**	0.455
	Filled with Grout from Processing Zirconia Calcine					
Cs-137	0.088	0.086	0.085	0.092	0.086	0.085
Sr-90	0.075	0.074	0.073	0.078	0.074	0.074
Tc-99	0.041	0.039	0.039	0.044	0.039	0.039
I-129	0.001	0.001	0.003	0.002	0.001	0.004
Pu-241	0.001	0.005	0.000	0.001	0.006	0.001
Total alpha	0.134	0.619	0.111	0.242	0.819	0.140
Cm-242	0.000	0.000	0.000	0.000	0.000	0.000
Sum of the fractions	0.340	0.824	0.312	0.459	**1.026**	0.342

Table 9 shows that:

1. For all Bin Sets and all Class C grout types, filling the bins containing risk-based residual calcine volumes will result in waste that meets Class C limits.

2. For the landfill closure case, Class C grout from SBW processing can be placed in any Bin Set and the resulting waste will remain Class C. Class C grout from processing calcine can be placed in Bin Sets 1 or 6 without exceeding Class C limits, but not Bin Set 4.

Filling Bin Set 4 with alumina calcine grout is not a plausible scenario. The only Bin Set containing alumina calcine exclusively is Bin Set 1; Bin Set 4 contains zirconia calcine, and other various mixtures of calcine types. In all the Bin Sets the overall ratio of zirconia to alumina calcine is 4.6 by mass. In processing calcine, calcine from different bins will be blended to minimize compositional variations. Thus it is very unlikely that grout from processing calcine high in alumina content would be returned to Bin Set 4.

The major contributor to exceeding the Class C limit when grout from processing calcine is returned to Bin Set 4 is the total alpha-emitting radionuclide content. Comparing the fraction for total alpha in Tables 9 (0.78 for alumina, 0.819 for zirconia) to the fraction for total alpha in Table 7 (0.0078 for alumina and 0.0465 for zirconia) shows that it is unlikely that adjustments could be made in separations facility design or operations to extract sufficient actinides to reduce the activity of the grout/residual calcine mixture in Bin Set 4 to below Class C limits. However, as indicated by comparing the fractions for the landfill residual calcine volume to the risk-based volumes, shows that the Class C limit could be met by removing a greater amount of residual calcine.

CALCULATION OF HEIGHT OF CLEAN GROUT LIFTS - CLASS C HEEL

For residual calcine volumes, both for landfill and risk-based closure scenarios, the amount of clean grout that would need to be added to the Bin Sets to result in waste meeting Class C limits was calculated. For these calculations, the density of grout was assumed to be 2300 kg/m^3. This density is typical of cement, but about 28% higher the density expected for grout from HLW treatment. Also, no safety margin was added in the calculations to account for uncertainties in the calcine activity data, apart from rounding the heights to the next higher foot. Table 10 summarizes these calculations.

Table 10. Volumes and Heights of Clean Grout Needed in Bin Set to Produce a Waste Meeting Class C Limits.

	Risk-Based Residual Calcine			**Landfill-Based Residual Calcine**		
Bin Set	**Volume, ft^3**	**Height, ft**	**Height, ft, Rounded**	**Volume, ft^3**	**Height, ft**	**Height, ft, Rounded**
1	602	1.9	2	1349	4.3	5
2	3078	3.7	4	4221	4.0	4
3	2822	3.4	4	5742	5.9	6
4	8472	18.4	19	11428	24.0	24
5	10795	15.3	16	16033	21.8	22
6	3115	3.4	4	4474	3.7	4
7	3410	1.8	2	4474	3.0	3

For the bin sets that have elliptical heads, all except Bin Set 1, the values for the height of cement shown in Table 10 are from the tangent line of the bottom head of the bins. The values shown for the cement volume include the volume of the heads. Calculations for Bin Set 7 assume that calcine that will be placed in Bin Set

7 will have the same activity as that in Bin Set 6. The values in Table 10 should be considered estimates. Calcine activity data has an estimated accuracy of ±100%.[6]

CALCULATION OF RESIDUAL CALCINE VOLUMES FOR 4-FT HEELS

Table 11 shows the maximum volume of residual calcine that could remain in the Bin Sets if a 4-foot lift of clean cement was added to form a heel with residual calcine.

Comparing the volumes for the Class C heel in Table 11 to the residual calcine volumes for risk-based closure shown on page 2 indicates that achieving Class C heel with a 4-ft lift of cement would require reducing the residual calcine volume by a factor of about 6 from the risk-based levels for Bin Sets 4 and 5. However, to leave a Class A heel, a reduction of more than three orders of magnitude over the risk-based volumes would be required for Bin Sets 1-5.

Table 11. Residual Calcine Volumes for 4-Ft Heel

Bin Set	**Maximum Volume of Residual Calcine, ft^3**	
	Class A Heel	**Class C Heel**
1	0.014	65
2	0.072	95
3	0.076	175
4	0.035	11
5	0.057	29
6	0.52	190

ADDITIONAL CLASS A GROUT DATA

Because the activity solely from risk-based and landfill residual calcine volumes was greater than Class A limits, the assessment did not include data for Class A grout. For the benefit of future analyses, additional data is presented in this section. Table 12 shows the radioactivity, in Curies, that would be present solely in Class A grout, if Class A grout were used to fill the Bin Sets. Table 12 does not include any activity from residual calcine. Table 13 shows the the activity in the Class A grout as fractions of Class A waste limits.

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[6] Based on communication with Doug Wenzel.

Table 12. Activity in Class A Grout, Curies.

	Bin Set 1			Bin Set 4		
Grout from	**Al calcine**	**Zr calcine**	**SBW**	**Al calcine**	**Zr calcine**	**SBW**
Cs-137	9.7E+01	5.9E+01	4.9E+01	2.3E+02	1.4E+02	1.2E+02
Sr-90	5.8E-05	1.6E-04	8.3E-02	1.4E-04	3.8E-04	2.0E-01
Tc-99	3.5E+01	1.3E+01	2.0E+00	8.2E+01	3.1E+01	4.8E+00
I-129	1.5E-02	6.1E-03	7.8E-02	3.6E-02	1.4E-02	1.8E-01
Pu-241	4.9E-09	8.8E-08	1.8E-10	1.2E-08	2.1E-07	4.3E-10
Tot alpha	2.9E-01	1.8E+00	1.5E-04	6.9E-01	4.4E+00	3.7E-04
Cm-242	7.6E-06	4.0E-07		1.8E-05	9.5E-07	
		Bin Set 2			**Bin Set 5**	
Cs-137	4.4E+02	2.7E+02	2.2E+02	4.8E+02	2.9E+02	2.4E+02
Sr-90	2.6E-04	7.3E-04	3.8E-01	2.8E-04	7.9E-04	4.1E-01
Tc-99	1.6E+02	5.9E+01	9.3E+00	1.7E+02	6.4E+01	1.0E+01
I-129	6.8E-02	2.8E-02	3.5E-01	7.4E-02	3.0E-02	3.8E-01
Pu-241	2.3E-08	4.0E-07	8.2E-10	2.4E-08	4.3E-07	8.9E-10
Tot alpha	1.3E+00	8.3E+00	7.0E-04	1.4E+00	9.0E+00	7.6E-04
Cm-242	3.5E-05	1.8E-06		3.7E-05	2.0E-06	
		Bin Set 3			**Bin Set 6**	
Cs-137	5.3E+02	3.2E+02	2.7E+02	7.2E+02	4.4E+02	3.6E+02
Sr-90	3.1E-04	8.7E-04	4.5E-01	4.3E-04	1.2E-03	6.2E-01
Tc-99	1.9E+02	7.0E+01	1.1E+01	2.6E+02	9.6E+01	1.5E+01
I-129	8.2E-02	3.3E-02	4.2E-01	1.1E-01	4.5E-02	5.8E-01
Pu-241	2.7E-08	4.8E-07	9.8E-10	3.7E-08	6.5E-07	1.3E-09
Tot alpha	1.6E+00	1.0E+01	8.4E-04	2.2E+00	1.4E+01	1.1E-03
Cm-242	4.1E-05	2.2E-06		5.6E-05	3.0E-06	

Table 13. Activity in Class A Grout as a Fraction of Class A Waste Limit.

	Class A limit	**Al calcine**	**Zr calcine**	**SBW**
	Ci/m3		**Fraction of limit**	
Cs-137	1	0.438	0.264	0.219
Sr-90	0.04	0.000	0.000	0.009
Tc-99	0.3	0.518	0.193	0.031
I-129	0.008	0.008	0.003	0.044
	nCi/g			
Pu-241	350	0.000	0.000	0.000
Tot alpha	10	0.073	0.457	0.000
Cm-242	2000	0.000	0.000	0.000
Sum of the fractions		1.037	0.918	0.303

Although Table 12 shows that the sum of the fractions is greater than 1 for alumina calcine, minor modifications could be made in the cesium removal process to reduce the cesium such that the Class A limits are met. Also, calcine blending, without process modifications would likely result in Class A grout.

CALCULATION METHOD SUMMARY

Table 2

Radionuclides concentrations in residual calcine for Bin Set 1 were taken from Reference 1, and for Bin Set 4 from Reference 2. The activities given in Reference 3 for liquid SBW were converted to calcine activities by the ratio of 4 million liters of calcine producing 845,000 kg of calcine (~700 m^3). All radionuclides in SBW were assumed to be 100% retained in calcine except for ^3H, for which it was assumed that none was retained. All radionuclide concentrations shown in Table 2 are decayed to the year 2016. From these concentrations, the total curies of each radionuclide was calculated using the mass of residual calcine.

Table 3

The radionuclide concentrations shown in Table 3 were calculated by dividing the activity in curies, in Table 2, by the total mass or volume of grout that would fill a particular Bin Set. The volume of the residual calcine, being negligible compared to the volume of the grout, was neglected.

Table 4

The fraction of Class C limits were calculated by dividing the concentrations in Table 3 by the Class C limits.

Table 5

The values in Table 5 are the residual calcine volumes for risk-based and landfill closure were multiplied by the inverse of the sum of the fractions shown in Table 4. The same residual calcine volumes to meet Class A limits are obtained regardless of whether risk-based or landfill residual calcine volumes are used in the calculations.

Table 6

Total curies of each radionuclide and total calcine volumes were obtained from Systems Engineering High Level Waste internet pages:

http://wcb08/˜.nichtt.wcb.inel/jm/Bins/CSSF1.htm
http://wcb08/˜.nichtt.wcb.inel/jm/Bins/CSSF2.htm
http://wcb08/˜.nichtt.wcb.inel/jm/Bins/CSSF3.htm
http://wcb08/˜.nichtt.wcb.inel/jm/Bins/CSSF4.htm
http://wcb08/˜.nichtt.wcb.inel/jm/Bins/CSSF5.htm
http://wcb08/˜.nichtt.wcb.inel/jm/Bins/CSSF6.htm

The radionuclide activities in this data are decayed to January 1, 2000. No activities are available in this data for ^{99}Tc or ^{129}I. The data used was last updated November 14, 1997. Radionuclide concentrations in Ci per kg were calculated from the total Curies, the total volume and the following densities:

Bin Set 1	1.09 g/cm^3	(from WINCO-1050)
Bin Set 2	1.36 g/cm^3	(from WINCO-1050)
Bin Set 3	1.53 g/cm^3	(from WINCO-1050)
Bin Set 4	1.60 g/cm^3	(estimated)
Bin Set 5	1.50 g/cm^3	(estimated)
Bin Set 6	1.20 g/cm^3	(estimated)

Table 7

The radioactivity in Class C grout was taken from the TRU Scoping Study material balance (Reference 4, Appendix 2). The sources of the activity data for the TRU Scoping Study material balance for calcine are References 1 and 2, although for SBW, the TRU Scoping Study material balance used SBW analysis data, and this data was not decayed. The activities from Reference 4 were converted to units consistent with Class C limits and divided by those limits to obtain the values in Table 7.

Table 8

Values in Table 8 are the sum of activity in residual calcine (Table 2) and in Class C grout. Radionuclide concentrations in Class C grout, as described in the method for Table 7, were taken from the TRU Scoping Study material balance, and multiplied by the mass of grout that would fill each bin set to obtain the total Ci in the grout.

Table 9

Values in Table 9 are the total Curies given in Table 8 divided by the limits for Class C grout.

Table 10

Two sets of activity data were used to calculate the activity of residual calcine in the Bin Sets. The activities of calcine in Bin Sets 1, 4 and 6 were based on References 1-3. The total curies in these three Bin Sets are shown in Table 2. For Bin Sets 2,3 and 5, calcine activity data from the HLW Program Systems Engineering Home pages (see Calculations for Table 6) were used to calculate the ratio of activities to a given Bin Set (2, 3 or 5) to either Bin Set 1 or 4. The activities in Table 2 for Bin Set 1 or 4 were multiplied by these ratios to obtain calcine activities for Bin Sets 2, 3 and 5. This, in effect, converted the HLW home page data to the same basis as used in the other calculations, Wenzel's data decayed to 2016. For Bin Set 3, activity ratios of Bin Set 3 to Bin Set 1 were used to calculate the required grout volume and height. For Bin Sets 2 and 5, the ratios of Bin Set 2 or 5 to Bin Set 4 was used for total alpha, ^{137}Cs, and ^{90}Sr, but since no data was available for ^{241}Pu for Bin Set 4, the ratio of Bin Set 2 or 5 to Bin Set 1 was used for ^{241}Pu. Once total curies in residual grout were calculated for all bin sets, the following procedure was used to calculate the volume and height of clean grout needed to leave Class C waste in the Bin Sets.

1. For each bin set, a volume of grout was assumed.
2. For each radionuclide, the activity in Ci/m^3 or nCi/g was calculated.
3. Ratios of the concentrations obtained in step 2 to the Class C limit were calculated.
4. Ratios obtained in Step 3 were added to obtain the "sum of the fractions".
5. The original volume estimates were multiplied by the inverse of the sum of the fractions. These new volumes would give a sum of the fractions of 1.00 for each bin set.
6. For Bin Sets with bottom elliptical heads (all exept Bin Set 1), the volume of the bottom heads was calculated.
7. The area of a cross section of the Bin Sets was then calculated. For Bin Sets 1, 5, 6, and 7, an "equivalent" area was calculated by subtracting from the total area of the outer bin set walls the area of inner sections which do not contain calcine.
8. The height of grout was then calculated by subtracting the head volume from the total grout voume obtained in step 5, and dividing the result by the cross sectional area.

For Bin Set 7, the calcine activity was assumed to be the same as Bin Set 6.

Table 11

The procedure for calculating residual calcine volumes for a specified (4-ft high) heel was as follows:

1. For each bin set, a volume of residual calcine was assumed.
2. For each radionuclide, the activity in Ci/m^3 or nCi/g was calculated using the known volume of grout, the assumed volume of calcine and calcine activity data (See procedure for Table 10).
3. Ratios of the concentrations obtained in step 2 to the Class A or C limit were calculated.
4. Ratios obtained in Step 3 were added to obtain the "sum of the fractions".
5. The original volume estimates were multiplied by the inverse of the sum of the fractions. These new volumes would give a sum of the fractions of 1.00 for each bin set.

Table 12

Activities in Class A grout shown in Table 11 were calculated by multiplying radionuclide concentrations in Class A grout, from Reference 4 Appendix 3, by the estimate volumes grout that would fill the Bin Sets.

Table 13

The values shown in Table 12 are ratios of the radionuclide concentrations in Class A grout, from Reference 4 Appendix 3, converted to equivalent units and then divided by the Class A waste limit.

References

1. D. R. Wenzel, *Evaluation of Radionuclide Inventory for Al Calcine*, Engineering Design File CPP-97067, EDF-FDO-004, October 14, 1997.
2. D. R. Wenzel, *Evaluation of Radionuclide Inventory for Zr Calcine*, Engineering Design File CPP-97068, EDF-FDO-003, October 14, 1997.
3. D. R. Wenzel, *Evaluation of Radionuclide Inventory for Sodium Bearing Waste*, Engineering Design File CPP-97080, EDF-FDO-006, November 26, 1997.
4. W. H. Landman, Jr., C. M. Barnes, *TRU Separations Options Scoping Study Report*, INEEL/EXT-97-01428, December, 1997 (Draft).
5. 10 CFR 61.55
6. J. R. Berreth, *Inventories and Properties of ICPP Calcined High-Level Waste*, WINCO-1050, February, 1988.

ENGINEERING DESIGN FILE

Form L-0431.2#
(05-96-Rev.#02)

Project File Number 015720
EDF Serial Number EDF-BSC-009
Functional File Number BC-06

Project/Task BIN SET CLOSURE STUDY
Sub task Estimated Bin, Tank, NWCF and grout Volume Production Accuracy

Title: ESTIMATED CSSF BIN, TFF TANK, NWCF VOLUME AND GROUT VOLUME PRODUCTION ACCURACY

SUMMARY 1/27/98

The purpose of this Engineering Design File (EDF) is to estimate the uncertainty (% error) of the volume calculations for the Calcine Solids Storage Facility (CSSF) bins, Tank Farm Facility (TFF) tanks, New Waste Calcining Facility (NWCF) and the estimated NRC Low Level Waste (LLW) grout production. This is to ensure accurate LLW grout dissemination in these areas. Further study is needed to reduce the calculated uncertainty.

Results

The uncertainty (% error) was estimated at **+/-0.6%** for each bin set and **+/-1.6%** (minimum volume uncertainty 7,131 m^3; standard volume 7,247 m^3; maximum volume uncertainty 7,363 m^3) for the entire CSSF bin sets, **+/-0.5%** for each TFF tank volume and **+/-1.7%** (minimum volume uncertainty 15,359 m^3; standard volume 15,624 m^3; maximum volume uncertainty 15,890 m^3) for the entire TFF tanks, as calculated in this EDF (see Table #1-5, Page 2 & 3). The uncertainties for the NWCF and grout production volumes are estimated to be **+/-20%** (minimum volume uncertainty 10,204 m^3; standard volume 12,756 m^3; maximum volume uncertainty 15,307 m^3) and **+/-15%** (NRC Class A Grout: minimum volume uncertainty 20,315 m^3; standard volume 23,900 m^3; maximum volume uncertainty 27,485 m^3. NRC Class C Grout: minimum volume uncertainty 19,040 m^3; standard volume 22,400 m^3; maximum volume uncertainty 25,760 m^3) respectively. The CSSF closure study group was not responsible for the NWCF and grout production volume calculations, therefore experts were used to give uncertainty estimates. Resources were unavailable to pursue more accurate NWCF and grout production volume uncertainty estimates at this time.

Conclusions

Void spaces will be produced during the TFF Tanks, CSSF Bin Sets, and NWCF closure process. NRC Class A or C grout can be created by a grouting facility to fill in these void spaces. If this occurs the TFF Tank voids will be filled first with LLW grout, the CSSF Bin Sets will be filled second and finally, if any LLW grout remains, the NWCF void space will be filled third. The following table represents the estimated volume range of void space remaining in the CSSF or the amount of LLW grout that can be emplaced in the NWCF after the LLW grouting campaign. The amount of void space remaining in the CSSF after a grouting campaign are shown as negative values and the amount of LLW grout that can be placed in the NWCF after a grouting campaign are shown as positive values.

(continued)

Distribution: B.C. Spaulding, M.M. Dahlmeir, B.R. Helm, D.J. Harrell, Project File (original +1)

Authors	Department	Reviewed Bo Spaulding	Approved Bo Spaulding
R. D. McAllister	4130		
Date		Date 1/29/98	Date 1/29/98

CSSF Void Space or LLW Grout Excess (placed in NWCF) After LLW Grout Campaign (from Table #5)

Campaign	Minimum Differential Volume (Cubic Meter)	Differential Volume (Cubic Meter)	Maximum Differential Volume (Cubic Meter)
LLW Grout Class A	-2,175	1,028	4,232
LLW Grout Class C	-3,450	-472	2,507

Note: Differential Volumes are the total estimated CSSF and TFF volumes added together and subtracted from the grout production volume. The resulting value gives the estimated amount of void space (volume) remaining in the CSSF (negative) or the amount of grout that could be emplaced in the NWCF (positive) after the LLW grouting campaign.

TABLE 1: CSSF Bin Volumes With Uncertainties

Describes each CSSF bin set volume with minimum and maximum ranges according to the estimated uncertainty.

Uncertainty per Individual Bin (+/-) 0.6 %

Total Normalized Uncertainty (+/-) 1.6 %

	Minimum CSSF Bin Volume				CSSF Bin Volume*				Maximum CSSF Bin Volume			
CSSF	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)
1	58,325	7,797	289	221	58,677	7,844	291	222	59,029	7,891	292	223
2	234,535	31,353	1,161	888	235,951	31,542	1,168	893	237,366	31,731	1,175	899
3	302,526	40,442	1,498	1,145	304,352	40,686	1,507	1,152	306,179	40,930	1,516	1,159
4	133,061	17,788	659	504	133,864	17,895	663	507	134,667	18,002	667	510
5	271,728	36,325	1,345	1,029	273,368	36,544	1,353	1,035	275,008	36,763	1,362	1,041
6	421,221	56,309	2,086	1,594	423,764	56,649	2,098	1,604	426,307	56,989	2,111	1,614
7	481,666	64,389	2,385	1,823	484,573	64,778	2,399	1,834	487,481	65,167	2,414	1,845
Total Volume (+/- 1.6%)	**1,883,916** **(normalized)**	**251,843** **(normalized)**	**9,328** **(normalized)**	**7,131** **(normalized)**	**1,914,549**	**255,938**	**9,479**	**7,247**	**1,946,182** **(normalized)**	**260,033** **(normalized)**	**9,631** **(normalized)**	**7,363** **(normalized)**

* CSSF Bin Volumes were obtained from EDF-BSC-001, PFN-15720

TABLE 2: TFF Tank Volumes With Uncertainties

Describes each tank volume with minimum and maximum ranges according to the estimated uncertainty.

Uncertainty per Individual Tank (+/-) 0.5 %

Total Normalized Uncertainty (+/-) 1.7 %

	Minimum TFF Tank Volume				TFF Tank Volume*				Maximum TFF Tank Volume			
TFF Tank	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)
180	402,211	53,768	1,991	1,523	404,232	54,038	2,001	1,530	406,253	54,308	2,011	1,538
181	402,211	53,768	1,991	1,523	404,232	54,038	2,001	1,530	406,253	54,308	2,011	1,538
182	366,938	49,053	1,817	1,389	368,782	49,299	1,826	1,396	370,626	49,545	1,835	1,403
183	366,938	49,053	1,817	1,389	368,782	49,299	1,826	1,396	370,626	49,545	1,835	1,403
184	366,938	49,053	1,817	1,389	368,782	49,299	1,826	1,396	370,626	49,545	1,835	1,403
185	366,938	49,053	1,817	1,389	368,782	49,299	1,826	1,396	370,626	49,545	1,835	1,403
186	366,938	49,053	1,817	1,389	368,782	49,299	1,826	1,396	370,626	49,545	1,835	1,403
187	366,938	49,053	1,817	1,389	368,782	49,299	1,826	1,396	370,626	49,545	1,835	1,403
188	366,938	49,053	1,817	1,389	368,782	49,299	1,826	1,396	370,626	49,545	1,835	1,403
189	366,938	49,053	1,817	1,389	368,782	49,299	1,826	1,396	370,626	49,545	1,835	1,403
190	366,938	49,053	1,817	1,389	368,782	49,299	1,826	1,396	370,626	49,545	1,835	1,403
Total Volume (+/- 1.7%)	**4,057,336** **(normalized)**	**542,387** **(normalized)**	**20,088** **(normalized)**	**15,359** **(normalized)**	**4,127,504**	**551,767**	**20,436**	**15,624**	**4,197,671** **(normalized)**	**561,147** **(normalized)**	**20,783** **(normalized)**	**15,890** **(normalized)**

* TFF Tank Volumes were obtained from EDF-TFC-029, PFN-73501

TABLE 3: NWCF Volume With Uncertainties

Describes the NWCF volume with minimum and maximum range according to the estimated uncertainty. These values were calculated using space occupancy drawings 057807 (NWCF second level), 057812 (NWCF third level) and elevation drawings 132320 through 132327, and 132334. The volume of equipment inside each NWCF room was found using the NWCF Safety Analysis Report, SAR 512C24.120/08-28-96/SA. For machinery/equipment not represented in the safety analysis report, a conglomerate of drawings was used for volume approximation.

NWCF Volume Uncertainty (+/-) 20 %*

	Minimum NWCF Volume				NWCF Volume**				Maximum NWCF Volume			
	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)
NWCF	**2,695,740**	**360,368**	**13,347**	**10,204**	**3,369,675**	**450,460**	**16,684**	**12,756**	**4,043,610**	**540,552**	**20,020**	**15,307**

* Value Obtained from Bill Landman, technical lead NWCF Deactivation Option for Low-Level Waste Grout Disposal Project,INEEL/EXT-97/01076.

** NWCF Volume was obtained from EDF-OFC-003, PFN-73601

TABLE 4: LLW Grout Volume With Uncertainties

Describes the grout production volume with minimum and maximum values according to the estimated uncertainty.

Grout Volume Uncertainty (+/-) 15 %*

	Minimum Grout Volume				Grout Volume**				Maximum Grout Volume			
LLW Grout	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)
Class A	5,366,652	717,417	26,571	20,315	6,313,708	844,020	31,260	23,900	7,260,764	970,623	35,949	27,485
Class B	5,029,832	672,391	24,903	19,040	5,917,450	791,048	29,298	22,400	6,805,067	909,705	33,693	25,760

* Value obtained from Charles Barnes, separations feed and waste volume authority.

** Grout Volumes were obtained from EDF-FDO-001, Rev.1 (TRU Separations), PFN-73301, Charles Barnes.

TABLE 5: LLW Grout and Volume Comparisons

This table compares total estimated CSSF bin and total TFF tank volumes to grout production volume. Differential Volumes are the total CSSF and TFF volumes added together and subtracted from the grout production volume. The resulting value gives the estimated amount of void space (volume) remaining in the CSSF or the amount of grout that can be emplaced in the NWCF after a LLW grouting campaign.

	Minimum Tank, Bin and Grout Volumes				Tank, Bin and Grout Volumes				Maximum Tank, Bin and Grout Volumes			
	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)
Total CSSF Bin Volume (+/- 1.6%)	1,883,916	251,843	9,328	7,131	1,914,549	255,938	9,479	7,247	1,945,182	260,033	9,631	7,363
Total TFF Tank Volume (+/- 1.7%)	4,057,338	542,387	20,088	15,359	4,127,504	551,767	20,436	15,624	4,197,671	561,147	20,783	15,890
Volume Sub Total	5,941,253	794,230	29,416	22,490	6,042,053	807,705	29,915	22,872	6,142,853	821,180	30,414	23,253
Production Volume												
LLW Grout Class A	5,366,652	717,417	26,571	20,315	6,313,708	844,020	31,260	23,900	7,260,764	970,623	35,949	27,485
LLW Grout Class C	5,029,832	672,391	24,903	19,040	5,917,450	791,048	29,298	22,400	6,805,067	909,705	33,693	25,760

CSSF Void Space or LLW Grout Excess (placed in NWCF) After LLW Grout Campaign

	Minimum Differential Volumes				Differential Volumes				Maximum Differential Volumes			
Campaign	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)	(gallons)	(cubic feet)	(cubic yards)	(cubic meters)
LLW Grout Class A*	-574,601	-76,813	-2,845	-2,175	271,655	36,315	1,345	1,028	1,117,911	149,443	5,535	4,232
LLW Grout Class C*	-911,420	-121,839	-4,513	-3,450	-124,603	-16,657	-617	-472	682,214	88,526	3,279	2,507

Note: *Values shown are calculated void space volume amounts remaining in the CSSF (negative) or calculated volume amounts exceeding the CSSF volume (positive)*

ESTIMATED ACCURACY OF TANK FARM FACILITY TANKS 180-190

ASSUMPTIONS:

① ALL TANKS HAVE COOLING COILS.

B: ENGINEERING JUDGEMENT: TANKS 180, 182, 183 185, 187, 188, 189, 190 HAVE COOLING COILS (8 OUT OF 11 TANKS) SEE TABLE 3-1, TANK FARM CLOSURE STUDY, INEEL/EXT-97-0204, JAN. 1998

② THERE ARE 30 COOLING COILS IN EACH TANK

B: DRAWINGS 105161, 106814, 117920, 106242

③ INSTRUMENTATION LINES AND COOLING SUPPORT BAR VOLUMES ARE NEGLEGABLE

B: INSTRUMENTATION LINES AND COOLING SUPPORT BAR VOLUMES WILL BE INSIGNIFICANT DUE TO THEIR SIZE AND NUMBER

④ COOLING PIPING RUNS VERTICALLY DOWN TANK WALL UNTIL MIDDLE OF TANK WALL IS REACHED. THEY TRAVEL AROUND THE TANK'S CIRCUMFERENCE HORIZONTALLY AND UP VERTICALLY WHERE IT BEGAN

B: TO SIMPLIFY COOLING PIPE VOLUME CALCULATIONS

⑤ DRAWING 106230 WHICH SHOWS THE VARIATIONS OF TANK WALL THICKNESS IS SIMILAR TO ALL TANK FARM TANKS

B: TO SIMPLIFY VOLUME ERROR CALCULATIONS, ENGINEERING JUDGEMENT

⑥ ROUNDING ERRORS FROM CALCULATING TANK/BIN VOLUMES WILL BE SIMILAR TO ROUNDING ERRORS FOUND IN OTHER VOLUME CALCULATIONS ENGINEERING JUDGEMENT

B: TO ESTIMATE THE PERCENT OF UNCERTAINTY IN TANK FARM TANKS & CSSF BINS VOLUME CALCULATIONS

⑦ CSSF BIN SET BIN DIMENSIONAL TOLERANCES ARE SIMILAR TO TANK FARM FACILITY TANK DIMENSIONAL TOLERANCES

B: TOLERANCES FOR TFF TANKS ARE NOT FOUND IN PRESENT RESOURCES. THIS ALLOWS SIMPLIFICATION OF TOLERANCE ERROR CALCULATIONS.

ASSUMPTIONS (CONTINUED)

⑧ VARIOUS UNCERTAINTIES (ERRORS) ARE INDEPENDENT & RANDOM

B: ENGINEERING JUDGEMENT DUE TO DRAWINGS CALCULATIONS ERRORS ETC. THIS IMPOSES QUADRATURE DETERMINATION OF ERRORS See Reference ① PG-14 THIS REPORT

⑨ UNCERTAINITIES CALCULATED FOR CYLINDRICAL VOLUME AND TANK CAP VOLUMES FOR TANK FARM TANKS ARE SIMILAR TO BIN SET BINS CYLINDRICAL VOLUME AND BIN CAPS.

B: ENGINEERING Judgement, TO SIMPLIFY the CALCULATION PROCESS & BECAUSE the TANKS AND BINS ARE SIMILAR IN NATURE.

⑩ INSIDE TFF TANK WALLS ARE flush

B: MIKE SWENSONS DRAWING ARCHIVES

CALCULATING VOLUME ERRORS FROM TFF COOLING COILS FOR ERROR ANALYSIS.

AVERAGED BIN WALL HEIGHT ≈ 22 feet (COOLING PIPES ONLY)
COOLING PIPE DIAMETER (DRAWING 105458) = 1.5 inches = .125 feet
INSIDE TANK DIAMETER = 50 feet
# of COOLING COILS (DRAWING 105161, 106242, 104814) = 30 pipes

→ TANK CIRCUMFERENCE :⇒ $2\pi R = \pi d$

$$50 \text{ feet } (\pi) \Rightarrow \underline{157.08} \text{ feet}$$

→ PIPE CROSSECTIONAL AREA ⇒ $\pi r^2_{\text{cooling pipe}} = \pi \left(\frac{d}{2}\right)^2$

$$\pi \left(\frac{.125}{2}\right)^2 = 12.272\text{E-}3 \text{ feet}^2$$

→ PIPE VOLUME ⇒

(LENGTH of COOLING PIPE)(CROSS. AREA)(# of PIPES)
(SEE ASSUMPTION ④)

$$(22 \text{ feet} + 157.08 \text{ feet})/\text{pipe}\ (12.272\text{E-}3 \text{ feet}^2)(30 \text{ pipes}) = \underline{65.929 \text{ feet}^3}$$

VOLUME DISCREPENCY

TANKS 180, 182, 183, 185, 187, 188, 189, 190 HAVE COOLING COILS.

ESTIMATED TFF TANK VOLUME FROM EDF-TFC-029

WM-180,181 ⇒ 54,038 ft^3
WM-182-190 ⇒ 49,299 ft^3

$$\% \text{ error} = \frac{\Delta \text{ Volume}}{\text{Original Volume}}$$

UNCERTAINITY DUE TO COOLING COILS = $\frac{\% \text{ ERROR}}{\text{ORIGINAL VOLUME}} \Rightarrow \frac{-66 \text{ ft}^3}{54038 \text{ ft}^3} \times 100 = -0.122 \simeq \boxed{-0.1\%}$
TANKS 180-181

$= \frac{\% \text{ ERROR}}{\text{ORIGINAL VOLUME}} \Rightarrow \frac{-66 \text{ ft}}{49{,}299 \text{ ft}^3} \times 100 = -0.134 \simeq \boxed{-0.1\%}$
TANKS 182-190

*NEGATIVE SIGN IS USE HERE BECAUSE THE COOLING COILS CAN ONLY SUBTRACT FROM THE ORIGINAL VOLUME

CALCULATING ROUNDING ERRORS FROM VOLUME CALCULATIONS. (PERCENT) (SEE ASSUMPTION ⑥) (5 SIGNIFICANT FIGURES COMPARED TO 3 SIGNIFICANT FIGURES)

VOLUME (5 SIGNIFICANT FIGURES) = (AREA) (HEIGHT)

- USING VALUES FROM PREVIOUS PAGE

$\text{AREA} = \pi (24.536)^2$

$\text{HEIGHT} = 8.1667$

$\text{VOLUME}_{Ⓐ} = \pi (24.536)^2 (8.1667)$

$= \underline{\underline{15.446 \text{ E3}}} \text{ ft}^3$

VOLUME (3 SIGNIFICANT FIGURES) = (AREA) (HEIGHT)

- USING VALUES FROM PREVIOUS PAGE

$\text{AREA} = \pi (24.5)^2$

$\text{HEIGHT} = 8.17$

$\text{VOLUME}_{Ⓑ} = \pi (24.5)^2 (8.17)$

$= \underline{\underline{15.4 \text{ E3}}} \text{ ft}^3$

COMPAR VOLUME$_{Ⓐ}$ TO VOLUME$_{Ⓑ}$

$\text{VOLUME}_{Ⓐ} = 15.446\text{E3}$

$\text{VOLUME}_{Ⓑ} = 15.4 \text{ E3}$

$\text{DIFFERENCE} = \text{VOLUME}_{Ⓐ} - \text{VOLUME}_{B}$

$= 15.446\text{E3} - 15.4 \text{ E3}$

$= 46 \text{ ft}^3$

Reference ①

$\text{FRACTIONAL UNCERTANITY} = \frac{\Delta \text{ VOLUME}}{\text{ORIGINAL VOLUME}} \times 100 =$

$\% \text{ ERROR} = \frac{46 \text{ ft}^3}{15.446\text{E3 ft}^3} = 0.298 \approx \boxed{\pm 0.3\%}$

CALCULATING DIMENSIONAL TOLERENCE UNCERTAINTIES (APPLIES TO BOTH TFF TANKS AND CSSF BINS) PERPETUATIATED BY VOLUME CALCULATIONS

FROM DRAWING 158570 OVERALL BIN HEIGHT IS 55 feet ± .75 inches = .0625 feet

→ FINDING % ERROR = $\frac{\Delta \text{ ERROR}}{\text{ORIGINAL DIMENSION}}$ (100)

$$\% \text{ ERROR} = \frac{.0625 \text{ feet}}{55 \text{ feet}} = \underline{\underline{0.1\%}}$$

0.1%: IS THE DIMENSIONAL TOLERANCE UNCERTAINTY FOR CSSF BINS AND TFF TANKS (SEE ASSUMPTION ⑦)

KNOWING THE DIMENSIONAL TOLERANCE UNCERTAINTIES THE % ERROR IN VOLUME CALCULATIONS CAN BE FOUND

→ CYLINDRICAL TANK VOLUMES WERE FOUND USING

CYLINDAR VOLUME = π (RADIUS)^2 (HEIGHT)

Reference ① (PG. 14-17 THIS REPORT)

$$(\text{RADIUS})^2 \text{ UNCERTAINITY} = \overset{(\text{RADIUS}) \cdot (\text{RADIUS})}{(0.1\%) + (0.1\%)} = 2(0.1\%)$$

$$(\text{HEIGHT}) \text{ UNCERTAINITY} = (0.1\%)$$

See ASSUMPTION ⑧
Reference ① (PG. 14-17 THIS REPORT) ↓

$$\underset{\text{QUADRATURE}}{\% \text{ ERROR}} = \sqrt{\underbrace{(2(0.1\%))^2}_{(\text{RADIUS}^2)\ \text{PORTION}} + \underbrace{(0.1\%)^2}_{(\text{HEIGHT})\ \text{PORTION}}}$$

INDEPENDENT & RANDOM UNCERTAINTIES

% ERROR CYLINDAR VOLUME EQUATION = 0.2%

CALCULATING VOLUME EQUATION ERRORS USING UNCERTAINITIES IN DIMENSIONS

→ SPHERICAL CAP CALCULATIONS

$$\underbrace{\frac{1}{6}\pi(\text{height})}_{\text{PART}\,Ⓐ}\underbrace{\left(3(\text{RADIUS})^2+(\text{height})^2\right)}_{\text{PART}\,Ⓑ}$$

$(\text{RADIUS})^2$ UNCERTAINITY $= 2(0.1\ \%) = 2.8\%$

(height) UNCERTAINITY $= 2(0.1\ \%) = 2.8\%$

% ERROR QUADRATURE PART Ⓑ

$$= \sqrt{\underbrace{(2(0.1\%))^2}_{(\text{RADIUS})^2} + \underbrace{(2(0.1\%))^2}_{(\text{height})^2}}$$

% ERROR QUADRATURE PART Ⓑ $= 0.283\% \simeq 0.3\%$

% ERROR QUADRATURE TOTAL

$$= \sqrt{\underbrace{(0.1\ \%)^2}_{\substack{\text{Height}\\ \text{PART}\,Ⓐ}} + (0.3\ \%)^2}$$

% ERROR QUADRATURE SPHERICAL CAP EQUATION $= 0.316\% \simeq 0.3\%$

→ UNCERTAINITY IN VOLUME CALCULATIONS

$$\text{TOTAL VOLUME} = \underset{(0.2\%)}{\text{CYLINDAR TANK VOLUME}} + \underset{(0.3\%)}{\text{SPHERICAL CAP VOLUME}}$$

$$\text{VOLUME UNCERTAINITY} = \sqrt{(0.2\%)^2 + (0.3\%)^2} = 0.361\%$$

VOLUME TANK UNCERTAINITY ≃ ±0.4 % ← TFF TANKS

→ UNCERTAINITY IN VOLUME CALCULATIONS (CONTINUED)

We know Bins have a top cap & bottom a cap while TFF tanks only have a top cap. This would increase the uncertainity in the bin volume calculations because of the extra cap

$$\text{Volume Uncertainity Bins} = \sqrt{\underset{\text{Cylindar}}{(0.2\%)^2} + \underset{\text{Top Cap}}{(0.3\%)^2} + \underset{\text{Bottom Cap}}{(0.3\%)^2}}$$

$$\text{Bin Volume Uncertainity} = \underline{\underline{\pm 0.5\%}}$$

TOTALING UNCERTAINITIES

UNCERTAINITIES

BINS	ERROR	TANKS	ERROR
OBSTRUCTIONS =	-0.1%	COOLING COILS =	-0.1%
ROUNDING ERRORS =	±0.3%	ROUNDING ERRORS =	±0.3%
BIN VOLUME EQUATION UNCERTAINTY =	±0.5%	TANK VOLUME EQUATION UNCERTAINTY =	± 0.4%

JUSTIFICATIONS for ABOVE TABLE

OBSTRUCTION

1.) A % ERROR (-0.1%) found By ESTIMATING TANK COOLING COIL VOLUME IS SIMILAR TO OBSTRUCTIONS found IN BIN SETS

B: ENGINEERING JUDGEMENT, COOLING COILS & OBSTRUCTION IN TANK AND BINS ARE PIPE LIKE, THEY RUN THROUGH-OUT TANK/BIN(S) & REPRESENT A SMALL VOLUME IN TANK/BIN(S)

2.) ROUNDING % ERRORS (±0.3%) FOUND BY CALCULATING VOLUME EQUATIONS AT 3 AND 5 SIGNIFICANT FIGURES

B: ENGINEERING JUDGEMENT, SIMILAR VOLUME CALCULATIONS ARE USED TO DETERMINE VOLUMES FOR BOTH TANK FARM & BIN SETS THEREFORE ROUNDING ERRORS WILL BE SIMILAR.

STATEMENTS

4.) BIN VOLUME UNCERTAINITY (±0.5%) IS FOUND BY ESTIMATING KNOWN DIMENSIONAL TOLERANCES AND APPLYING THESE TOLERANCE ERRORS IN VOLUME CALCULATIONS (BIN BOTTOM, BIN DOME AND BIN CYLINDA

5.) TANK VOLUME UNCERTAINITY (±0.4%) IS FOUND BY ESTIMATING KNOWN DIMENSIONAL TOLERANCES & APPLYING THESE TOLERANCE ERRORS IN VOLUME CALCULATIONS (TANK DOME & TANK CYLINDAR)

→ ADDING FOUND UNCERTAINTIES:

* NOTE: THERE ARE MORE NEGATIVE UNCERTAINTIES THAN POSSITIVE UNCERTAINTIES. BECAUSE OF THIS THE QUADRATURE EQUATION MUST BE SOLVED FOR NEGATIVE UNCERTAINTIES SEPARATLY FROM POSSITIVE UNCERTAINTIES.

BINSET ⇒ QUADRATURE EQUATION ERROR CALCULATION

$$(-)\ \frac{\text{ERROR \%}}{\text{BINSET}} = \sqrt{(-0.1\%)^2 + (-0.3\%)^2 + (-0.5\%)^2} \Big/ \text{BINSET}$$

$(-)\ \frac{\text{ERROR \%}}{\text{BIN SET}} = 0.591\ \% \Rightarrow -\underline{0.6\%}$ NEGATIVE UNCERTAINTY PER BIN SET

$$(+)\ \frac{\text{ERROR \%}}{\text{BIN SET}} = \sqrt{(0.3\%)^2 + (0.5\%)^2} \Big/ \text{BIN SET}$$

$(+)\ \frac{\text{ERROR \%}}{\text{BIN SET}} = .583\% \Rightarrow \underline{+0.6\%}$ POSSITIVE UNCERTAINTY PER BIN SET

TANK FARM QUADRATURE EQUATION ERROR CALCULATION

$$(-)\ \frac{\text{ERROR \%}}{\text{TANK}} = \sqrt{(-0.1\%)^2 + (-0.3)^2 + (-0.4)^2} \Big/ \text{TANK}$$

$(-)\ \frac{\text{ERROR \%}}{\text{TANK}} = -0.510 \Rightarrow \underline{-0.5\ \%}$ NEGATIVE UNCERTAINTY PER TANK

$$(+)\ \frac{\text{ERROR \%}}{\text{TANK}} = \sqrt{(0.3\%)^2 + (0.4\%)^2} \Big/ \text{TANK}$$

$(+)\ \frac{\text{ERROR \%}}{\text{TANK}} = .500\% \Rightarrow \underline{+\ 0.5\%}$ POSSITIVE UNCERTAINTY PER TANK

WHEN SUMMING THE TOTAL VOLUMES FOR BIN SETS AND TANK FARM THE UNCERTAINTY MUST STILL BE NORMALIZED USING QUADRATURE EQUATION (BECAUSE UNCERTAINTIES ARE STILL RANDOM AND INDEPENDENT). THIS WILL GIVE A TOTAL NORMALIZED UNCERTAINTY

BIN SETS

UNCERTAINITY = 0.6%/BIN SET

# of BIN SETS = 7

→ TOTAL NORMALIZED UNCERTAINTY

TOTAL NORMALIZED UNCERTAINITY FOR ENTIRE CSSF $= \sqrt{(0.6\%)_1^2 + (0.6\%)_2^2 + \ldots + (0.6\%)_7^2}$

$\uparrow$ # of BINS

$= 1.587 \approx \boxed{\pm 1.6\%}$

TANK FARM

UNCERTAINTY = 0.5%/ TANK

# of TANKS = 11

→ TOTAL NORMALIZED UNCERTAINITY

TOTAL NORMALIZED UNCERTAINTY FOR ENTIRE TFF $= \sqrt{(0.5\%)_1^2 + (0.5\%)_2^2 + \ldots + (0.5\%)_{11}^2}$

$\uparrow$ # of TANKS

$= 1.658 \approx \boxed{\pm 1.7\%}$

References:

① AN INTROduction TO ERROR ANALYSIS - THE Study of UNCERTAINTIES IN PHYSICAL MEASUREMENTS, JOHN R. TAYLOR, 1982 & PG-58

EXAMPLE #1

Suppose that we wish to find the efficiency of a D.C. electric motor by using it to lift a mass m through a height h. The work accomplished is mgh, and the electric energy delivered to the motor is VIt, where V is the applied voltage, I the current, and t the time for which the motor runs. The efficiency is then

$$\text{efficiency, } e = \frac{\text{work done by motor}}{\text{energy delivered to motor}}$$
$$= \frac{mgh}{VIt}.$$

Let us suppose that m, h, V, and I can all be measured with 1 percent accuracy,

$$(\text{fractional uncertainty for } m, h, V, \text{ and } I) = 1\%,$$

and that the time t has an uncertainty of 5 percent,

$$(\text{fractional uncertainty for } t) = 5\%.$$

(Of course, g is known with negligible uncertainty.) If we now compute the efficiency e, then, according to our old rule ("fractional errors add"), we have an uncertainty

$$\frac{\delta e}{e} \approx \frac{\delta m}{m} + \frac{\delta h}{h} + \frac{\delta V}{V} + \frac{\delta I}{I} + \frac{\delta t}{t}$$
$$= (1 + 1 + 1 + 1 + 5)\% = 9\%.$$

On the other hand, if we are confident that the various uncertainties are independent and random, then we can compute $\delta e/e$ by the quadratic sum to give

$$\frac{\delta e}{e} = \sqrt{\left(\frac{\delta m}{m}\right)^2 + \left(\frac{\delta h}{h}\right)^2 + \left(\frac{\delta V}{V}\right)^2 + \left(\frac{\delta I}{I}\right)^2 + \left(\frac{\delta t}{t}\right)^2}$$
$$= \sqrt{1^2 + 1^2 + 1^2 + 1^2 + 5^2}\,\%$$
$$= \sqrt{29}\,\% \approx 5\%.$$

Clearly, the quadratic sum leads to a significantly smaller estimate for δe. Furthermore, it will be seen that, to one significant figure, the uncertainties

EXAMPLE #1 CONTINUED

in m, h, V, and I *make no contribution at all* to the uncertainty in e computed in this way; that is, to one significant figure, we have found (in this example)

$$\frac{\delta e}{e} = \frac{\delta t}{t}.$$

This striking simplification is easily understood. When numbers are added in quadrature, they are squared first and then summed. The process of squaring greatly exaggerates the importance of the larger numbers. Thus, if one number is 5 times any of the others (as in our example), then its square is 25 times that of the others, and we can usually neglect the others entirely.

This example illustrates how it is usually better, and often easier, to combine errors in quadrature. The example also illustrates what the type of problem is in which the errors *are* independent, and for which addition in quadrature is justified. (For the moment we take for granted that the errors are random. We will discuss this more difficult point in Chapter 4.) The five quantities measured (m, h, V, I, and t) are physically distinct quantities, with different units, and are measured by entirely different processes. It is almost inconceivable that the sources of error in any one quantity are correlated with those in any other. Therefore the errors can reasonably be treated as independent and combined in quadrature.

EXAMPLE #2:

Measurement of g with a Simple Pendulum

As a first example, suppose that we measure g, the acceleration of gravity, using a simple pendulum. The period of such a pendulum is well-known to be $T = 2\pi\sqrt{l/g}$, where l is the length of the pendulum. Thus if l and T are measured, we can find g as

$$g = 4\pi^2 l/T^2. \tag{3.28}$$

This gives g as the product or quotient of three factors, $4\pi^2$, l, and T^2. If the various uncertainties are independent and random, the fractional uncertainty in our answer is just the quadratic sum of the fractional uncertainties in these factors. The factor $4\pi^2$ has no uncertainty, and the fractional uncertainty in T^2 is twice that in T:

$$\frac{\delta(T^2)}{T^2} = 2\frac{\delta T}{T}.$$

Thus the fractional uncertainty in our answer for g will be

$$\frac{\delta g}{g} = \sqrt{\left(\frac{\delta l}{l}\right)^2 + \left(2\frac{\delta T}{T}\right)^2}. \tag{3.29}$$

Suppose we measure the period T for one value of the length l and get the results[5]

$$l = 92.95 \pm .1 \text{ cm},$$
$$T = 1.936 \pm .004 \text{ sec}.$$

Our best estimate for g is easily found from (3.28) as

$$g_{\text{best}} = \frac{4\pi^2 \times (92.95 \text{ cm})}{(1.936 \text{ sec})^2} = 979 \text{ cm/sec}^2.$$

To find our uncertainty in g using (3.29), we need the fractional uncertainties in l and T. These are easily calculated (in the head) as

$$\frac{\delta l}{l} = 0.1\% \quad \text{and} \quad \frac{\delta T}{T} = 0.2\%.$$

---

[5] Although at first sight an uncertainty $\delta T = .004$ sec may seem unrealistically small, one can easily achieve it by timing several oscillations. If one can measure with an accuracy of .1 sec, as is certainly possible with a stopwatch, then by timing 25 oscillations one will find T within .004 sec.

(CONTINUED) →

EXAMPLE #2 (CONTINUED)

Substituting into (3.29), we find

$$\frac{\delta g}{g} = \sqrt{(0.1)^2 + (2 \times 0.2)^2}\,\% = 0.4\%;$$

whence

$$\begin{aligned}\delta g &= 0.004 \times 979 \text{ cm/sec}^2 \\ &= 4 \text{ cm/sec}^2.\end{aligned}$$

Thus our final answer, based on these measurements, is

$$g = 979 \pm 4 \text{ cm/sec}^2.$$

If this experiment is now repeated (as most such experiments should be) with different values for the parameters, it will not be necessary to repeat the uncertainty calculations in complete detail. With a little thought, one can easily record the various values of l, T, and g *and* the corresponding uncertainty calculations all in a single tabulation (see Problem 3.13).

APPENDIX

EDF - BSC - 001
EDF - TFC - 029

INEL ENGINEERING DESIGN FILE

Form L-0431.2#
(05-96-Rev.#02)

Project File Number 015720

EDF Serial Number EDF-BSC-001

Functional File Number C-01

Project/Task	Calcined Solids Storage Facility Closure Study
Sub task	Groundwork for Design - CSSF Volume Calculations

TITLE: Calcined Solids Storage Facilities - Volume Calculations

SUMMARY

This Engineering Design File provides volumetric information that is necessary for cost estimating and radiation exposure estimates. For each of the seven Calcined Solids Storage Facilities (CSSFs), the following information was calculated: (1) bin capacity, (2) volume of calcine remaining following CRTP activities, (3) vault void volumes, and (4) equivalent number of filled 55-gallon drums.

The following table provides a summary of the remaining calcine volumes for Risk-Based Clean Closure and Closure to Landfill Standards after all removal activities have been completed.

CSSF	Total Calcine Volume Remaining in Bin Set Following Risk-Based Clean Closure		Total Calcine Volume Remaining in Bin Set Following Closure to Landfill Standards	
	(FT^3)	(M^3)	(FT^3)	(M^3)
1	31.2	(0.9)	70.0	(2.0)
2	88.1	(2.5)	120.8	(3.4)
3	149.4	(4.2)	303.9	(8.6)
4	49.7	(1.4)	67.1	(1.9)
5	106.5	(3.0)	158.2	(4.5)
6	162.9	(4.6)	233.9	(6.6)
7	178.4	(5.0)	233.9	(6.6)
Total	**766.2**	**(21.6)**	**1,187.8**	**(33.6)**

The following pages contain the methodology, assumptions, and results of the calculations. The supporting hand and software calculations are also included in the body of this EDF. See tables provided in the body of this EDF for details of the results.

Distribution: D. J. Harrell, MS 3211; B. R. Helm, MS 3765; B. C. Spaulding, MS 3765; M. M. Dahlmeir, MS 3765; S. P. Swanson, MS 3765; Project File (Original +1)

Authors	Department	Reviewed	Approved
Craig DeCoria	MC&IE 4130		
Steven Swanson	MC&IE 4130	Date	Date

Introduction

The following information was calculated to support cost estimates and radiation exposure calculations for closure activities at the Calcined Solids Storage Facility (CSSF). Within the estimate, volumes were calculated to determine the required amount of grout to be used during closure activities. The remaining calcine on the bin walls, supports, piping, and floor was also calculated to approximate the remaining residual calcine volumes at different stages of the removal process.

The estimates for remaining calcine and vault void volume are higher than what would actually be experienced in the field, but are necessary for bounding purposes. The residual calcine in the bins may be higher than what is experienced in the field as it was assumed that the entire bin volume is full of calcine before removal activities commence. The vault void volumes are higher as the vault roof beam volumes were neglected.

The estimations that follow should be considered rough order of magnitude, due to the time constraints as dictated by the project's scope of work. Should more accurate numbers be required, a new analysis would be necessary.

Methodology

The volumes of the bin heads (top and bottom domes) were estimated by assuming an ASME flanged and dished shape geometry for CSSFs 2-5, while an ellipsoidal geometry was assumed for the sixth and seventh bin sets. Volumes and surface areas for the heads were retrieved from pre-calculated volumes in reference 1. The cylindrical volume of the bin was then calculated and added to the head volumes. For CSSFs 5-7, an annular volume was subtracted. The total volume was then calculated for the entire bin set.

Based on a report concerning retrieval testing performed on CSSF 1 (Reference 3), it was assumed that 95% of the total bin volume would be removed during the Calcined Retrieval and Transport Project (CRTP) activities. Additional calcine was then added onto the walls, supports, internal piping, and external piping.

Calcine was assumed to remain on the internal bin supports and piping after the CRTP performed their removal activities. A 45° accumulation slope was assumed for these fixtures. The calcine film on the bin walls was assumed to be two particles thick with an average particle size of .4mm for CSSF 1 and .5mm for CSSFs 2 through 7 (See EDF-BSC-002 for particle size information).

99% of the calcine in the distributor and external piping was assumed to be removed during CRTP activities (1% remaining on the walls, expansion joints, etc.). Of the remaining calcine in the distributor and external piping, 95% was assumed to be removed by a pipe crawler robot during final removal activities – 90% of which falls to the bin floor, and 10% of which attaches to the bin walls.

80% of the calcine on the bin walls (calcine deposited during CRTP activities and during final removal activities), supports, and internal piping was assumed to be removed by carbon dioxide blasting and falls to the bin floor.

During the last step of the final removal activities, it was assumed that 95% of the calcine at the bottom of the bin could be removed by a robot and vacuum. See page 6 for a review of the assumptions.

Hand calculations were performed to gather initial data (See the attached sheets). Excel software was then used to manipulate the information done by hand. See the Excel printout for the results of all the calculations.

Results

Calculations indicate that out of the initial 255,984 cubic feet of calcine at the CSSF area, approximately 13,345 cubic feet of calcine will remain after the Calcine Retrieval and Transport Project (CRTP) performs its activities. At closure (after Bin Set Closure Project activities), approximately 766 cubic feet of calcine are estimated to remain for Risk-Based Clean Closure and 1,188 cubic feet for Closure to Landfill Standards. This is an additional reduction of over 12,579 cubic feet of calcine (1,711 55-gallon drums) for Risk-Based Clean Closure and 12,157 cubic feet (1,653 55-gallon drums) for Closure to Landfill Standards. Thus, approximately 94.7% of the initial calcine is estimated to be removed from the bins during CRTP activities, while an additional 5.0% is estimated to be removed by the BSCP removal activities during Risk-Based Clean Closure (4.7% is estimated for Closure to Landfill Standards).

The volume of grout necessary for grouting the piping entering the bins has also been calculated and is estimated at 686 cubic feet per bin set. The estimated height of the calcine in the bottom of a bin after initial removal is estimated at 2 feet.

The following tables summarize information that was estimated by hand and software calculations. See the attached copy of the Excel output for the results.

Risk-based Closure

Table 1. Remaining Calcine Volumes (Risk-based Clean Closure)

CSSF	Total Calcine Volume Remaining in Bin Set Following Risk-based Clean Closure FT^3	Total Calcine Volume Remaining in Bin Set Following Risk-Based Clean Closure (M^3)
1	31.2	0.9
2	88.1	2.5
3	149.4	4.2
4	49.7	1.4
5	106.5	3.0
6	162.9	4.6
7	178.4	5.0

LFS - BOTTOM ONLY

Table 2. Summary of Calcine Volume at Various Stages in the Removal Process (Risk-based Clean Closure)

* TOTAL w/ PIPING, SUPP ETC

CSSF Bin Set #	Initial Calcine Volume[1A] FT^3 (M^3)	Calcine Volume After CRTP Removal[B] FT^3 (M^3)	Calcine Volume After Bin Set Closure FT^3 (M^3)	Percent Calcine Removed - by CRTP %	Total Percent Calcine Removed (CRTP+BSCP) %
1	7,848 (222)	443 (13)	31 (1)	94.4	99.6
2	31,550 (893)	1,619 (46)	88 (3)	94.9	99.7
3	40,694 (1,152)	2,237 (63)	149 (4)	94.5	99.6
4	17,898 (506)	917 (26)	50 (1)	94.9	99.7
5	36,552 (1,035)	1,894 (54)	106 (3)	94.8	99.7
6	56,657 (1,604)	2,925 (83)	163 (5)	94.8	99.7
7	64,786 (1,835)	3,311 (94)	178 (5)	94.9	99.7

Table 3. Calcine Volumes Remaining on Bin Surfaces Following BSCP Closure Activities (Risk-based Closure)

CSSF	Calcine Left on Bin Walls FT^3 (M^3)	Calcine Left on Supports FT^3 (M^3)	Calcine Left on Piping FT^3 (M^3)	Calcine Left on External Piping FT^3 (M^3)	Calcine on Floor FT^3 (M^3)
1	.9 (.0)	8.5 (.2)	0 (0)	.2 (0)	21.6 (.6)
2	6.9 (.2)	0.2 (.0)	0 (0)	.3 (0)	80.6 (2.3)
3	8.9 (.3)	30.3 (.9)	0 (0)	.3 (0)	109.8 (3.1)
4	3.9 (.1)	0 (0)	0 (0)	.1 (0)	45.7 (1.3)
5	12.1 (.3)	0 (0)	0 (0)	.3 (0)	94.1 (2.7)
6	17.2 (.5)	0 (0)	0 (0)	.3 (0)	145.4 (4.1)
7	13.1 (.4)	0 (0)	0 (0)	.3 (0)	164.9 (4.7)

Table 4. Calcine Volumes Removed During CRTP and BSCP Activities (Risk-based Closure)

CSSF	Total Volume Removed by CRTP FT^3 (M^3)	Total Volume Removed by CRTP+BSCP FT^3 (M^3)	Total Volume Removed During BSCP Activities FT^3 (M^3)
1	7,406 (210)	7,817 (221)	411 (21)
2	29,931 (848)	31,462 (891)	1,531 (43)
3	38,457 (1089)	40,544 (1148)	2 ,087 (59)
4	16,981 (481)	17,849 (506)	868 (25)
5	34,658 (981)	36,445 (1032)	1,787 (51)
6	53,732 (1522)	56,494 (1600)	2 ,762 (78)
7	61,475 (1741)	64,607 (1829)	3,312 (88)

---

[1]

[A] Volume of calcine currently in each bin set. It is assumed for bounding purposes that the bins are filled to maximum capacity.

[B] The Calcine Retrieval and Transportation Project will remove approximately 95% of the original calcine volume (EDF-BSC-005)

Table 5. Summary of Grout Estimates

CSSF	Volume of Clean Grout Necessary to Fill Vault FT^3 (M^3)	Volume of Grout Necessary to Fill Piping and Distributor FT^3 (M^3)
1	17,025 (482)	686 (19)
2	75,513 (2138)	686 (19)
3	75,294 (2132)	686 (19)
4	49,617 (1405)	686 (19)
5	96,187 (2724)	686 (19)
6	134,824 (3818)	686 (19)
7	126,695 (3588)	686 (19)

Closure to Landfill Standards

Table 6. Remaining Calcine Volumes (Closure to Landfill Standards)

CSSF	Total Calcine Volume Remaining in Bin Set Following Closure to Landfill Standards (FT^3)	Total Calcine Volume Remaining in Bin Set Following Closure to Landfill Standards (M^3)
1	69.9	2.0
2	120.8	3.4
3	303.9	8.6
4	67.1	1.9
5	158.2	4.5
6	233.9	6.6
7	233.9	6.6

Table 7. Summary of Calcine Volume at Various Stages in the Removal Process (Closure to Landfill Standards)

CSSF Bin Set #	Initial Calcine Volume[C] FT^3 (M^3)	Calcine Volume After CRTP Removal[D] FT^3 (M^3)	Calcine Volume After Bin Set Closure FT^3 (M^3)	Percent Calcine Removed - by CRTP %	Total Percent Calcine Removed (CRTP+BSCP) %
1	7,848 (222)	443 (13)	70 (2)	94.4	99.1
2	31,550 (893)	1,619 (46)	121 (3.4)	94.9	99.6
3	40,694 (1,152)	2,237 (63)	304 (8.6)	94.5	99.3
4	17,898 (506)	917 (26)	67 (1.9)	94.9	99.6
5	36,552 (1,035)	1,894 (54)	158 (4.5)	94.8	99.6
6	56,657 (1,604)	2,925 (83)	234 (6.6)	94.8	99.6
7	64,786 (1,835)	3,311 (94)	234 (6.6)	94.9	99.6

[C] Volume of calcine currently in each bin set. It is assumed for bounding purposes that the bins are filled to maximum capacity.

[D] The Calcine Retrieval and Transportation Project will remove approximately 95% of the original calcine volume (EDF-BSC-005)

Table 8. Calcine Volumes Remaining on Bin Surfaces Following BSCP Closure Activities (Closure to Landfill Standards)

CSSF	Calcine Left on Bin Walls FT^3 (M^3)	Calcine Left on Supports FT^3 (M^3)	Calcine Left on Piping FT^3 (M^3)	Calcine Left on External Piping FT^3 (M^3)	Calcine on Floor FT^3 (M^3)
1	4.0 (0.1)	42.4 (1.2)	0 (0)	3.9 (.1)	19.6 (.6)
2	33.9 (2.0)	1.0 (0.0)	.2 (0)	6.9 (.2)	78.9 (2.2)
3	43.9 (1.2)	151.5 (4.3)	0 (0)	6.9 (.2)	101.7 (2.9)
4	19.4 (0.5)	0 (0)	0 (0)	2.9 (.1)	44.7 (1.3)
5	60.0 (1.7)	0 (0)	0 (0)	6.9 (.2)	91.4 (2.6)
6	85.4 (2.4)	0 (0)	0 (0)	6.9 (.2)	141.6 (4.0)
7	65.1 (1.8)	0 (0)	0 (0)	6.9 (.2)	162.0 (4.6)

Table 9. Calcine Volumes Removed during CRTP and BSCP Activities (Closure to Landfill)

CSSF	Total Volume Removed by CRTP FT^3 (M^3)	Total Volume Removed by CRTP+BSCP FT^3 (M^3)	Total Volume Removed During BSCP Activities FT^3 (M^3)
1	7,406 (210)	7,778 (220)	372 (10)
2	29,931 (848)	31,429 (890)	1,498 (42)
3	38,457 (1089)	40,390 (1144)	1,933 (55)
4	16,981 (481)	17,831 (505)	850 (24)
5	34,658 (981)	36,393 (1031)	1,736 (50)
6	53,732 (1522)	56,423 (1598)	2,691 (76)
7	61,475 (1741)	64,552 (1828)	3,077 (87)

Table 10. Summary of Grout Estimates (Duplicate of Risk-based)

CSSF	Volume of Clean Grout Necessary to Fill Vault FT^3 (M^3)	Volume of Grout Necessary to Fill Piping and Distributor FT^3 (M^3)
1	17,025 (482)	686 (19)
2	75,513 (2138)	686 (19)
3	75,294 (2132)	686 (19)
4	49,617 (1405)	686 (19)
5	96,187 (2724)	686 (19)
6	134,824 (3818)	686 (19)
7	126,695 (3588)	686 (19)

Miscellaneous

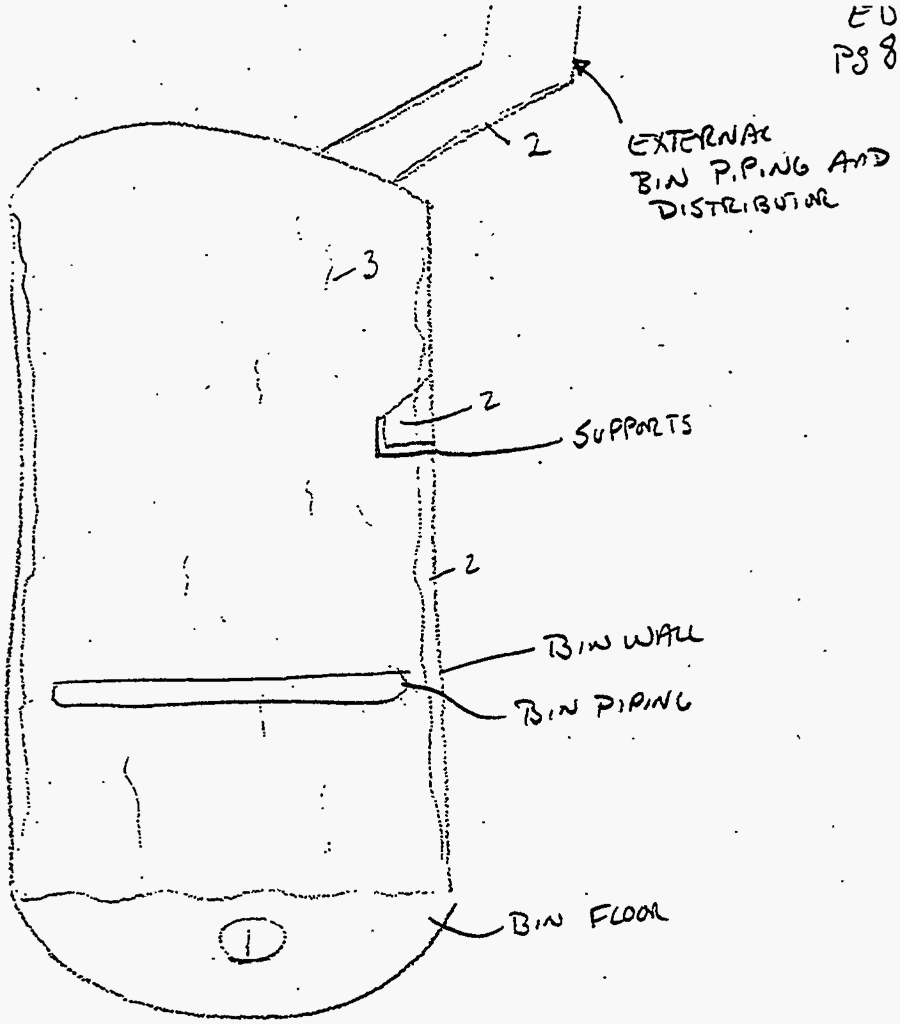
Additional information has been provided at the end of this EDF. This information does not have a reference (gathered from Dan Staiger of LMITCO) and has not been reviewed for accuracy. The information in these pages does relate to the volume calculations for the bin sets and is included to provide a more detailed summary of the work performed. This information may be useful should additional volume calculations be required.

References

1 Megyesy, E. F. Pressure Vessel Handbook Tenth Edition. Pressure Vessel Publishing, Inc. July 1, 1995.
2 Information provided by Dan Staiger. See pages 35 through 56 of this EDF.
3 Griffith, D. L. "Status of Calcine Retrieval Development Work – DLG-06096" September 26, 1996.

Attached Information

The following information is provided on the indicated pages.



STEP 1 - CRTP REMOVAL

95% of Bin Volume Removed -> leaves 5% on floor

STEP 2 - Add calcine on walls, supports, internal piping, + external piping

Bin Wall thickness (.8 mm CSSF 1
1 mm CSSF 2-7)

SUPPORTS + PIPING - ASSUMED 45° slope accumulation

EXTERNAL PIPING - ASSUMED 1% of volume is remaining calcine

STEP 3 - FINAL REMOVAL

-> CLEAN OUT EXTERNAL PIPING
ASSUMED 95% of remaining calcine removed
-> 90% of which falls to the bin floor
10% of which sticks to the bin walls.

STEP 4 - FINAL REMOVAL

-> CLEAN OFF BIN WALLS, SUPPORTS, + INTERNAL PIPING
ASSUMED 80% falls to floor and 20% is fixed contamination

STEP 5 - FINAL REMOVAL

-> CLEAN FLOOR
ASSUMED 95% of calcine on floor is removed by robot

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This is an Excel printout of data manipulation that was accomplished using the information provided by hand calculations.
The first columns of information are in cubic feet, while the second column is in cubic meters.

Risk Based Closure - Includes the cleaning of the bin walls, supports, internal and external piping, and floor.

INITIAL CONDITIONS FOR THE BIN SETS

CSSF	NUMBER OF BINS PER BIN SET	TOTAL BIN SET VOLUME (CU.FT)	TOTAL BIN SET VOLUME (CU.M.)	TOTAL STARTING CALCINE VOLUME (CU.FT)
1	4	7844	222.1169792	7848.355551
2	7	31,542	893.1685056	31549.62221
3	7	40,686	1152.097325	40693.62221
4	3	17,895	506.729136	17898.26666
5	7	36,544	1034.809139	36551.62221
6	7	56649	1604.118403	56656.62221
7	7	64778	1834.30567	64785.62221
		SUM OF TOTAL BIN VOLUME	SUM OF TOTAL BIN VOLUME	SUM OF TOTAL BIN VOLUME
		255938	7247.345158	255983.7333

CONDITIONS AFTER CALCINED RETRIEVAL AND TRANSPORTATION PROJECT ACTIVITIES
(INITIAL CSSF CLOSURE PROJECT CONDITIONS)

After CRFP →

CSSF	CALCINE LEFT ON FLOOR (CU.FT)	CALCINE LEFT ON FLOOR (CU.M)	CALCINE LEFT ON WALLS (CU.FT)	CALCINE LEFT ON WALLS (CU.M)
1	392.2	11.10584896	4.01	0.113550368
2	1577.1	44.65842528	33.88	0.959373184
3	2034.3	57.60486624	43.88	1.242541184
4	894.75	25.3364568	19.4	0.54934592
5	1827.2	51.74045696	59.98	1.698441664
6	2832.45	80.20592016	85.4	2.41825472
7	3238.9	91.71528352	65.1	1.84342368
	SUM OF CALCINE IN ALL CSSF	SUM OF ~~CALCINE IN ALL~~ CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
	12796.9	362.3672579	311.65	8.82493072

CONDITIONS AT CLOSURE (AFTER CSSF CLOSURE ACTIVITIES)

CSSF	CALCINE LEFT ON FLOOR (CU.FT)	CALCINE LEFT ON FLOOR (CU.M)	CALCINE LEFT ON WALLS (CU.FT)	CALCINE LEFT ON WALLS (CU.M)
1	21.648876	0.613026892	0.87648	0.024819109
2	80.578533	2.281726203	6.90834	0.195565449
3	109.848653	3.110562337	8.90834	0.252199049
4	45.650357	1.292672029	3.93586	0.11145096
5	94.078533	2.664003003	12.12834	0.343379145
6	145.357833	4.116068685	17.21034	0.487341756
7	164.868333	4.668543612	13.15034	0.372375548
	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
	662.031118	18.74660276	63.11204	1.787131014

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TOTAL STARTING CALCINE VOLUME (CU.M)
222.2403145
893.3843423
1152.313162
506.8216375
1035.024976
1604.33424
1834.521507
SUM OF TOTAL BIN VOLUME
7248.640179

Initial

CALCINE LEFT ON SUPPORTS (CU.FT)	CALCINE LEFT ON SUPPORTS (CU.M)	CALCINE LEFT ON PIPES (CU.FT)	CALCINE LEFT ON PIPES (CU.M)
42.4	1.20083232	0	0
1.05	0.02973264	0.175	0.00495544
151.45	4.28857936	0.028	0.00079287
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
194.9	5.51894432	0.203	0.00574831

CALCINE LEFT ON SUPPORTS (CU.FT)	CALCINE LEFT ON SUPPORTS (CU.M)	CALCINE LEFT ON PIPES (CU.FT)	CALCINE LEFT ON PIPES (CU.M)
8.48	0.240128464	0	0
0.21	0.005946528	0.035	0.000991088
30.29	0.857715872	0.0056	0.000158574
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
38.98	1.103788864	0.0406	0.001149662

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Δ Distribute &
Ext. Piping

CALCINE LEFT IN EXTERNAL PIPING (CU.FT)	CALCINE LEFT IN EXTERNAL PIPING (CU.M)	TOTAL CALCINE LEFT IN THE BIN SET (CU.FT)	TOTAL CALCINE LEFT IN THE BIN SET (CU.M)
3.92	0.111001856	442.53	12.5310335
6.86	0.194253248	1619.065	45.84673979
6.86	0.194253248	2236.518	63.3310329
2.94	0.083251392	917.09	25.96905411
6.86	0.194253248	1894.04	53.63315187
6.86	0.194253248	2924.71	82.81842813
6.86	0.194253248	3310.86	93.75296045
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
41.16	1.165519488	13344.813	377.8824008

CALCINE LEFT IN EXTERNAL PIPING (CU.FT)	CALCINE LEFT IN EXTERNAL PIPING (CU.M)	TOTAL CALCINE LEFT IN THE BIN SET (CU.FT)	TOTAL CALCINE LEFT IN THE BIN SET (CU.M)
0.196	0.005550093	31.201356	0.883522558
0.343	0.009712662	88.072873	2.49394193
0.343	0.009712662	149.393593	4.230348494
0.147	0.00416257	49.733217	1.408285559
0.343	0.009712662	106.547873	3.01709481
0.343	0.009712662	162.911173	4.613123104
0.343	0.009712662	178.361673	5.050631822
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
2.058	0.058275974	766.221758	21.69694828

EQUIVALENT NUMBER OF 55-GALLON DRUMS	TOTAL PERCENTAGE REMOVED %	TOTAL CALCINE REMOVED (CU.FT)	TOTAL CALCINE REMOVED (CU.M)
60.18408	94.36149398	7405.825551	209.709281
220.19284	94.86819529	29930.55721	847.5376025
304.166448	94.50400854	38457.10421	1088.982129
124.72424	94.87609601	16981.17666	480.8525833
257.58944	94.818178	34657.58221	981.3918241
397.76056	94.83783204	53731.91221	1521.515812
450.27698	94.88951424	61474.76221	1740.768547
SUM OF CALCINE IN ALL CSSF	AVERAGE REMOVAL	AVERAGE REMOVAL	AVERAGE REMOVAL
1814.894568	94.73647401	34662.7029	981.5368254

EQUIVALENT NUMBER OF 55-GALLON DRUMS	TOTAL PERCENTAGE REMOVED %	TOTAL CALCINE REMOVED (CU.FT)	TOTAL CALCINE REMOVED (CU.M)
4.243384416	99.60244722	7817.154195	221.3567919
11.97791073	99.72084334	31461.54934	890.8904004
20.31752865	99.63288205	40544.22862	1148.082813
6.763717612	99.72213389	17848.53345	505.4133519
14.49051073	99.70850029	36445.07434	1032.007881
22.15591053	99.71245873	56493.71104	1599.721117
24.25718753	99.72468942	64607.26054	1829.470875
SUM OF CALCINE IN ALL CSSF	AVERAGE REMOVAL	AVERAGE REMOVAL	AVERAGE REMOVAL
104.2061591	99.68913642	36459.6445	1032.420461

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Landfill Calculations - Assumes only floor is cleaned (95% removal).
Does not include cleaning the bin walls, supports, or internal and external piping.

INITIAL CONDITIONS FOR THE BIN SETS

CSSF	NUMBER OF BINS PER BIN SET	TOTAL BIN SET VOLUME (CU.FT)	TOTAL BIN SET VOLUME (CU.M.)	TOTAL STARTING CALCINE VOLUME (CU.FT)
1	4	7844	222.1169792	7848.355551
2	7	31,542	893.1685056	31549.62221
3	7	40,686	1152.097325	40693.62221
4	3	17,895	506.729136	17899.26666
5	7	36,544	1034.809139	36551.62221
6	7	56649	1604.118403	56656.62221
7	7	64778	1834.30567	64785.62221
		SUM OF TOTAL BIN VOLUME	SUM OF TOTAL BIN VOLUME	SUM OF TOTAL BIN VOLUME
		255938	7247.345158	255983.7333

CONDITIONS AFTER CALCINED RETRIEVAL AND TRANSPORTATION PROJECT ACTIVITIES
(INITIAL CONDITIONS FOR CSSF CLOSURE PROJECT)

CSSF	CALCINE LEFT ON FLOOR (CU.FT)	CALCINE LEFT ON FLOOR (CU.M)	CALCINE LEFT ON WALLS (CU.FT)	CALCINE LEFT ON WALLS (CU.M)
1	392.2	11.10584896	4.01	0.113550368
2	1577.1	44.65842528	33.88	0.959373184
3	2034.3	57.60486624	43.88	1.242541184
4	894.75	25.3364568	19.4	0.54934592
5	1827.2	51.74045696	59.98	1.698441664
6	2832.45	80.20592016	85.4	2.41825472
7	3238.9	91.71528352	65.1	1.84342368
	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
	12796.9	362.3672579	311.65	8.82493072

CONDITIONS AT CLOSURE (AFTER CSSF CLOSURE ACTIVITIES)

CSSF	CALCINE LEFT ON FLOOR (CU.FT)	CALCINE LEFT ON FLOOR (CU.M)	CALCINE LEFT ON WALLS (CU.FT)	CALCINE LEFT ON WALLS (CU.M)
1	19.61	0.555292448	4.01	0.113550368
2	78.855	2.232921264	33.88	0.959373184
3	101.715	2.880243312	43.88	1.242541184
4	44.7375	1.26682284	19.4	0.54934592
5	91.36	2.587022848	59.98	1.698441664
6	141.6225	4.010296008	85.4	2.41825472
7	161.945	4.585764176	65.1	1.84342368
	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
	639.845	18.1183629	311.65	8.82493072

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TOTAL STARTING CALCINE VOLUME (CU.M)
222.2403145
893.3843423
1152.313162
506.8216375
1035.024976
1604.33424
1834.521507
SUM OF TOTAL BIN VOLUME
7248.640179

CALCINE LEFT ON SUPPORTS (CU.FT)	CALCINE LEFT ON SUPPORTS (CU.M)	CALCINE LEFT ON PIPES (CU.FT)	CALCINE LEFT ON PIPES (CU.M)
42.4	1.20063232	0	0
1.05	0.02973264	0.175	0.00495544
151.45	4.28857936	0.028	0.00079287
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
194.9	5.51894432	0.203	0.00574831

CALCINE LEFT ON SUPPORTS (CU.FT)	CALCINE LEFT ON SUPPORTS (CU.M)	CALCINE LEFT ON PIPES (CU.FT)	CALCINE LEFT ON PIPES (CU.M)
42.4	1.20063232	0	0
1.05	0.02973264	0.175	0.00495544
151.45	4.28857936	0.028	0.00079287
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
194.9	5.51894432	0.203	0.00574831

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CALCINE LEFT IN EXTERNAL PIPING (CU.FT)	CALCINE LEFT IN EXTERNAL PIPING (CU.M)	TOTAL CALCINE LEFT IN THE BIN SET (CU.FT)	TOTAL CALCINE LEFT IN THE BIN SET (CU.M)
3.92	0.111001856	442.53	12.5310335
6.86	0.194253248	1619.065	45.84673979
6.86	0.194253248	2236.518	63.3310329
2.94	0.083251392	917.09	25.96905411
6.86	0.194253248	1894.04	53.63315167
6.86	0.194253248	2924.71	82.81842813
6.86	0.194253248	3310.86	93.75298045
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
41.16	1.165519488	13344.813	377.8824008

CALCINE LEFT IN EXTERNAL PIPING (CU.FT)	CALCINE LEFT IN EXTERNAL PIPING (CU.M)	TOTAL CALCINE LEFT IN THE BIN SET (CU.FT)	TOTAL CALCINE LEFT IN THE BIN SET (CU.M)
3.92	0.111001856	69.94	1.980476992
6.86	0.194253248	120.82	3.421235776
6.86	0.194253248	303.933	8.606409974
2.94	0.083251392	67.0775	1.899420152
6.86	0.194253248	158.2	4.47971776
6.86	0.194253248	233.8825	6.622803976
6.86	0.194253248	233.905	6.623441104
SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF	SUM OF CALCINE IN ALL CSSF
41.16	1.165519488	1187.758	33.63350573

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EQUIVALENT NUMBER OF 55-GALLON DRUMS	TOTAL PERCENTAGE REMOVED %	TOTAL CALCINE REMOVED (CU.FT)	TOTAL CALCINE REMOVED (CU.M)
60.18408	94.36149398	7405.825551	209.709281
220.19284	94.86819529	29930.65721	847.5376025
304.166448	94.50400854	38457.10421	1088.982129
124.72424	94.87609601	16981.17666	480.8525833
257.58944	94.818176	34657.58221	981.3916241
397.76056	94.83783204	53731.91221	1521.515812
450.27698	94.88951424	61474.76221	1740.768547
SUM OF CALCINE IN ALL CSSF	AVERAGE REMOVAL	AVERAGE REMOVAL	AVERAGE REMOVAL
1814.894568	94.73647401	34662.7029	981.5368254

EQUIVALENT NUMBER OF 55-GALLON DRUMS	TOTAL PERCENTAGE REMOVED %	TOTAL CALCINE REMOVED (CU.FT)	TOTAL CALCINE REMOVED (CU.M)
9.51184	99.10885791	7778.415551	220.2598375
16.43152	99.61704771	31428.80221	889.9631066
41.334888	99.25311863	40389.68921	1143.706752
9.12254	99.62522907	17831.18916	504.9222173
21.5152	99.56718747	36393.42221	1030.545258
31.80802	99.587193	56422.73971	1597.711436
31.81108	99.63895539	64551.71721	1827.898066
SUM OF CALCINE IN ALL CSSF	AVERAGE REMOVAL	AVERAGE REMOVAL	AVERAGE REMOVAL
161.535088	99.48536991	36399.42504	1030.715239

INEL **ENGINEERING DESIGN FILE**

Form L-0431.2#
(05-96-Rev.#02)

Project File Number: 73501
EDF Serial Number: EDF-TFC-029
Functional File Number: RD-01

Project/Task: CPP TANK FARM CLOSURE STUDY
Sub task: Tank and Vault Void Volumes and Dimensions

Title: TYPICAL VAULT DIMENSIONS AND APPROXIMATE TANK AND VAULT VOID VOLUMES

SUMMARY

This document gives definitive vault and pillar dimensions, total vault, tank void and vault void volumes pertaining to the ICPP Tank Farm vaults. The dimensions were taken from the drawing collection of Mike Swenson. The dimensions are close to the dimensions found in several drawings (see attachments)

Vault void volume is the space between the tank and vault walls. Tank void volume is the space inside the tank. Total vault volume is the entire vault space excluding the tank. These volumes have been calculated for each of the three vault designs (i.e. Cast in Place, Pillar and Panel, and Square vaults) and two tank designs. Pillar volumes for vaults WM 180-186 were subtracted from the vault volume for accuracy.

The following volumes are close approximations and are preliminary in nature. Additional work and further study is needed to obtain better accuracy:

WM 180-181 (drawings 103362, Chicago Bridge and Iron 5-7915)			
Total Vault Volume:	3,386 yd^3	2,589 m^3	91,421 ft^3
Tank Void Volume:	2,001 yd^3	1,530 m^3	54,038 ft^3
Vault Void Volume:	1,384 yd^3	1,059 m^3	37,383 ft^3
WM 182-186 (drawings 106217, 106220, 106230, 106214, 105164, 105588)			
Total Vault Volume:	3,229 yd^3	2,469 m^3	87,194 ft^3
Tank Void Volume:	1,826 yd^3	1,396 m^3	49,299 ft^3
Vault Void Volume:	1,404 yd^3	1,073 m^3	37,895 ft^3
WM 187-190 (drawings 106308, 106310, 106242)			
Total Vault Volume:	3,737 yd^3	2,857 m^3	100,902 ft^3
Tank Void Volume:	1,826 yd^3	1,396 m^3	49,299 ft^3
Vault Void Volume:	1,911 yd^3	1,461 m^3	51,603 ft^3

Distribution: B.R. Helm, D.J. Harrell, B.C. Spaulding, R.A Gavalya and WTP EIS Studies Library on distribution.

Authors	Department	Reviewed	Approved
K.D. McAllister	4130		
Date 12-23-97		Date 1/12/98	Date 1/12/98

Finding Vault Volume for
Cast in Place Vaults WM - 180 & 181

106311
23' tall tanks

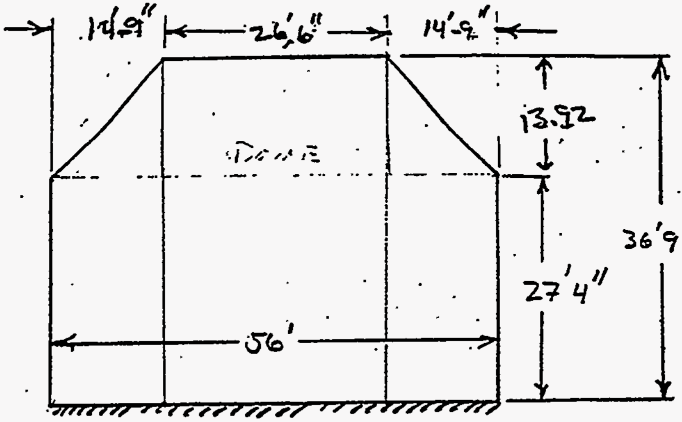


Figure #1

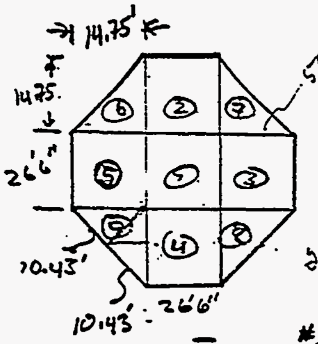
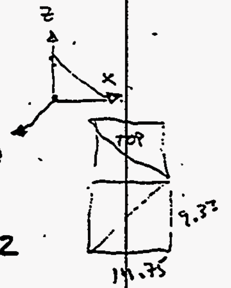


Figure #2

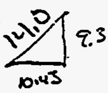


Ⓐ Vault wall thickness .... 2'4"
Ⓑ octagonal sloping roof
Ⓒ Assume Pillars Similar to WM 182-186
Ⓓ Assume Equal Distance of sloping roof

Ⓕ Assume Vault Area Has Pillars
Ⓖ Dimensions From Mike Swenson & "Evaluation of Existing Vaults for vehicle Loads, HLWTFR Project," L.E. Wall & S. Bolnarch, Aug. 1993

$$\sqrt{(14.75)^2 + (14.75)^2} = 20.86$$

$$\sqrt{(9.33)^2 + (14.75)^2} = 17.45$$



TOTAL VOLUME = Vault Dome Volume + octagonal Volume

Octagonal Volume

$$56' \times 56' = 3136\ ft^2$$

for 4 corners

Find & Sub: corner area => 14.75 × 14.75 × 2 => 435.125 ft²

total octagonal area = 2701 ft² => (3136 - 435.125)

octogonal volume = 2701 ft² × 27.33 ft = 73,824 ft³

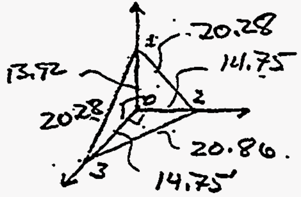
2734 yd³

Vault Dome Volume

Finding Volume of each Section (see figure #2) to Determine Dome Volume.

①	26.5' × 26.5' × 13.92' =>	9775 ft³
②③	26.5' × 14.75' × 13.92'	5441 ft³
④⑤	26.5' × 14.75' × 13.92'	5441 ft³
⑥⑦⑧⑨	Tetrahedron	2019 ft³

=> 22,667



Finding Volume for Sections ⑥⑦⑧⑨

Tetrahedron volume

$$V = \sqrt{\frac{|\Delta|}{288}} \Rightarrow \Delta = \begin{vmatrix} 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & d_{01}^2 & d_{02}^2 & d_{03}^2 \\ 1 & d_{01}^2 & 0 & d_{12}^2 & d_{13}^2 \\ 1 & d_{02}^2 & d_{12}^2 & 0 & d_{23}^2 \\ 1 & d_{03}^2 & d_{13}^2 & d_{23}^2 & 0 \end{vmatrix}$$

From Pg - 309 Standard Mathematical Tables & Formulas

$$\begin{vmatrix} 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & 193.77 & 217.56 & 217.56 \\ 1 & 193.77 & 0 & 411.28 & 411.28 \\ 1 & 217.56 & 411.28 & 0 & 435.14 \\ 1 & 217.56 & 411.28 & 435.14 & 0 \end{vmatrix}$$

$\sqrt{(18.67)^2 + (18.67)^2} = 26.40$

$(13.92)^2 = 193.77$
$(14.75)^2 = 217.56$
$(20.28)^2 = 411.28$
$(20.86)^2 = 435.14$

$V = \sqrt{\frac{|\Delta|}{288}} \Rightarrow \sqrt{254766.4} \Rightarrow 504.74$

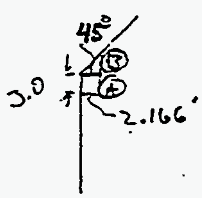
Volume under one corner $\longrightarrow$ $\underline{V = 504.74\ ft^3}$

Total Volume under 4 corners $\Rightarrow$ 504.74 (4)
$\underline{2019\ ft^3}$

Total volume of Vault Dome $\underline{22,667\ ft^3}$ ← w/o Pillars Subtracted

Octogonal volume $\underline{73,824\ ft^3}$

Pillar volume



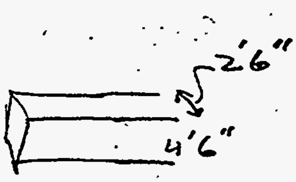
Ⓐ $2.167 \times 3.0 = 6.5$
Ⓑ $\frac{2.167 \times 2.167}{2} = \underline{2.35}$
$8.85\ ft^2$
} Pillar Areas

$8.85 \times 8 = 70.78\ ft^2$ ← total area

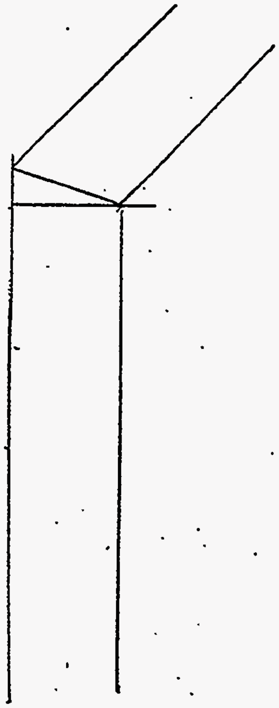
Pillar Volume $\longrightarrow$ Volume $= 70.78\,(27.33) = \underline{1935\ ft^3}$

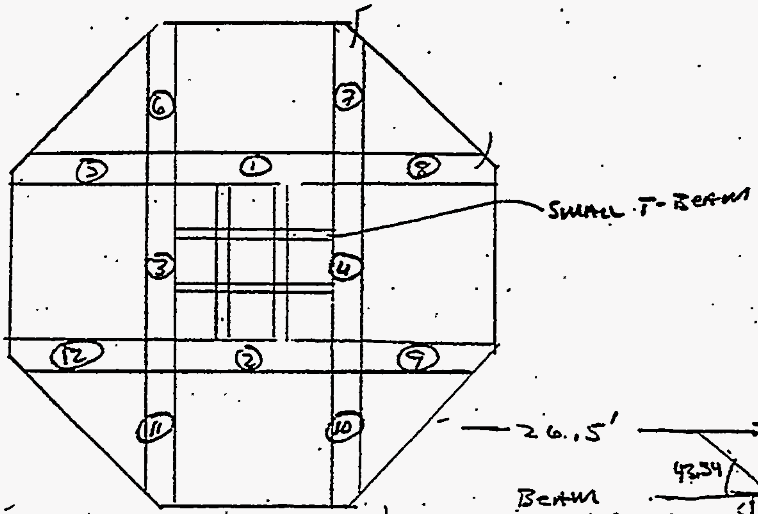
Dome T-Beams Volumes

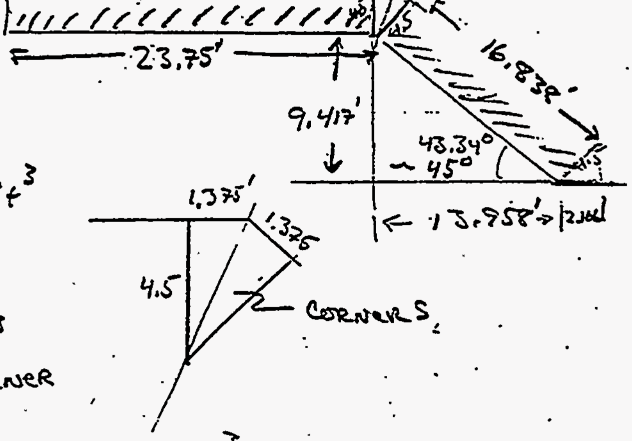
Large T-Beam Size ⇒



Small T-Beam







①②③④

23.75' × 4.5' × 2.5'

= 267.2 ft^3
Horiz. Beam

1.375' × 4.5 × 2.5

= 15.5 ft^3
Horiz. Beam Corner

267.2 ft^3 + 15.5 ft^3 = 282.7 ft^3 ← for 1 Horiz. Beam

282.7 × 4 = 1130.6 ft^3 ← Total Horiz. Beam (4)

⑤-⑫

16.838' × 4.5' × 2.6'

= 197.0 ft^3
Ang. Beam

1.375' × 4.5' × 2.6'

= 16.1 ft^3
Ang Beam Corner

1970 + 16.1 = 213.1 ft^3 ← for 1 Horiz Beam

8 × 213.1 ft^3 = 1705 ft^3 ← Total Angle Beam (8)

SMALL T-BEAMS

$2.5' \times 1.5' \times 21.5'$

$= 80.625 ft^3$

$80.625 ft^3 \times 2 \Rightarrow \underline{161.25} ft^3$

$2.5' \times 1.5' \times 6.917$

$= 25.94 ft^3$

$25.94 \times 2 = \underline{51.88} ft^3$

$2.5' \times 1.5' \times 4.667'$

$= \underline{17.5} ft^3$

$(51.88 + 17.5)2 = \underline{138.76}$

$161.25 + 138.76 = 300 ft^3$ ← TOTAL SMALL BEAM Volume

Volumes of All Dome Beams

$1130.6 ft^3 + 1705 ft^3 + 300 ft^3$

$= \underline{3135 ft^3}$

Volumes of Pillar

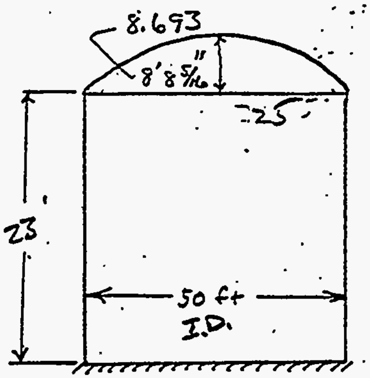
$= \underline{1935 ft^3}$

FINAL VAULT VOLUME

$22,667 + 73,824 - 3135 - 1935 ft^3$

$=$ $\boxed{\begin{array}{l} 91,421 ft^3 \\ 338'6 yd^3 \\ 2589 m^3 \end{array}}$

Finding tank volume for
WM-180 & 181



Volume of Cylindrical Portion of Tank

$\pi r^2(h) \Rightarrow 45160\ ft^3$

$\underline{1673\ yd^3}$

Volume of Dome Portion

Equation from
CRC Standard Mathematical
Tables & Formulae 30th
edition, Daniel Zwillinger p 341

$\frac{1}{6}\pi h\left(3a^2+h^2\right) =$

$= \frac{1}{6}(\pi)(8.693)\left(3(25)^2+(8.693)^2\right)$

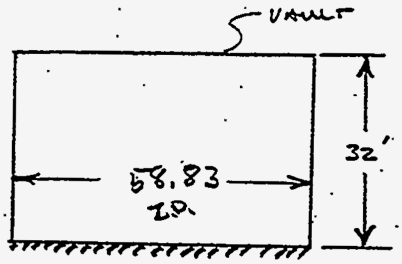
$= 8878\ ft^3$

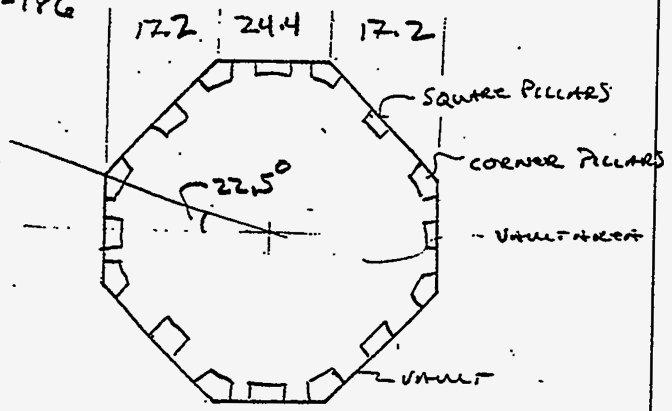
$\underline{329\ yd^3}$

TOTAL TANK VOLUME = 45160 + 8878 = 54038 ft³
= 2001 yd³

VAULT VOID VOLUME = 91421 - 54038 = $\boxed{37383\ ft^3}$
(TANK IN VAULT)
= $\boxed{1384\ yd^3}$
= $\boxed{1059\ m^3}$

Finding Vault Volume for
Pillar & Panel Vaults WM-182-186



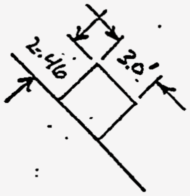


Ⓐ Vaults have Pillars

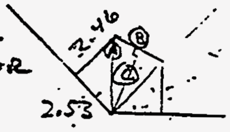
Ⓑ Vault wall thickness = 0.6'

Ⓒ Dimensions from Mike Swenson and "Evaluation of Existing Vaults for Vehicle Loads, HLWTFR Project," L.E. Mauk and S. Bolourchi, Aug, 1993

★★Ⓓ Volume of T-Beams protruding from ceiling are neglegable for these calculations



SQUARE PILLARS



CORNER PILLARS

$\tan\theta = \frac{OPP}{Adj}$

OPP = .22 ft

2.75 - .22 ft => 2.53'

Finding length Ⓐ

$Ⓐ = \sqrt{(2.53)^2+(2.46)^2} \Rightarrow \underline{\underline{3.53 \text{ ft}}}$

Finding length Ⓑ

from Drawing 106220 2' 9½" => 2.79 ft

Finding length Ⓒ

$x^2+y^2=z^2 \Rightarrow x^2-z^2=-y^2 \Rightarrow \sqrt{-x^2+z^2} = y = Ⓒ$

$\sqrt{-\left(\frac{2.79}{2}\right)^2+(3.53)^2} = Ⓒ \to \underline{\underline{3.24}} \text{ ft}$

Finding Area of 1 corner Pillar

$\frac{2.79}{2}\times 3.2 = 4.46 \text{ ft}^2$

$2.46\times 2.53 = \underline{6.22 \text{ ft}^2}$

$\boxed{10.69 \text{ ft}^2}$

Finding Area of 8 Corner Pillars

$10.69\ (8) = \underline{85.5\ ft^2}$

Finding Area of 8 Square Pillars

$(2.46)(3.0)(8) = \underline{59\ ft^2}$

TOTAL PILLAR AREA

$85.5\ ft^2 + 59\ ft^2 \Rightarrow \boxed{144.5\ ft^2}$

Finding Vault Area w/o Pillars

$(58.8)^2 = \underline{3461.4\ ft^2}$

full corners $(17.2)(17.2) = 295.8\ ft^2$

Area of Missing Corners $2(295.84) \Rightarrow \underline{591.7\ ft^2}$

Octogonal Vault Area w/o Pillars $= 3461.4 - 591.7\ ft^2$

$= \underline{2869.3\ ft^2}$

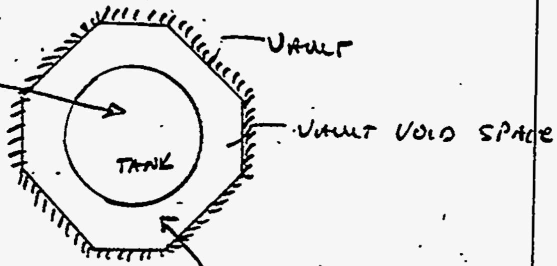
Total Vault Area including Pillars $2869.3 - 144.5$

$\boxed{2724.8\ ft^2}$

Finding tank area

$A_T = \frac{1}{4}\pi(D)^2$

$A_T = 1963.4\ ft^2$



Finding Area of Vault Void Space

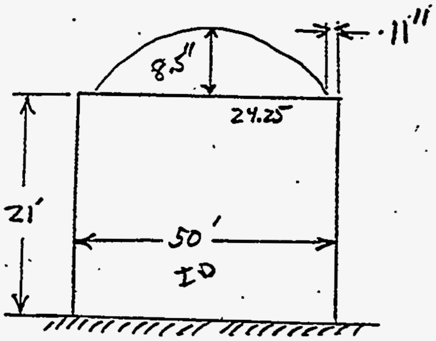
$2724.8\ ft^2 - 1963.5 ft^2 \Rightarrow \boxed{761.3\ ft^2}$

TOTAL
Volume of Vault (including Pillars)

$2724.8\ ft^2(32\ ft) = \underline{87194\ ft^3} \Rightarrow \boxed{\underline{3229}\ yd^3}$

Drawing 105588

Finding Volume of tank



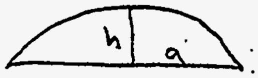
$\pi r^2\ height =$

$\pi(25)^2(21') = \underline{41233\ ft^3}$

Cylindrical Volume

Dome Volume

$\frac{1}{6}\pi h(3a^2+h^2) = 8066\ ft^3$



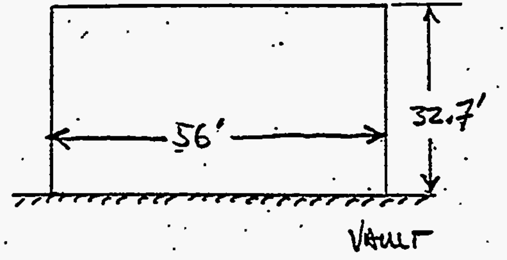
h = 8.5
a = 24.1

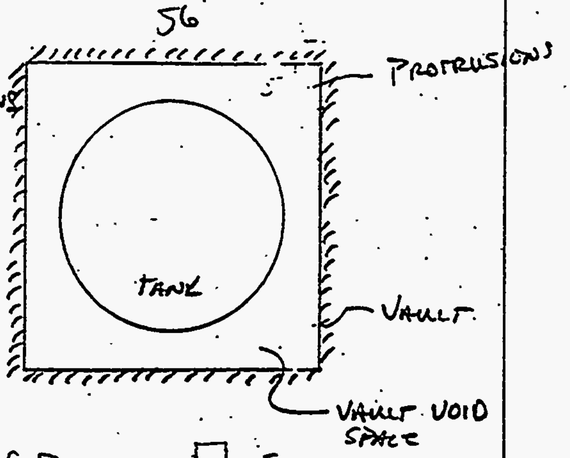
Total tank volume = $41233 + 8066 = 49299\ ft^3 = 1396\ m^3 = 1826\ yd^3$

Vault void space Volume = $87194 - 49299 = \boxed{37895\ ft^3 \quad 1404\ yd^3 \quad 1073\ m^3}$
(tank in vault)

Finding Vault Volume for Square Vaults
WM - 187 - 190

★ Volume of T-Beams Protruding from ceiling are Negligable for these calculations

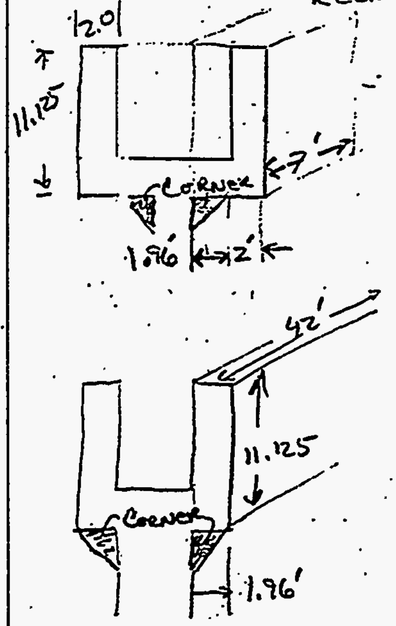




Roof Beams

Approximate Vault Volume

$56' \times 56' \times 32.6' \Rightarrow 102234\ ft^3$



Rectangle Protrusions $\Rightarrow$

$11.125 \times 7' \times 3.96' \Rightarrow 308.4\ ft^3$

$56' - 14' \Rightarrow 42'$

$42' \times 11.125' \times 1.96' \Rightarrow 915.81\ ft^3$

Add in corners

$\frac{1.96 \times 1.96 \times 56'}{2} \Rightarrow 107.6\ ft^3$

Total $1332\ ft^3$

Subtract Protrusions

$102{,}234 - 1332 \Rightarrow \boxed{100{,}902\ ft^3}$

Total Vault Volume $\rightarrow$ $3737\ yd^3$ $2857\ m^3$

Vault Void

$100{,}902\ ft^3 - 49299\ ft^3 \Rightarrow$ $51{,}603\ ft^3$ $1911\ yd^3$ $1461\ m^3$

Tank Volumes Are Same As Tank 182-186

INEL

ENGINEERING DESIGN FILE

Form L-0431.2#
(05-96-Rev.#02)

Project File Number 015720
EDF Serial Number EDF-BSC-010
Functional File Number C-04

Project/Task BIN SET CLOSURE STUDY
Sub task Calcine Removal Time

Title: CSSF BIN SET CALCINE REMOVAL TIME

SUMMARY

The purpose of this Engineering Design File (EDF) is to estimate the time to remove calcine from the CSSF (Calcined Solids Storage Facility) bin walls and bin bottom for Risk Based Clean Closure (RBCC) and Closure to Land Fill Standards (CLFS) options.

The following calculations are general approximations for the entire CSSF Bin Sets using a 10-hour workday. Nominal CSSF bin dimensions and types (cylindrical) were used to simplify the calculation process. Further study is needed to determine exact values for each individual CSSF bin.

Results:

Estimated Number of Working Days to Clean All 50 CSSF Interior Bin Walls	430	workdays
Estimated Number of Working Days to Clean Bin Bottom [RBCC]	1168	workdays
Estimated Number of Working Days to Clean Bin Bottom [CLFS]	1123	workdays

Conclusion:

Total Working Days to Clean All CSSF Bin Sets [RBCC]	**1598**	**workdays**
Total Working Days to Clean All CSSF Bin Sets [CLFS]	**1553**	**workdays**

Distribution: B.C. Spaulding, M.M. Dahlmeir, B. Helm, D. Harrell and project file (original +1)

Authors Department	Reviewed	Approved
K.D. McAllister 4130		
Date 2/2/98	Date 2/2/98	Date 2/2/98

ASSUMPTIONS

① 12 FOOT DIAMETER TANK
ENGINEERING JUDGEMENT
BASIS: NOMINAL BIN DIAMETER IN CSSF BIN SETS (EDF-BSC-007)

② 6 INCH CO_2 NOZZLE SPRAY FOOTPRINT
ENGINEERING JUDGEMENT
BASIS: MIDDLE RANGE SPRAY FOOT PRINT Chosen for BOUNDING PURPOSES (EDF-BSC-003)

③ 10 SECOND CO_2 SPRAY/CLEANING TIME (SEE FIGURE #1)

BASIS: ESTIMATED TIME TO SPRAY DOWN INTERIOR BIN WALL 1 FOOT USING AN LDUA. VALUE WAS OBTAINED USING ENGINEERING JUDGEMENT AND CONSERVATISM (FOR BOUNDING PURPOSES)

④ 4 SECOND RETURN (SEE FIGURE #1)

BASIS: ESTIMATED TIME FOR LDUA TO RETURN TO ITS STARTING POSITION AFTER SPRAYING DOWN 1 FOOT AND MOVE HORIZONTALLY 3 inches VALUE OBTAINED USING ENGINEERING Judgement AND CONSERVATISM (FOR BOUNDING PURPOSES)

⑤ CO_2 BLASTING SPRAY WILL BE ANGLED DOWNWARD (SEE FIGURE #1)
BASIS: TO ENSURE CALCINE FALLS TOWARD BIN BOTTOM

⑥ CO_2 BLASTING OF BIN INTERIOR WILL OCCURE IN A RASTER PATTERN (SEE FIGURE #1)

BASIS: TO ENSURE UNIFORM BIN WALL CLEANING

⑦ CO_2 BLASTING SPRAY DOWN COLUMNS (6 INCH HORIZONTAL 12 INCHES VERTICAL) WILL OVER LAP EACH OTHER HORIZONTALLY BY 3 INCHES AND VERTICALLY BY 6 INCHES. (SEE FIGURE #1)
BASIS: TO PREVENT CONTAMINATED AREAS INSIDE THE BIN FROM BEING MISSED & TO ALLOW CO_2 BLASTING SPRAY TO PASS OVER AN AREA TWICE (TWICE CLEANED AREA)

⑧ OBSTRUCTIONS WILL BE PRESENT INSIDE EACH BIN

BASIS: DUE TO THERMOWELLS, INTERIOR BIN WALL STIFFINERS AND BIN DESIGN.

⑨ UNEXPECTED START & STOPS WILL BE PRESENT DURING THE INTERIOR BIN CLEANING PROCESS (ESTIMATED 1.5 DAYS/BIN)

BASIS: TO ENSURE START & STOP TIMES ARE ACCOUNTED FOR WHILE CALCULATING CLEANING TIME. ESTIMATES FROM ENGINEERING JUDGEMENTS.

⑩ ONE CLEANING CYCLE IS DEFINED AS SPRAYING A 6 INCH COLUMN OF CO_2 DOWN 12 INCHES, RETURNING TO THE STARTING PLACE AND MOVING HORIZONTALLY 3 INCHES

BASIS: TO CLARIFY AND DEFINE A CLEANING CYCLE FOR CALCULATION PURPOSES

⑪ LENGTH OF BINS ARE 60 FEET TALL & CYLINDRICAL

BASIS: AVERAGE LENGTH & TYPE OF BINS CALCULATED BY AVERAGING BIN SET # 3 & # 7 BIN LENGTHS (EDF-BSC-007)

⑫ A CO_2 BLASTER MECHANISM WILL BE ATTACHED TO THE MANIPULATOR OF THE LDUA.

BASIS: TO VERIFY CO_2 BLASTER LOCATION & EXPLAIN HOW IT WILL BE MOVED ALONG THE WALL.

⑬ ONE DAY OF WORK IS 10 HOURS => 10 HOURS/DAY

BASIS: TO AGREE WITH COST ESTIMATES AND BOUNDING PURPOSES

⑭ RETRIEVAL RATE IS 100 lb/hr (~ 45 kg/hr)

BASIS: BASED ON STUDIES FROM "STATUS OF CALCINE RETRIEVAL DEVELOPMENT WORK" - DLG-06-96, D.L. GRIFFITH, SEPTEMBER 26, 1996

⑮ 20% OF CALCINE REMAINS ON WALLS, PIPING, BIN SUPPORTS & EXTERNAL PIPING (DISTRIBUTOR)

BASIS: ENGINEERING JUDGEMENT - FOR BOUNDING PURPOSES

⑯ MOST CALCINE CAN BE REMOVED FROM BIN BOTTOM

BASIS: BASED ON STUDIES FROM "STATUS OF CALCINE RETRIEVAL DEVELOPMENT WORK" - DLG-06-96, D.L. GRIFFITH, SEPTEMBER 26, 1996 - 99% OF CALCINE CAN BE REMOVED

TANK CIRCUMFRENCE:

CIRCUMFRENCE = 2π R = 12 feet (π)

= <u>37.7 feet</u>

CYCLES TO CLEAN TANK WALLS:

NOZZLE MOVES HORIZONTALLY (ACROSS) 3 inches
NOZZLE MOVES VERTICALLY (DOWN) 6 inches

$$\frac{\text{BIN Circumference}}{\text{HORIZONTAL SPRAY MOVEMENT/CYCLE}} = \frac{37.7 \text{ feet}}{0.25 \text{ feet}} = 150.8 \text{ cycles} \Rightarrow \underline{151}$$

# of TIMES TO MOVE HORIZONTALLY AROUND BIN CIRCUMFERENCE

→ # of CYCLES TO MOVE VERTICALLY DOWN BIN

BIN LENGTH 60 feet
VERTICAL NOZZLE MOVEMENT/CYCLES = 6 inches ⇒ .5 feet/Cycles

$$\frac{\text{BIN LENGTH}}{\text{VERTICAL SPRAY MOVEMENT/CYCLE}} = \frac{60 \text{ feet}}{0.5 \frac{\text{feet}}{\text{cycles}}} = \underline{\underline{120}}$$

# of TIMES TO MOVE VERTICALLY DOWN BIN LENGTH

→ TOTAL # of MOVEMENTS TO CLEAN BIN

151 × 120 = <u>18120 TOTAL CYCLES TO CLEAN BIN INTERIOR</u>

BIN WALL CLEANING TIME
# of BINS = 50
TOTAL CLEANING CYCLES = 18120
TIME TO CLEAN DOWN 1 FOOT = 10 SEC.
TIME TO RETURN & MOVE HORIZONTALLY = 4 SEC.
SHIFTS = 10 HOURS/DAY

→ TIME TO CLEAN BIN

18120 CYCLES (10 SEC.) = 181200 SEC. TO CLEAN VERTICALLY

18120 CYCLES (4 SEC) = 72480 SEC. TO RETURN TO START & MOVE 3 INCHES

→ TIME TO CLEAN BIN (CONTINUED)

TOTAL = 181200 + 72480 SECONDS

= 253 680 SECONDS

= **70.5 HOURS** ESTIMATED TO CLEAN EACH BIN

→ # of WORKING DAYS

$$70.5 \text{ Hours}/\text{Bin} \left(\frac{1}{10 \text{ Hours}/\text{Day}}\right) = \underline{7.1 \text{ WORKING DAYS}/\text{BIN}}$$

UNEXPECTED START & STOPS = 1.5 WORKING DAYS/BIN
(ENGINEERING JUDGEMENT
SEE ASSUMPTION ⑨)

TOTAL WORKING DAYS = 7.1 + 1.5 = 8.6 DAYS/BIN
TO CLEAN BIN WALLS.

BINS IN CSSF = 50 BINS

$$8.6 \frac{\text{DAYS}}{\text{BIN.}} (50 \text{ BIN}) \Rightarrow \boxed{430 \text{ WORKING DAYS}}$$

TO CLEAN ALL CSSF
BIN WALLS, PIPING, &
BIN SUPPORTS

BIN BOTTOM CLEANING TIME

Reference ⓐ

BIN BOTTOM RETRIEVAL RATE = 100 lb/Hr

~ 45 Kg/Hr

Reference ⓑ TOTAL AMOUNT of CALCINE left IN BIN BOTTOMS

$= 12796.9\ ft^3$

Reference ⓑ PG-10a-10c MIDDLE TABLE

TOTAL AMOUNT of CALCINE left ON INTERIOR BINS WALLS, PIPING, SUPPORTS & EXTERNAL PIPING

$= 574.91\ ft^3$

[RBCC]

RISK BASED CLEAN CLOSURE (CLEANING BIN BOTTOM AND 80% of CALCINE LEFT ON WALLS, PIPING, BIN SUPPORTS & EXTERNAL PIPING (SEE ASSUMPTION 15)

$$\underbrace{12796.9\ ft^3}_{\text{(CALCINE LEFT BIN BOTTOM)}} + \underbrace{574.91\ ft^3}_{\text{(CALCINE LEFT of WALLS etc)}}\underbrace{(.80)}_{\text{(AMOUNT CALCINE CLEANED)}} \quad \underbrace{13,257\ ft^3}_{\text{TOTAL CALCINE IN BINS}}$$

CLOSURE TO LAND FILL STANDARDS (CLEANING ONLY BIN BOTTOM)

$= 12,796.9\ ft^3$

TOTAL CALCINE IN BINS

BIN BOTTOM CALCINE RETRIEVAL TIME

Reference ⓒ

DENSITY of CALCINE = 1.4 g/cm³ = 39.644E3 g/ft³

$$\left(\text{RETRIEVAL RATE}\right)\left(\frac{1}{\text{DENSITY}}\right) = \frac{\text{VOLUME}(ft^3)}{\text{HOUR}} \qquad \text{CONVERSION FROM } g \rightarrow ft^3$$

$$45000\ \frac{g}{Hr}\ \frac{1}{39.644E3}\cdot\frac{ft^3}{g} \Rightarrow \underline{1.14\ ft^3/Hr}$$

→ TIME TO REMOVE CALCINE [RBCC]

$$\underbrace{\left(\frac{1}{1.14\ ft^3/Hr}\right)}_{\text{HOUR/VOLUME}}\ \underbrace{\left(13,257\ ft^3\right)}_{\text{RBCC BIN BOTTOM VOLUME}} = \underline{11,679\ \text{HOURS TO REMOVE CALCINE}}$$

→ TIME TO REMOVE CALCINE [RBCC] (CONTINUED)

WORKING 10 HOUR/DAY.

$\left(\text{RBCC HOURS TO REMOVE CALCINE}\right)\left(\frac{1}{\text{WORKING HOURS/DAY}}\right) = $ WORKING DAYS [RBKC]

$11{,}679 \text{ HOURS} \left(\frac{1}{10 \text{ HOURS/DAY}}\right) = \boxed{1168 \text{ WORKING DAYS [RBCC]}}$

→ TIME TO REMOVE CALCINE [CLFS]

$\left(1.14 \text{ ft}^3/\text{Hr}\right)^{-1}\left(12796.9 \text{ ft}^3\right) = \underline{11{,}225 \text{ HOURS}}$

HOUR/VOLUME — CLFS BIN BOTTOM VOLUME

WORKING 10 HOURS/DAY

$\left(\text{CLFS HOURS TO REMOVE CALCINE}\right)\left(\frac{1}{\text{WORKING HOURS/DAY}}\right) = $ WORKING DAYS [CLFS]

$11{,}225 \text{ HOURS} \left(\frac{1}{10 \text{ HOURS/DAY}}\right) = \boxed{1123. \text{ WORKING DAYS [CLFS]}}$

ESTIMATED TOTAL TIME TO CLEAN CSSF (CALCINED SOLIDS STORAGE FACILITY)

430 WORKING DAYS (from PAGE 5) TO CLEAN BIN WALLS, PIPING & BIN SUPPORTS + 1168 WORKING DAYS TO CLEAN BIN BOTTOM [RBCC] = $\boxed{1598 \text{ WORKING DAYS}}$ [RBCC]

430 WORKING DAYS (from Page 5) + 1123 WORKING DAYS [CLFS] = $\boxed{1553 \text{ WORKING DAYS}}$ [CLFS]

RESULTS – # DAYS TO CLEAN CSSF BINS (50)

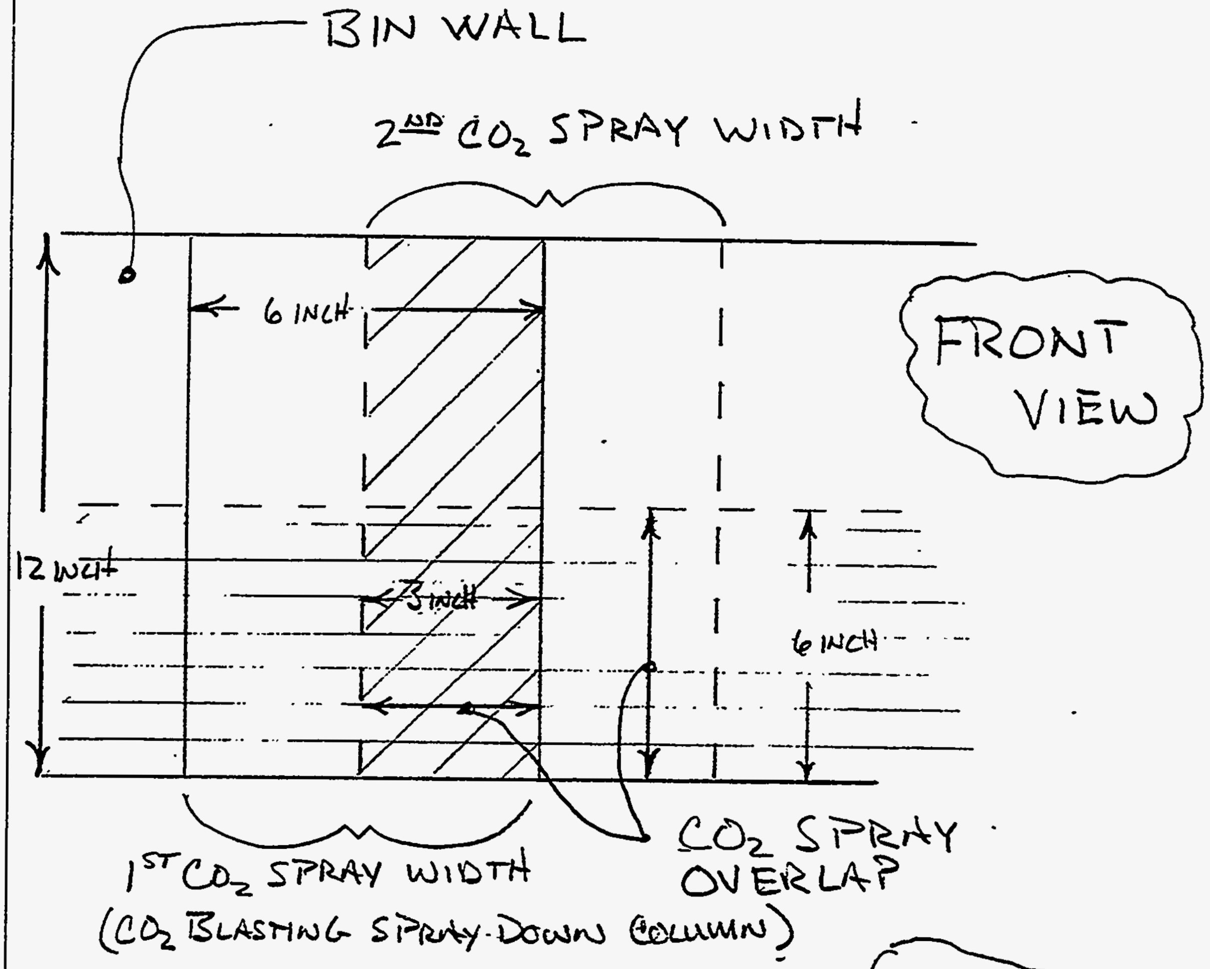
RBCC = 1598 DAYS ⇒ 1598 days/50 bins = 32 DAYS/BIN
CLFS = 1553 DAYS ⇒ 1553 days/50 bins = 31 DAYS/BIN

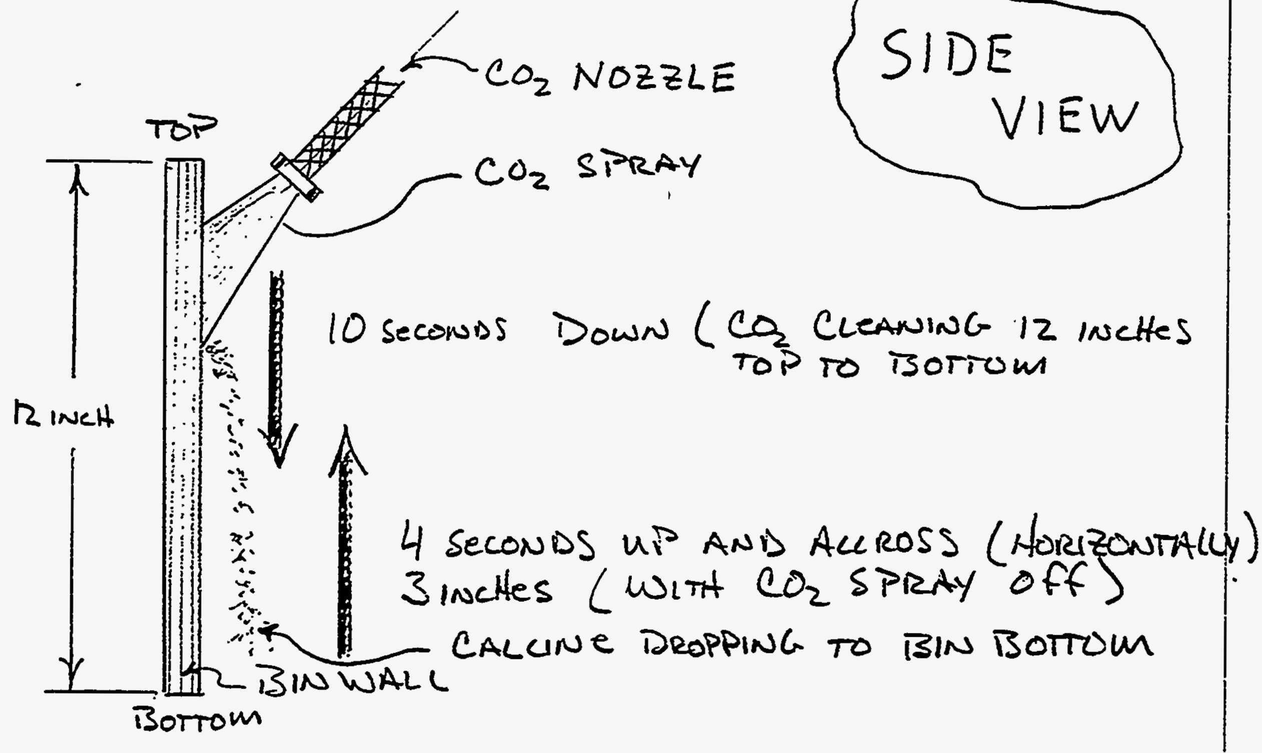
Reference ⓐ - STATUS OF CALCINE RETRIEVAL DEVELOPMENT WORK - DLG-06-96, D.L. GRIFFITH, SEPTEMBER 26 1996.

ⓑ - CALCINE SOLIDS STORAGE FACILITY - VOLUME CALCULATIONS, STEVE SWANSON, EDF-BSC-001

ⓒ - WASTE INVENTORIES / CHARACTERIZATION STUDY, R.S. GARCIA, SEPTEMBER 1997, INEL/EXT-97-00600 : P-14

FIGURE #1


BIN WALL
2ND CO_2 SPRAY WIDTH
FRONT VIEW
6 INCH
12 INCH
3 INCH
6 INCH
CO_2 SPRAY OVERLAP
1ST CO_2 SPRAY WIDTH
(CO_2 BLASTING SPRAY-DOWN COLUMN)


SIDE VIEW
CO_2 NOZZLE
TOP
CO_2 SPRAY
10 SECONDS DOWN (CO_2 CLEANING 12 INCHES TOP TO BOTTOM
12 INCH
4 SECONDS UP AND ACCROSS (HORIZONTALLY) 3 INCHES (WITH CO_2 SPRAY OFF)
CALCINE DROPPING TO BIN BOTTOM
BIN WALL
BOTTOM

INEL

ENGINEERING DESIGN FILE

Form L-0431.2#		Project File Number	015720
(05-96-Rev.#02)		EDF Serial Number	EDF-BSC-011
		Functional File Number	A-01

Project/Task CPP BIN SET CLOSURE STUDY
Sub task Waste Disposal

TITLE: Bin Set Waste Classification Assumptions

SUMMARY:

The purpose of this Engineering Design File is to provide cost bounding assumptions for final equipment management, waste determinations and subsequent disposal during and after Bin Set Closure. As part of the RCRA Closure process, all temporary structures and equipment installed for use during the activity must be removed. Structures and equipment would be decontaminated, if possible, for reuse. If the equipment and structures could not be decontaminated, they would be disposed of, thus requiring a hazardous waste determination (40 CFR 265.111). Based on this hazardous waste determination, the waste would be managed (stored, treated, and disposed of) in accordance with the requirements applicable to the waste. The attached table identifies the anticipated management of structures and equipment following completion of the Calcine Retrieval and Transportation and Bin Set Closure activities. The assumed waste classifications are based on current knowledge.

Reference:

1. Bin Set Closure Starting Conditions, January 1998, EDF-BSC-005

Distribution:; D. J. Harrell, MS 3211; B. R. Helm, MS 3765; B. C. Spaulding, MS 3765; M. M. Dahlmeir, MS 3765; Project Files (Original +1)

Authors	Department	Reviewed	Approved
K. Craig DeCoria	MC&IE 4130		
		Date	Date
C DeCoria	1-29-98	1-29-98	1/29/98

Table Component removed and assumed waste classification.

Component	Assumed Waste Classification [a]
Bridge Crane One bridge crane will be installed on each Bin Set (7 total) (Figure 1)	Mixed Waste or uncontaminated solid waste (noncompactible, nonconditional industrial waste) [d]
Remote hole saw	Mixed waste– remote handled
Ventilation, Instrumentation, and Control building (VIC) This is a pre-manufactured, steel building separate from the confinement enclosure. One per Bin Set (7 total)	Uncontaminated solid waste (noncompactible, nonconditional industrial waste)
Confinement enclosure Pre-manufactured steel building on top of each Bin Set (7 total) (Figure 1)	Mixed waste–remote handled or Uncontaminated solid waste (noncompactible, nonconditional industrial waste)[d]
Auxiliary Heating unit (one per Bin Set 7 total)	Uncontaminated solid waste (noncompactible, nonconditional industrial waste)
Jumper retrieval piping (shielded) Double wall, heavy pipe encased in concrete (one per Bin Set 7 total)	Mixed waste– remote handled
Remote Core-drilling platform (7 total) (Figure 1)	Mixed waste–remote handle or Uncontaminated solid waste (noncompactible, nonconditional industrial waste)[d]
Remote Welding and Cutting equipment	Mixed waste– remote and contact handled [c]
Vertical Deployment Apparatus (VDA) One per Bin Set (7 total) (Figure 1)	Mixed waste–remote handled or Uncontaminated solid waste (noncompactible, nonconditional industrial waste)[d]
Shielding and riser plugs (new and existing 100 Total)	Mixed waste–contact handled
Remote equipment	Mixed waste- remote handled
CO_2 blasting equipment (this equipment won't come in contact with calcine) (2 sets)	Uncontaminated solid waste (noncompactible, nonconditional industrial waste) [g]
HEPA Filters (63 total)	Mixed waste–contact handled
Ducting	Mixed waste–contact handled

Component	Assumed Waste Classification [a]
Retrieval lines	Mixed waste–remote handled
Portable Drilling Dust collector	Mixed waste (Contaminated internally)–contact handled
Closed Circuit Television (CCTV) (2 total)	Mixed waste–remote handled
Control Consoles	Store for future use.
Cameras and Lighting (100 total)	Mixed waste–remote handled
Extension tubes for camera and lighting (100 total)	Mixed waste–remote handled
Clean grout Grouting manifold (8 total) (Figure 5)	Uncontaminated solid waste (noncompactible, nonconditional industrial waste)
Class C Grouting manifold (8 total) (Figure 6)	Mixed waste–remote handled
LDUA There will be 7 LDUAs (Figure 3)	Uncontaminated solid waste (noncompactible, nonconditional industrial waste) Mixed wastes–contact handled [c]
Pipe Crawler Robots (7 total) (Figure 2)	Mixed waste–left in bin [f]
Tractor Robots (53 total) (Figure 4)	Mixed waste–left in bin [f]
Robots control tethers, and hose lines	Mixed Waste–left in bin [f]
Personal Protective Equipment	Mixed waste–Contact handled

Component	Assumed Waste Classification [a]

a. Future studies may show that the calcine can be delisted. If this occurs, the equipment listed as mixed waste could be disposed of as LLW (radioactive waste).

b. Approximate quantity in each classification is based on preliminary information. Further detailed information would be necessary to estimate this more accurately.

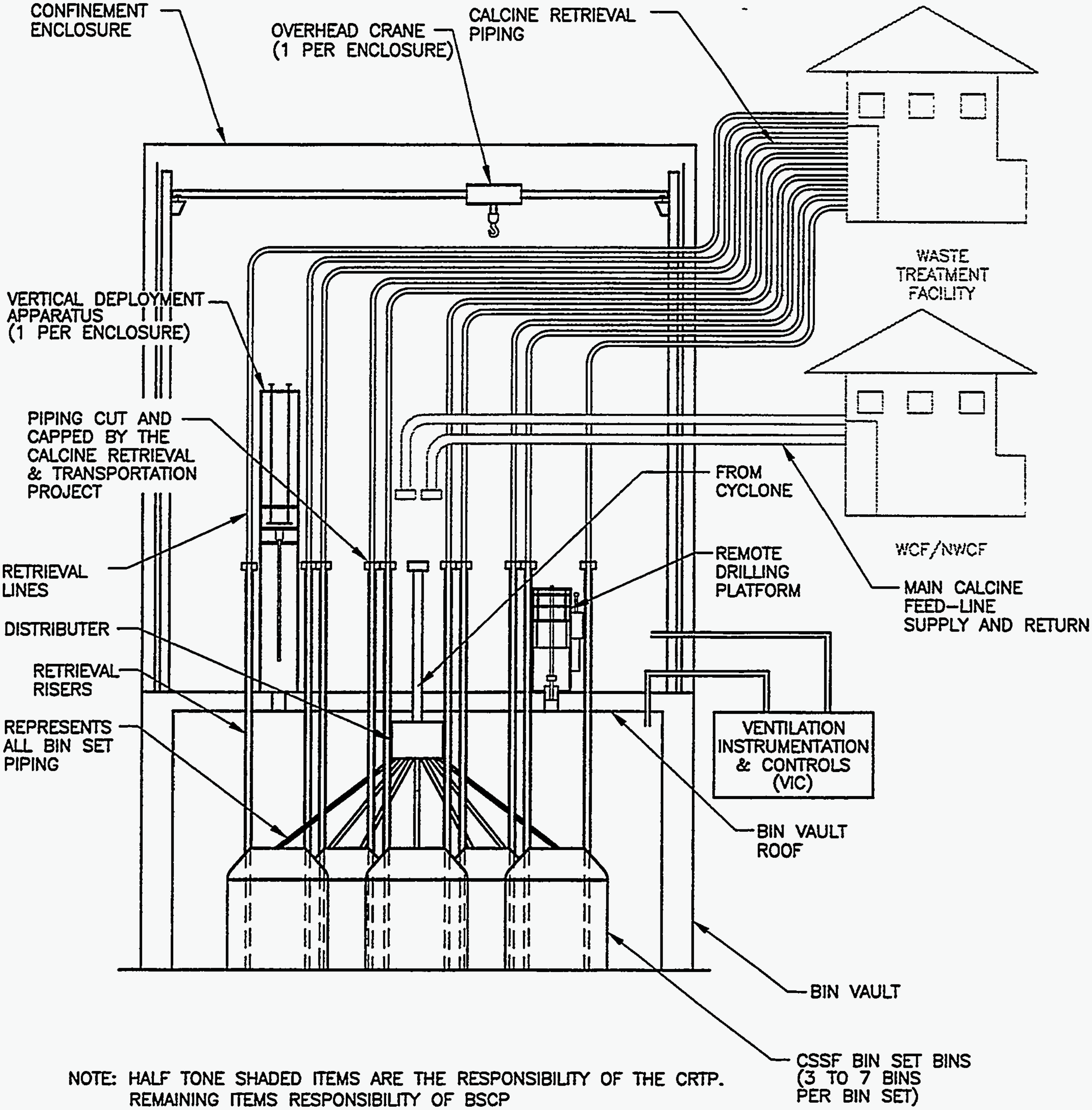
c. It is assumed that the cutting and welding tip, which is deployed within the bin prior to calcine retrieval, will require remote handling. The remaining pieces of the cutting and welding equipment would be contact handled.

d. The confinement enclosure will be designed by the CRTP so as to minimize the contamination risk. It is assumed for cost bounding purposes that one confinement enclosure will become contaminated due to unforeseen circumstances. If the confinement enclosure becomes contaminated, the equipment in that enclosure will become contaminated.

e. At completion of closure activities, at least seven LDUA's are assumed to require disposal. It is assumed the LDUA's will be sized for disposal such that approximately half of the LDUA can be disposed of as uncontaminated solid waste. Only the section of the LDUA that came in contact with the calcine will require management as mixed waste.

f. For the purposes of this study, it is assumed that due to the high level of contamination and the nature of the robots small crevices inaccessible pieces, etc which would be difficult to decontaminate), a new robot will be required for each bin. This practice follows ALARA principals, minimizing the exposure to personnel.

g. The CO_2 blasting equipment (excluding hoses) will be located such that it will not come in contact with calcine.



NOTE: HALF TONE SHADED ITEMS ARE THE RESPONSIBILITY OF THE CRTP.
REMAINING ITEMS RESPONSIBILITY OF BSCP

FIGURE 1

CALCINE RETRIEVAL AND TRANSPORTATION
AND BIN SET CLOSURE PROJECT BOUNDARIES

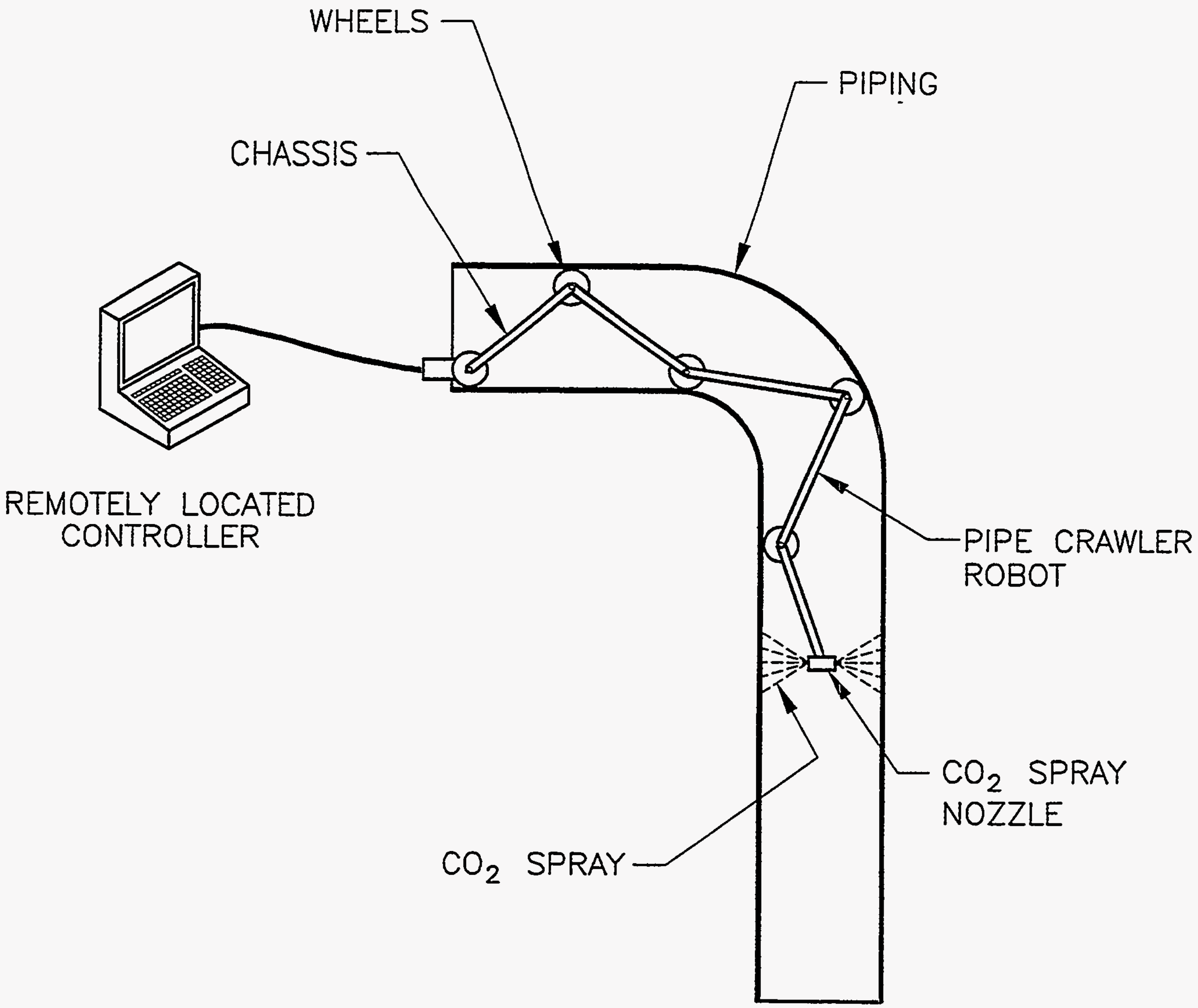


FIGURE 2

PIPE CRAWLING ROBOT

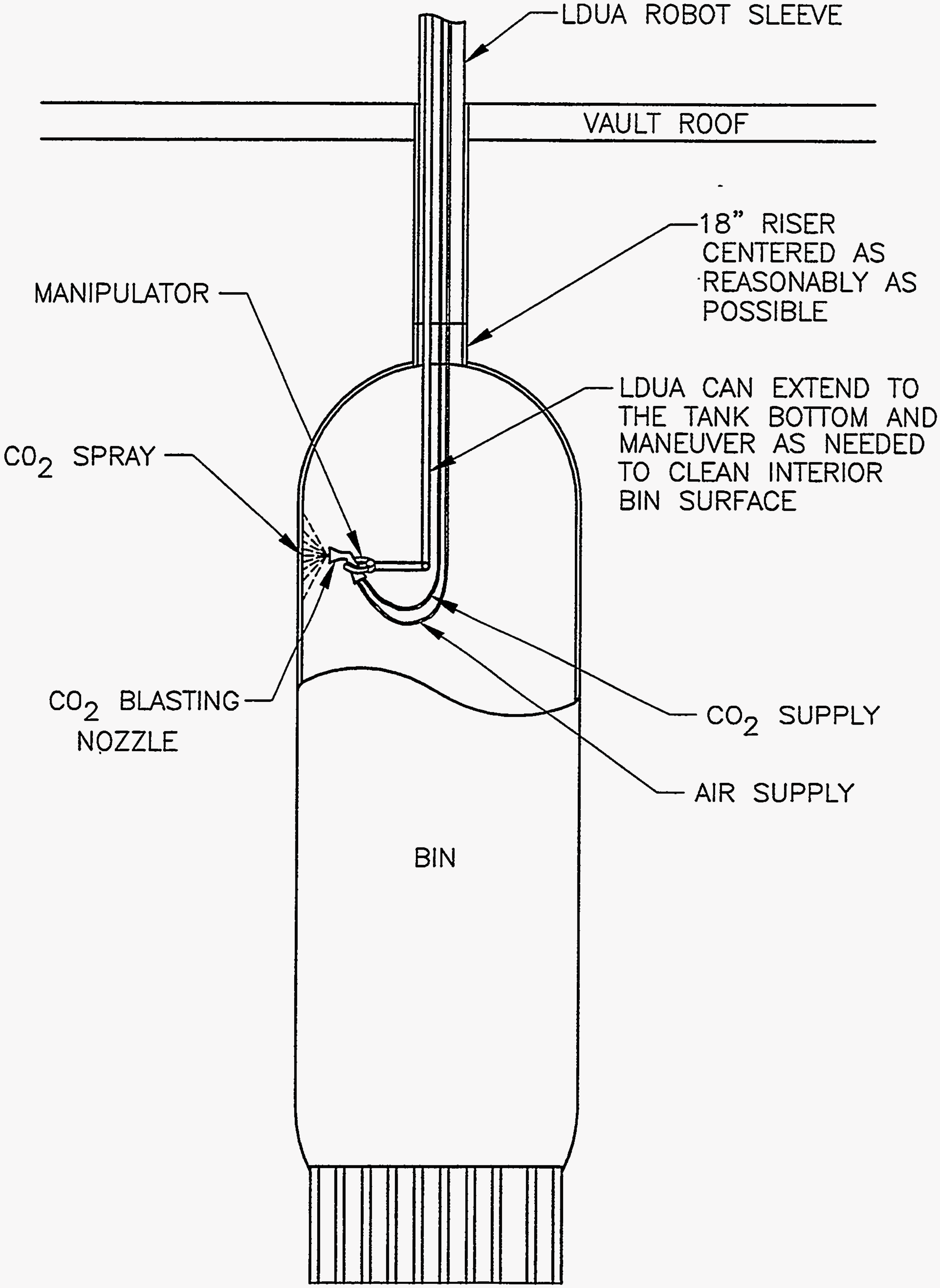


FIGURE 3
LIGHT DUTY UTILITY ARM AND CARBON DIOXODE
BLASTING EQUIPMENT LAYOUT

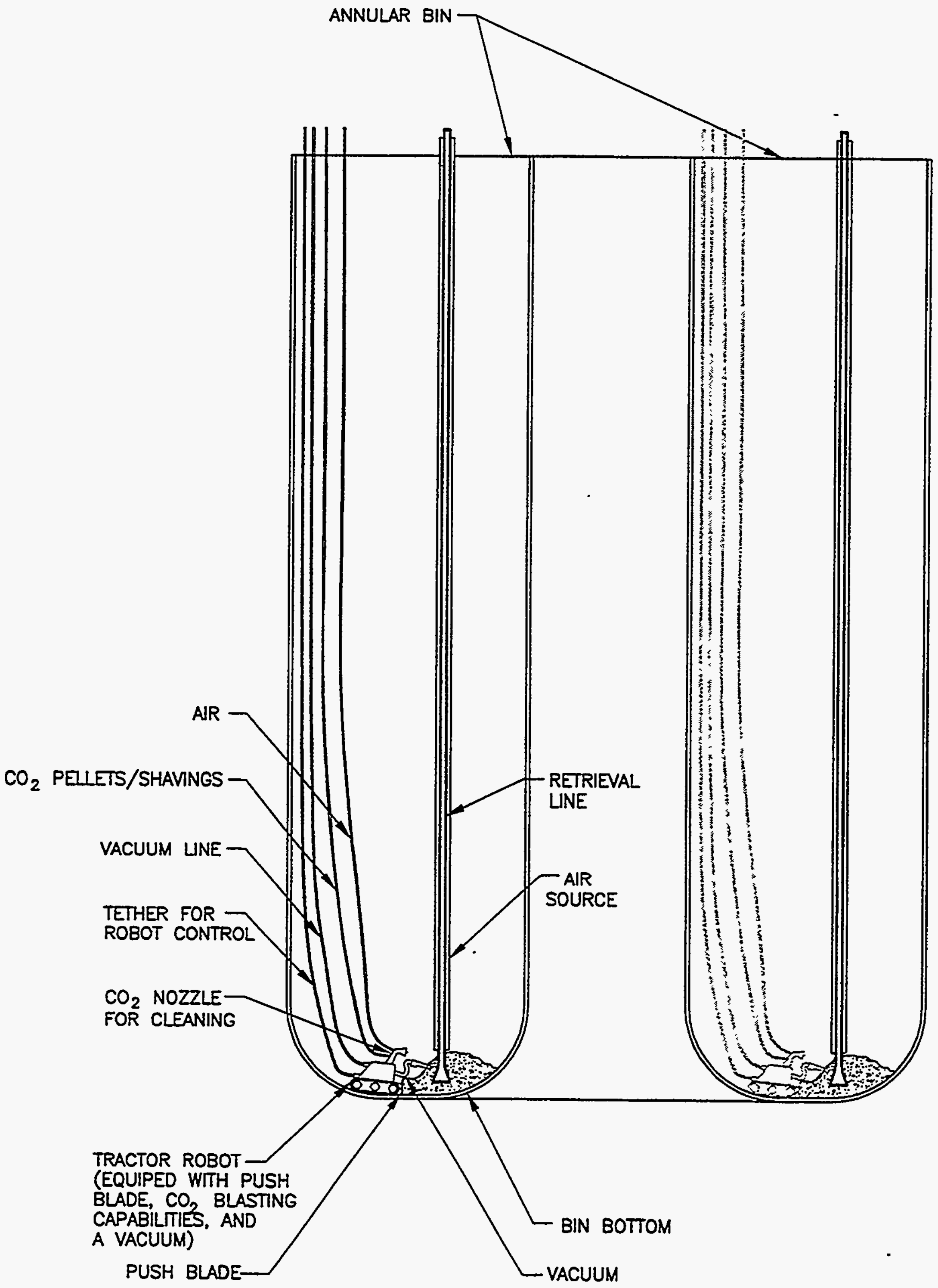


FIGURE 4

TRACTOR/VACUUM ROBOT FOR BIN BOTTOM CLEANING (SHOWN IN ANNULAR BIN – TYPICAL OF BINS IN BIN SETS 5 – 7)

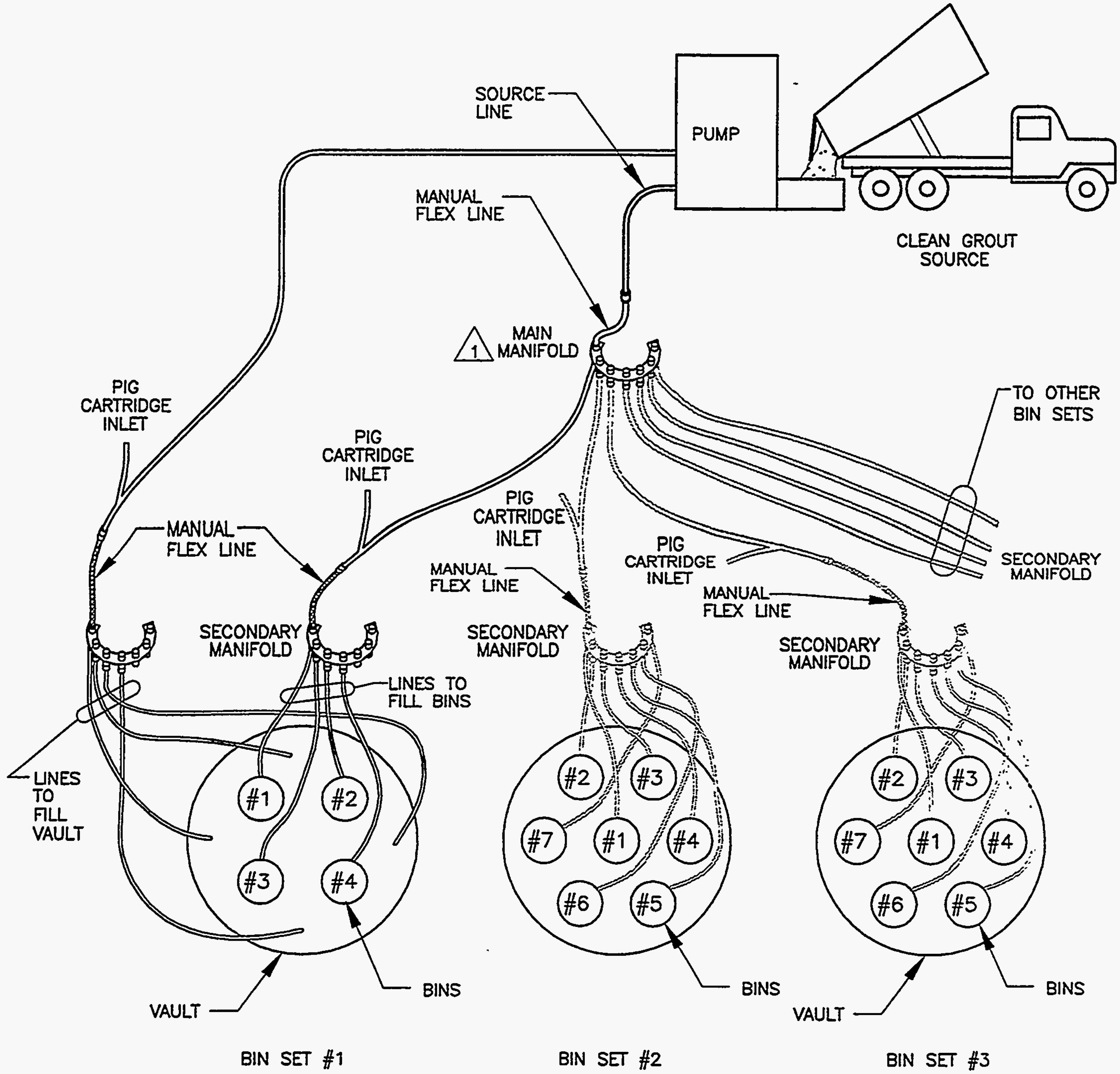


FIGURE 5

GROUT MANIFOLD ARRANGEMENT FOR
BIN VOID MANAGEMENT – CLEAN GROUT

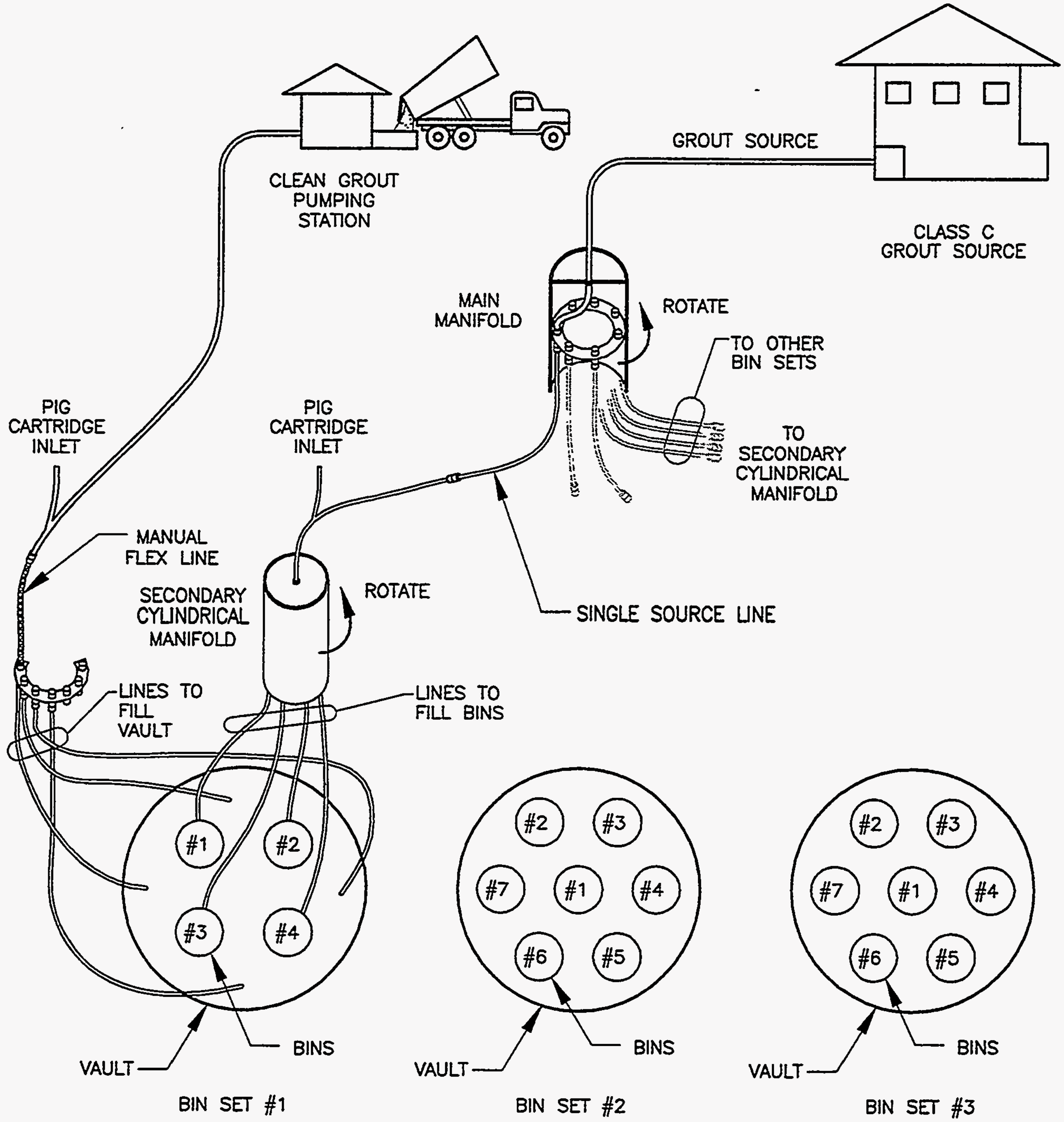


FIGURE 6

GROUT MANIFOLD ARRANGEMENT FOR
FOR BIN VOID MANAGEMENT – CLASS C GROUT

431.02#
06/17/97
Rev. #04

ENGINEERING DESIGN FILE

Function File Number - C-02
EDF Serial Number - EDF-BSC-012
Page 1 of 22

Project File Number 015720

Project/Task Bin Set Closure Evaluations

Subtask Estimates of Bin Set Flush Composition

Title: Bin Set Waste Composition After Flushing With Nitric Acid

Summary:

Following retrieval of calcine from the Bin Sets in the Calcine Solids Storage Facility (CSSF), residual amounts of calcine will remain on the bin walls, floor, supports and piping. One option for removing this residual calcine is to flush the bin sets with nitric acid. This EDF contains estimates of flush effluent volumes and compositions. Flushing conceivably could be used to remove calcine from the bins immediately after retrieval, which would attempt to remove about thirteen thousand cubic feet of calcine, or after other closure activities, in an effort to remove much smaller amounts of calcine.

If nitric acid flushing is used immediately following calcine retrieval from the bin sets, a minimum of 3-8 million liters of waste liquid would be produced. This waste could be processed in the proposed Waste Treatment Facilities (WTF). However, processing in the WTF would either add 1-4 years to the WTF schedule, resulting in a failure to meet deadlines of the Batt agreement, or necessitating an increase in the size and hence cost of the WTF.

Little data is available to accurately determine the dissolution efficiency. For removal immediately after retrieval, and based on small-scale dissolution experiments, perhaps 60-70% of the total calcine would dissolve. However, different chemical and radionuclide species will leach from the calcine at different rates.

Calcine is typically dissolved in boiling nitric acid at an acid to calcine ratio of 10-15 liters acid per kg calcine. For calcine dissolution in the Waste Treatment Facilities, 12-13 liters of 5 molar HNO_3 per kg calcine is used in a stirred tank dissolver with a batch time of 35 hours. These conditions of temperature and possibly residence time are not attainable for dissolution of residual calcine in the bin sets.

If used to remove smaller amounts of calcine as part of other closure activities, an estimated 0.6 million to 3 million liters of liquid waste would be produced. The estimated amount of calcine dissolved, corresponding to these volumes, is 50-90%.

Distribution (complete package): M.M. Dahlmeir, K. C. Decoria, R. A. Gavalya, B. R. Helm, D. J. Harrell, B. C. Spaulding
Distribution (summary package only): J. J. McCarthy

Author C. M Barnes	Dept. 4170	Reviewed	Date 1/29/98	Approved	Date 1/29/98
CMBarnes	1/29/98	LMITCO Review	Date	LMITCO Approval	Date

After retrieval of calcine from the bins in the Calcine Solids Storage Facility (CSSF), small amounts of calcine will remain on the bin walls, floor, supports, and internal and external piping. Flushing the bins with acid will result in a liquid waste stream. This EDF contains estimates of compositions of these wastes.

Estimates of the total residual calcine volumes in the Bin Sets are as follows:[1]

	Immediately Following Retrieval	Following Risk-Based Closure Activities
Bin Set 1	443 ft^3	31.2 ft^3
Bin Set 2	1619 ft^3	88.1 ft^3
Bin Set 3	2237 ft^3	149.4 ft^3
Bin Set 4	917 ft^3	49.7 ft^3
Bin Set 5	1894 ft^3	106.5 ft^3
Bin Set 6	2925 ft^3	162.9 ft^3
Bin Set 7	3311 ft^3	178.4 ft^3.

Leaching or dissolution of ICPP calcine has been the subject of several studies. Early studies showed that only small amounts of the major chemical species of calcine were leached from calcine using water. For example, only 0.01% of the aluminum in alumina calcine was leached in 50 days from calcine with water at 25°C.[2] For zirconia calcine, about 0.12% of the aluminum, 3% of the calcium, 1% of the fluoride, and 55% of the nitrate was leached in 1800 hours with water at 25°C.[3]

However, much higher percentages of calcine can be dissolved using nitric acid. While most dissolution studies of calcine in nitric acid have used elevated temperatures, one recent study used a matrix of conditions that included tests at 25°C.[4] These results are shown in Table 1.

Table 1 shows that, depending on the experimental conditions and the type of calcine, the amount of calcine dissolved ranged from 39-98%. Higher amounts of calcine dissolved with higher acid to calcine ratios and more concentrated acid. Also, for the same conditions, more zirconia-sodium calcine dissolved than alumina-sodium calcine.

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[1] Data received from S. Swanson, January 14, 1998.

[2] B. E. Paige, *Leachability of Alumina Calicne Produced in the Idaho Waste Calcining Facility*, IN-1011, July, 1966.

[3] M. W. Wilding,D. W. Rhodes, *Leachability of Zirconia Calicne Produced in the Idaho Waste Calcining Facility*, IN-1298, June, 1969.

[4] R. S. Herbst, D. S. Fryer, K. N. Brewer, C. K. Johnson, T. A. Todd, *Experimental Results: Pilot Plant Calcine Dissolution and Liquid Feed Stability*, INEL-95/0097, February, 1995.

Table 1. Dissolution of Calcine in Nitric Acid at 25°C.

Experimental Conditions			Wt % Dissolved	
Time, hrs	Acid Conc., Mol/L	L Acid per kg Calcine	Zirconia-Sodium Calcine	-Alumina-Sodium Calcine
0.5	2	5	48.7	38.8
0.5	2	100	74.6	65.4
2-4	2	5	49.7	41.2
2-4	2	100	90.2	71.7
0.5	8	5	57.9	56.4
0.5	8	100	88.0	74.2
2-4	8	5	64.7	60.0
2-4	8	100	97.8	81.7

Based on the dissolution results shown in Table 1, several cases were chosen for calculation of the compositions and volume of acid flushes of calcine bin sets. For dissolution of calcine present in the bins immediately after retrieval, calculations were made for acid to calcine ratios of 5 liters per kg, 15 liters per kg, and 30 liters per kg. The lowest of this ratios represents the approximate minimum requirement for 8 molar nitric acid, while 15 liters per kg represents the approximate minimum requirement for 4 molar nitric acid, and also represents approximately the amount of acid that would completely fill the bin sets. The minimum ratios are set by calcine chemistry. The higher ratio of 30% was used to represent a case of higher dissolution efficiency.

Extrapolating linearly from the data in Table 1 for 2-4 hours, the expected dissolution efficiencies for these conditions are as follows:

Liters acid per kg calcine	4 molar HNO_3	8 molar HNO_3
5	50-60%	60-65%
15	55-60%	60-70%
30	60-65%	65-75%

It should be kept in mind that the the data in Table 1 was generated in experiments conducted in laboratory glassware, with the acid/calcine mixture stirred during the tests. The different fluid dynamics of spraying acid into bins, the different residence times and the potential of residual calcine being shielded from acid sprays or flows could result in different dissolution efficiencies than those estimated above. Testing is recommended in apparatus more representative of bin set geometry to better determine the amount of acid required and dissolution efficiency for bin set flushes. A multi-step decontamination process may lead to reduced decontamination waste volumes and increased efficiencies.

The amount of liquid waste that would be produced from flushing bin sets after retrieval is shown in Table 2. The Feasibility Study for the Waste Treatment Facilities[5] (WTF) did not consider liquid waste from Bin Set Closure in its design basis feeds. The WTF could conceivably process the waste, but it would require either larger equipment or an extended schedule. The WTF was designed for a liquid (dissolved calcine) flow rate of 900 L/hr, based on dissolution using 5 molar nitric acid.[5] At this flowrate, to process the volumes of waste shown in Table 2 in the WTF would take 1 year for an acid to calcine ratio of 5 L/kg, 2 years for a ratio of 15 L/kg, and 4 years for a ratio of 30 L/kg. Extending the WTF schedule beyond the present completion date of 2035 would not comply with the Settlement Agreement between the DOE and the State of Idaho (commonly called "the Batt agreement"), which requires that all high level waste stored at the ICPP be processed by 2035. There is a two-year window in the WTF schedule which may allow earlier processing of calcine, however there is no room to extend the schedule beyond this two-year period. Also, the EIS Option in which Class C grout is produced, the TRU Separations / Class C Option, does not have this window, as the schedule for this option is constrained by the closure of the remote-handled storage facilities at the Waste Isolation Pilot Plant (WIPP).

Table 2. Estimates of Liquid Waste from Bin Set Flushes Immediately Following Calcine Retreival.

Bin Set	Volume of Liquid Waste, Liters		
	5 L acid/kg calcine	15 L acid/kg calcine	30 L acid/kg calcine
1	70,000	200,000	410,000
2	310,000	940,000	1,900,000
3	480,000	1,500,000	2,900,000
4	210,000	620,000	1,200,000
5	400,000	1,200,000	2,400,000
6	500,000	1,500,000	3,000,000
7	560,000	1,700,000	3,400,000
Total	2,500,000	7,600,000	15,000,000

Rather than extending the schedule, an increase in plant capacty of 9-18% would be required to process the bin set flush liquid, based on acid to calcine ratios of 15-30 liters/kg. Assuming a capacity scaling exponent of 0.7, the cost of the separations facilities would increase by 6-12%. The Total Estimated Cost (TEC) for Waste Separations (WS), Calcine Dissolution (CD) and Low Activity Waste Treatment (LAWT) facilities is $686 million for the Full Separations WTF,[5] or $688

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[5] Fluor Daniel, Inc., *Idaho Chemical Processing Plant Waste Treatment Facilities Feasibility Study Report*, December, 1997.

for the same processing units in the TRU Separations / Class C Option.[6] Thus the incremental TEC is about $40-80 million. Temporary storage of the flush effluent may add additional costs.

Compositions of the liquid waste are given later in this EDF.

The volumes shown in Table 2 are equivalent to about 30-40% of the volume of the bin sets for the ratio of 5 liters of acid per kg of calcine, 90-130% of the volume of the bin sets for the ratio of 15 liters/kg and 180-250% of the volume of the bin sets for the ratio of 30 liters/kg.

Calculations of dissolution of the much smaller quantities of calcine estimated to remain in the bin sets after risk-based closure activities used higher ratios of acid to calcine. The purpose of this acid cleaning would be to remove very high percentages of the residual calcine, hence higher ratios of acid to calcine were used to achieve higher dissolution efficiency.

Table 3 shows the amount of acid that would be required for the various bin sets and the various acid to calcine ratios. The values shown in Table 3 are simply the amount of calcine multiplied by the acid to calcine ratio, and hence apply to any molarity of nitric acid. As discussed above, dissolution efficiencies are estimates based solely on the experimental data, shown in Table 1, and obtained in a much different apparatus than would be used in Bin Set flushing.

Table 3. Estimated Acid Requirement for Removal of Residual Calcine from the CSSF.

Bin Set	**Risk-Based Residual Calcine**		**Acid, liters**		
	Ft^3	**Kg**	**20 L/kg**	**50 L/kg**	**100 L/kg**
1	31.2	960	19,000	48,000	96,000
2	88.1	3390	68,000	170,000	340,000
3	149.4	6470	130,000	320,000	650,000
4	49.7	2250	45,000	110,000	230,000
5	106.5	4530	90,000	230,000	450,000
6	162.9	5540	110,000	280,000	550,000
7	178.4	6060	120,000	300,000	610,000
Total	766.2	29,200	580,000	1,460,000	2,920,000
Estimated amount of calcine dissolved[a]			50-70%	60-80%	>85%

(a) These estimates need to be confirmed by tests done in apparatus representative of bin set flushing.

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[6] See Appendix 4 of W. H. Landman, Jr., C. M. Barnes, *TRU Separations Option Scoping Study Report, INEEL/EXT-97-01428*, December, 1997 (Draft).

Tables 4-21 show the composition of the rinse effluent assuming complete dissolution of calcine. Thus the concentrations shown are the maximum concentrations that could be expected. For incomplete dissolution, the concentration of the more soluble species, both chemical species and radionuclides, will approach the maximum, while the concentration of less soluble species will be some fraction of that shown. The concentration of acid used in the flush affects only the hydrogen ion (H^+) and nitrate ion (NO_3^-) concentrations. Tables 3-8 are based on calcine compositions from Table 3f of INEL/EXT-97-00600.

Compositions are given in Tables 4-9 for residual calcine volumes "after retrieval", and in Tables 13-18 for residual calcine volumes "after risk-based closure". Compositions are presented for Bin Sets 1-6. Insufficient data is available at present to predict the chemical composition of calcine that will be placed in Bin Set 7.

Tables 10-12 ("after retrieval" calcine volumes) and Tables 19-21 ("after risk-based closure" calcine volumes) present radiological composition estimates for acid rinses of the calcine Bin Sets. Tables 10 and 19 show the radiological composition estimates for Bin Set 1, which contains alumina calcine; Tables 11 and 20 show estimates for Bin Set 4 which contains zirconia calcine; and Tables 12 and 21 show estimates for Sodium-Bearing Waste calcine, which will be a large percentage of the calcine in Bin Set 6. The data shown in these tables are based on radionuclide inventories recently calculated by Doug Wenzel.[7] All activities shown in these tables have been decayed to January, 2016.

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[7] D. R. Wenzel, *Evaluation of Radionuclide Inventory for Zr Calcine*, EDF-FDO-003, October 14, 1997, D. R. Wenzel, *Evaluation of Radionuclide Inventory for Al Calcine*, EDF-FDO-004, October 14, 1997, D. R. Wenzel, *Evaluation of Radionuclide Inventory for Sodium Bearing Waste*, EDF-FDO-006, November 26, 1997.

Table 4. Bin Set 1 Rinse Effluent Composition Estimates ("After Retrieval" Residual Calcine Volume).

	Concentrations, Mol/l		
L acid/kg calcine	5	15	30
Al+3	3.1E+00	1.1E+00	5.7E-01
B+3	3.4E-02	1.2E-02	6.4E-03
Fe+3	4.4E-03	1.6E-03	8.1E-04
Hg+2	2.5E-02	8.9E-03	4.6E-03
K+	3.0E-03	1.1E-03	5.5E-04
Na+	1.2E-01	4.5E-02	2.3E-02
PO4-3	4.4E-02	1.6E-02	8.2E-03
SO4-2	3.9E-02	1.4E-02	7.2E-03
H+, 4 M acid	Not feasible	2.1	3.0
NO3-, 4 M acid	Not feasible	3.8	3.9
H+, 8 M acid	2.4	5.9	6.9
NO3-, 8 M acid	7.1	7.7	7.8

Table 5. Bin Set 2 Rinse Effluent Composition Estimates ("After Retrieval" Residual Calcine Volume).

	Concentrations, Mol/l		
L acid/kg calcine	5	15	30
Al+3	1.2E+00	4.5E-01	2.3E-01
B+3	7.3E-02	2.6E-02	1.4E-02
Ca+2	1.0E+00	3.7E-01	1.9E-01
Cr+3	5.9E-03	2.2E-03	1.1E-03
Fe+3	2.9E-03	1.0E-03	5.3E-04
F-	1.9E+00	6.9E-01	3.6E-01
Hg+2	7.3E-03	2.7E-03	1.4E-03
K+	6.7E-03	2.4E-03	1.2E-03
Mg+2	3.4E-02	1.2E-02	6.4E-03
Na+	5.4E-02	2.0E-02	1.0E-02
PO4-3	4.5E-03	1.6E-03	8.4E-04
Sn+4	1.9E-03	6.7E-04	3.4E-04
SO4-2	1.1E-02	3.9E-03	2.0E-03
U+4	2.7E-06	1.0E-06	5.1E-07
Zr+4	1.6E-01	5.7E-02	2.9E-02
H+, 4 M acid	0.7	2.8	3.4
NO3-, 4 M acid	3.5	3.8	3.9
H+, 8 M acid	4.2	6.6	7.3
NO3-, 8 M acid	7.0	7.7	7.8

Table 6. Bin Set 3 Rinse Effluent Composition Estimates ("After Retrieval" Residual Calcine Volume).

	Concentrations, Mol/l		
L acid/kg calcine	5	15	30
Al+3	5.9E-01	2.2E-01	1.1E-01
B+3	1.0E-01	3.6E-02	1.9E-02
Ca+2	1.3E+00	4.7E-01	2.4E-01
Cl-	1.9E-03	6.8E-04	3.5E-04
Cr+3	1.0E-02	3.8E-03	1.9E-03
Fe+3	5.5E-03	2.0E-03	1.0E-03
F-	2.3E+00	8.3E-01	4.3E-01
Gd+3	2.0E-05	7.4E-06	3.8E-06
Hg+2	4.6E-04	1.7E-04	8.5E-05
K+	8.2E-03	3.0E-03	1.5E-03
Mg+2	6.1E-02	2.2E-02	1.1E-02
Mn+2	2.5E-04	8.9E-05	4.6E-05
Na+	7.5E-02	2.7E-02	1.4E-02
Ni+2	7.7E-05	2.8E-05	1.4E-05
PO4-3	1.8E-02	6.6E-03	3.4E-03
Sn+4	2.5E-03	9.1E-04	4.6E-04
SO4-2	1.1E-02	4.0E-03	2.1E-03
U+4	5.4E-06	2.0E-06	1.0E-06
Zr+4	2.1E-01	7.6E-02	3.9E-02
H+, 4 M acid	1.2	3.0	3.5
NO3-, 4 M acid	3.6	3.8	3.9
H+, 8 M acid	4.7	6.8	7.4
NO3-, 8 M acid	7.1	7.7	7.8

Table 7. Bin Set 4 Rinse Effluent Composition Estimates (“After Retrieval” Residual Calcine Volume).

	Concentrations, Mol/l		
L acid/kg calcine	5	15	30
Al+3	5.1E-01	1.8E-01	9.4E-02
B+3	1.2E-01	4.3E-02	2.2E-02
Ca+2	1.3E+00	4.9E-01	2.5E-01
Cl-	5.2E-03	1.9E-03	9.6E-04
Cr+3	8.7E-03	3.2E-03	1.6E-03
Fe+3	1.2E-02	4.2E-03	2.1E-03
F-	2.4E+00	8.6E-01	4.4E-01
Gd+3	1.4E-04	5.1E-05	2.6E-05
Hg+2	4.0E-04	1.5E-04	7.5E-05
K+	1.4E-02	5.2E-03	2.7E-03
Mg+2	2.3E-02	8.4E-03	4.3E-03
Na+	1.4E-01	5.2E-02	2.7E-02
Sn+4	2.6E-03	9.4E-04	4.8E-04
U+4	2.8E-05	1.0E-05	5.2E-06
Zr+4	2.2E-01	7.9E-02	4.1E-02
H+, 4 M acid	1.2	3.0	3.5
NO3-, 4 M acid	3.6	3.9	3.9
H+, 8 M acid	4.7	6.8	7.4
NO3-, 8 M acid	7.1	7.7	7.8

Table 8. Bin Set 5 Rinse Effluent Composition Estimates ("After Retrieval" Residual Calcine Volume).

Concentrations, Mol/l

L acid/kg calcine	5	15	30
Al+3	5.6E-01	2.0E-01	1.0E-01
B+3	1.1E-01	4.1E-02	2.1E-02
Ca+2	1.2E+00	4.3E-01	2.2E-01
Cd+2	3.4E-02	1.2E-02	6.3E-03
Cl-	8.4E-03	3.0E-03	1.6E-03
Cr+3	2.8E-03	1.0E-03	5.3E-04
Fe+3	1.2E-02	4.5E-03	2.3E-03
F-	1.8E+00	6.7E-01	3.4E-01
Gd+3	2.2E-05	7.9E-06	4.1E-06
Hg+2	1.5E-03	5.6E-04	2.9E-04
K+	3.6E-02	1.3E-02	6.7E-03
Mg+2	3.9E-02	1.4E-02	7.3E-03
Mn+2	4.7E-04	1.7E-04	8.8E-05
Na+	2.9E-01	1.1E-01	5.4E-02
Nb+5	3.4E-03	1.2E-03	6.3E-04
Ni+2	2.2E-04	8.0E-05	4.1E-05
PO4-3	8.2E-05	3.0E-05	1.5E-05
Sn+4	1.7E-03	6.3E-04	3.2E-04
SO4-2	8.4E-02	3.1E-02	1.6E-02
U+4	8.1E-05	2.9E-05	1.5E-05
Zr+4	1.5E-01	5.5E-02	2.8E-02
H+, 4 M acid	1.1	3.0	3.5
NO3-, 4 M acid	3.7	3.9	3.9
H+, 8 M acid	4.6	6.8	7.4
NO3-, 8 M acid	7.2	7.7	7.9

Table 9. Bin Set 6 Rinse Effluent Composition Estimates ("After Retrieval" Residual Calcine Volume).

	Concentrations, Mol/l		
L acid/kg calcine	5	15	30
Al+3	2.6E+00	9.4E-01	4.8E-01
B+3	2.2E-02	8.1E-03	4.1E-03
Ca+2	1.3E-01	4.7E-02	2.4E-02
Cd+2	5.5E-03	2.0E-03	1.0E-03
Cl-	1.1E-02	3.9E-03	2.0E-03
Cr+3	2.7E-03	9.9E-04	5.1E-04
Fe+3	1.3E-02	4.8E-03	2.4E-03
F-	2.1E-01	7.8E-02	4.0E-02
Gd+3	1.3E-06	4.7E-07	2.4E-07
Hg+2	1.4E-03	5.1E-04	2.6E-04
K+	5.5E-02	2.0E-02	1.0E-02
Mg+2	1.7E-02	6.1E-03	3.1E-03
Mn+2	4.2E-03	1.5E-03	7.8E-04
Mo+6	2.4E-04	8.6E-05	4.4E-05
Na+	5.7E-01	2.1E-01	1.1E-01
Ni+2	1.1E-03	4.1E-04	2.1E-04
PO4-3	1.1E-02	3.9E-03	2.0E-03
Pb+2	3.9E-04	1.4E-04	7.3E-05
Sn+4	1.4E-04	5.0E-05	2.6E-05
SO4-2	5.4E-02	2.0E-02	1.0E-02
U+4	1.3E-05	4.9E-06	2.5E-06
Zr+4	2.0E-02	7.2E-03	3.7E-03
H+, 4 M acid	-1.8	1.9	2.9
NO3-, 4 M acid	3.5	3.8	3.9
H+, 8 M acid	1.7	5.7	6.8
NO3-, 8 M acid	7.0	7.7	7.8

Table 10. Estimated Radionuclide Concentrations in Bin Set 1 Flush Effluent (Alumina Calcine, "After Retrieval" Residual Calcine Volume)

L Acid/kg Calcine	**5**	**15**	**30**		**5**	**15**	**30**
	Ci/Liter	Ci/Liter	Ci/Liter		Ci/Liter	Ci/Liter	Ci/Liter
Am-241	1.0E-04	3.5E-05	1.8E-05	**U-237**	3.7E-09	1.2E-09	6.3E-10
Am-243	1.9E-09	6.6E-10	3.3E-10	**U-238**	1.1E-09	3.8E-10	1.9E-10
Cm-242	2.9E-09	9.9E-10	5.0E-10	**Ba-137m**	6.4E-01	2.2E-01	1.1E-01
Cm-244	5.8E-09	2.0E-09	9.9E-10	**Ce-144**	8.7E-21	3.0E-21	1.5E-21
Np-237	9.7E-07	3.3E-07	1.7E-07	**Cs-134**	3.5E-09	1.2E-09	6.0E-10
Pa-233	9.7E-07	3.3E-07	1.7E-07	**Cs-135**	8.9E-06	3.0E-06	1.5E-06
Pu-238	3.7E-04	1.2E-04	6.3E-05	**Cs-137**	6.8E-01	2.3E-01	1.2E-01
Pu-239	4.6E-05	1.6E-05	7.9E-06	**Eu-152**	5.8E-06	2.0E-06	9.9E-07
Pu-240	1.5E-05	5.2E-06	2.6E-06	**Eu-154**	3.1E-04	1.1E-04	5.3E-05
Pu-241	1.6E-04	5.5E-05	2.8E-05	**Eu-155**	1.9E-05	6.4E-06	3.2E-06
Pu-242	1.4E-09	4.7E-10	2.4E-10	**Pm-147**	2.5E-06	8.5E-07	4.3E-07
Th-230	9.5E-08	3.2E-08	1.6E-08	**Ru-106**	5.0E-17	1.7E-17	8.6E-18
Th-231	1.9E-08	6.6E-09	3.3E-09	**Sb-125**	1.0E-07	3.5E-08	1.8E-08
U-232	1.3E-10	4.4E-11	2.2E-11	**Sm-151**	1.4E-02	4.7E-03	2.3E-03
U-233	1.4E-10	4.6E-11	2.3E-11	**Sr-90**	6.2E-01	2.1E-01	1.1E-01
U-234	2.9E-06	9.9E-07	5.0E-07	**Tc-99**	3.5E-04	1.2E-04	6.0E-05
U-235	1.9E-08	6.6E-09	3.3E-09	**Y-90**	6.2E-01	2.1E-01	1.1E-01
U-236	4.6E-08	1.6E-08	7.9E-09	**I-129**	5.8E-07	2.0E-07	9.9E-08

Table 11. Estimated Radionuclide Concentrations in Bin Set 4 Flush Effluent (Zirconia Calcine, "After Retrieval" Residual Calcine Volume).

L Acid/kg Calcine	**5**	**15**	**30**		**5**	**15**	**30**
	Ci/Liter	Ci/Liter	Ci/Liter		Ci/Liter	Ci/Liter	Ci/Liter
Am-241	3.3E-04	1.1E-04	5.6E-05	**U-237**	3.3E-08	1.1E-08	5.6E-09
Am-243	5.6E-12	1.9E-12	9.6E-13	**U-238**	7.1E-10	2.4E-10	1.2E-10
Cm-242	7.1E-11	2.4E-11	1.2E-11	**Ba-137m**	1.8E-01	6.2E-02	3.1E-02
Cm-244	1.3E-11	4.3E-12	2.2E-12	**Co-60**	1.1E-05	3.7E-06	1.9E-06
Np-237	7.3E-08	2.5E-08	1.3E-08	**Cs-134**	5.6E-07	1.9E-07	9.6E-08
Pa-233	7.3E-08	2.5E-08	1.3E-08	**Cs-135**	3.7E-06	1.2E-06	6.3E-07
Pu-238	2.9E-03	9.9E-04	5.0E-04	**Cs-137**	1.9E-01	6.5E-02	3.3E-02
Pu-239	4.6E-05	1.6E-05	7.9E-06	**Eu-152**	9.3E-06	3.2E-06	1.6E-06
Pu-240	4.2E-05	1.4E-05	7.3E-06	**Eu-154**	7.5E-04	2.6E-04	1.3E-04
Pu-241	1.4E-03	4.6E-04	2.3E-04	**Eu-155**	1.1E-06	3.7E-07	1.9E-07
Pu-242	9.7E-08	3.3E-08	1.7E-08	**Pm-147**	1.1E-04	3.9E-05	2.0E-05
Th-230	5.6E-10	1.9E-10	9.6E-11	**Sb-125**	3.5E-06	1.2E-06	6.0E-07
Th-231	1.5E-08	5.0E-09	2.5E-09	**Sm-151**	4.2E-03	1.4E-03	7.3E-04
U-232	1.4E-10	4.9E-11	2.4E-11	**Sr-90**	2.5E-01	8.5E-02	4.3E-02
U-233	9.1E-12	3.1E-12	1.6E-12	**Tc-99**	6.0E-05	2.0E-05	1.0E-05
U-234	2.3E-06	7.9E-07	4.0E-07	**Y-90**	2.5E-01	8.5E-02	4.3E-02
U-235	1.5E-08	5.0E-09	2.5E-09	**I-129**	9.8E-08	3.4E-08	1.7E-08
U-236	3.9E-08	1.3E-08	6.6E-09				

Table 12. Estimated Radionuclide Concentrations in Bin Set 6 Flush Effluent (Sodium Bearing Waste Calcine, "After Retrieval' Residual Calcine Volume).

L Acid/kg Calcine	**5**	**15**	**30**		**5**	**15**	**30**
	Ci/Liter	Ci/Liter	Ci/Liter		Ci/Liter	Ci/Liter	Ci/Liter
Am-241	6.0E-05	2.0E-05	1.0E-05	**U-238**	2.4E-08	8.0E-09	4.0E-09
Am-243	2.4E-08	8.0E-09	4.0E-09	**Ba-137m**	4.0E-02	1.4E-02	6.8E-03
Cm-242	1.4E-08	4.6E-09	2.3E-09	**Ce-144**	6.6E-12	2.3E-12	1.1E-12
Cm-244	1.2E-06	4.0E-07	2.0E-07	**Cs-134**	3.0E-07	1.0E-07	5.1E-08
Np-237	3.3E-06	1.1E-06	5.6E-07	**Cs-135**	1.0E-06	3.4E-07	1.7E-07
Pa-233	3.3E-06	1.1E-06	5.6E-07	**Cs-137**	4.2E-02	1.4E-02	7.2E-03
Pu-238	3.8E-04	1.3E-04	6.5E-05	**Eu-152**	1.5E-06	4.9E-07	2.5E-07
Pu-239	6.1E-05	2.1E-05	1.0E-05	**Eu-154**	6.4E-05	2.2E-05	1.1E-05
Pu-240	1.2E-05	4.0E-06	2.0E-06	**Eu-155**	3.0E-05	1.0E-05	5.1E-06
Pu-241	1.5E-04	5.2E-05	2.6E-05	**Pm-147**	6.2E-06	2.1E-06	1.1E-06
Pu-242	8.9E-09	3.0E-09	1.5E-09	**Pr-144**	6.6E-12	2.3E-12	1.1E-12
Th-230	1.0E-09	3.4E-10	1.7E-10	**Ru-106**	1.4E-10	4.6E-11	2.3E-11
Th-231	2.4E-08	8.0E-09	4.0E-09	**Sb-125**	5.6E-07	1.9E-07	9.6E-08
U-232	2.1E-09	7.1E-10	3.6E-10	**Sm-151**	3.4E-04	1.2E-04	5.9E-05
U-233	2.7E-10	9.3E-11	4.7E-11	**Sr-90**	4.3E-02	1.5E-02	7.3E-03
U-234	9.1E-07	3.1E-07	1.6E-07	**Tc-99**	1.1E-05	3.7E-06	1.9E-06
U-235	2.4E-08	8.0E-09	4.0E-09	**Y-90**	4.3E-02	1.5E-02	7.3E-03
U-236	3.7E-08	1.3E-08	6.4E-09	**I-129**	9.1E-06	3.1E-06	1.6E-06
U-237	3.9E-09	1.3E-09	6.7E-10				

Table 13. Bin Set 1 Rinse Effluent Composition Estimates (Risk-Based Residual Calcine Volume).

	Concentrations, Mol/l		
L acid/kg calcine	20	50	100
Al+3	8.4E-01	3.4E-01	1.7E-01
B+3	9.5E-03	3.9E-03	1.9E-03
Fe+3	1.2E-03	4.9E-04	2.5E-04
Hg+2	6.8E-03	2.8E-03	1.4E-03
K+	8.2E-04	3.3E-04	1.7E-04
Na+	3.4E-02	1.4E-02	7.0E-03
PO4-3	1.2E-02	5.0E-03	2.5E-03
SO4-2	1.1E-02	4.4E-03	2.2E-03
H+, 4 M acid	2.6	3.4	3.7
NO3-, 4 M acid	3.9	4.0	4.0
H+, 8 M acid	6.4	7.4	7.7
NO3-, 8 M acid	7.7	7.9	7.9

Table 14. Bin Set 2 Rinse Effluent Composition Estimates (Risk-Based Residual Calcine Volume).

	Concentrations, Mol/l		
L acid/kg calcine	20	50	100
Al+3	3.4E-01	1.4E-01	7.0E-02
B+3	2.0E-02	8.2E-03	4.1E-03
Ca+2	2.8E-01	1.2E-01	5.8E-02
Cr+3	1.6E-03	6.7E-04	3.4E-04
Fe+3	7.9E-04	3.2E-04	1.6E-04
F-	5.3E-01	2.2E-01	1.1E-01
Hg+2	2.0E-03	8.3E-04	4.2E-04
K+	1.8E-03	7.5E-04	3.8E-04
Mg+2	9.4E-03	3.8E-03	1.9E-03
Na+	1.5E-02	6.1E-03	3.1E-03
PO4-3	1.2E-03	5.1E-04	2.6E-04
Sn+4	5.1E-04	2.1E-04	1.1E-04
SO4-2	2.9E-03	1.2E-03	6.0E-04
U+4	7.6E-07	3.1E-07	1.6E-07
Zr+4	4.3E-02	1.8E-02	8.9E-03
H+, 4 M acid	3.1	3.6	3.8
NO3-, 4 M acid	3.9	3.9	4.0
H+, 8 M acid	6.9	7.6	7.8
NO3-, 8 M acid	7.7	7.9	7.9

Table 15. Bin Set 3 Rinse Effluent Composition Estimates (Risk-Based Residual Calcine Volume).

	Concentrations, Mol/l		
L acid/kg calcine	20	50	100
Al+3	1.6E-01	6.7E-02	3.4E-02
B+3	2.8E-02	1.1E-02	5.7E-03
Ca+2	3.6E-01	1.5E-01	7.4E-02
Cl-	5.1E-04	2.1E-04	1.1E-04
Cr+3	2.9E-03	1.2E-03	5.9E-04
Fe+3	1.5E-03	6.2E-04	3.1E-04
F-	6.3E-01	2.6E-01	1.3E-01
Gd+3	5.6E-06	2.3E-06	1.2E-06
Hg+2	1.3E-04	5.2E-05	2.6E-05
K+	2.3E-03	9.3E-04	4.7E-04
Mg+2	1.7E-02	6.9E-03	3.5E-03
Mn+2	6.8E-05	2.8E-05	1.4E-05
Na+	2.1E-02	8.5E-03	4.3E-03
Ni+2	2.1E-05	8.7E-06	4.4E-06
PO4-3	5.0E-03	2.1E-03	1.0E-03
Sn+4	6.9E-04	2.8E-04	1.4E-04
SO4-2	3.1E-03	1.2E-03	6.3E-04
U+4	1.5E-06	6.1E-07	3.1E-07
Zr+4	5.8E-02	2.4E-02	1.2E-02
H+, 4 M acid	3.2	3.7	3.8
NO3-, 4 M acid	3.9	4.0	4.0
H+, 8 M acid	7.1	7.6	7.8
NO3-, 8 M acid	7.7	7.9	7.9

Table 16. Bin Set 4 Rinse Effluent Composition Estimates (Risk-Based Residual Calcine Volume).

	Concentrations, Mol/l		
L acid/kg calcine	20	50	100
Al+3	1.4E-01	5.7E-02	2.9E-02
B+3	3.3E-02	1.3E-02	6.7E-03
Ca+2	3.7E-01	1.5E-01	7.6E-02
Cl-	1.4E-03	5.8E-04	2.9E-04
Cr+3	2.4E-03	9.8E-04	4.9E-04
Fe+3	3.2E-03	1.3E-03	6.5E-04
F-	6.5E-01	2.7E-01	1.3E-01
Gd+3	3.8E-05	1.6E-05	7.9E-06
Hg+2	1.1E-04	4.6E-05	2.3E-05
K+	3.9E-03	1.6E-03	8.1E-04
Mg+2	6.4E-03	2.6E-03	1.3E-03
Na+	4.0E-02	1.6E-02	8.2E-03
Sn+4	7.1E-04	2.9E-04	1.5E-04
U+4	7.7E-06	3.2E-06	1.6E-06
Zr+4	6.0E-02	2.5E-02	1.2E-02
H+, 4 M acid	3.2	3.7	3.8
NO3-, 4 M acid	3.9	4.0	4.0
H+, 8 M acid	7.1	7.6	7.8
NO3-, 8 M acid	7.8	7.9	7.9

Table 17. Bin Set 5 Rinse Effluent Composition Estimates (Risk-Based Residual Calcine Volume).

	Concentrations, Mol/l		
L acid/kg calcine	20	50	100
Al+3	1.5E-01	6.3E-02	3.2E-02
B+3	3.1E-02	1.3E-02	6.4E-03
Ca+2	3.2E-01	1.3E-01	6.6E-02
Cd+2	9.4E-03	3.8E-03	1.9E-03
Cl-	2.3E-03	9.4E-04	4.8E-04
Cr+3	7.8E-04	3.2E-04	1.6E-04
Fe+3	3.4E-03	1.4E-03	7.1E-04
F-	5.1E-01	2.1E-01	1.0E-01
Gd+3	6.0E-06	2.5E-06	1.2E-06
Hg+2	4.3E-04	1.7E-04	8.8E-05
K+	9.9E-03	4.0E-03	2.0E-03
Mg+2	1.1E-02	4.4E-03	2.2E-03
Mn+2	1.3E-04	5.3E-05	2.7E-05
Na+	8.1E-02	3.3E-02	1.7E-02
Nb+5	9.3E-04	3.8E-04	1.9E-04
Ni+2	6.0E-05	2.5E-05	1.2E-05
PO4-3	2.3E-05	9.3E-06	4.7E-06
Sn+4	4.8E-04	2.0E-04	9.9E-05
SO4-2	2.3E-02	9.5E-03	4.8E-03
U+4	2.2E-05	9.1E-06	4.6E-06
Zr+4	4.2E-02	1.7E-02	8.6E-03
H+, 4 M acid	3.2	3.7	3.8
NO3-, 4 M acid	3.9	4.0	4.0
H+, 8 M acid	7.1	7.6	7.8
NO3-, 8 M acid	7.8	7.9	8.0

Table 18. Bin Set 6 Rinse Effluent Composition Estimates (Risk-Based Residual Calcine Volume).

	Concentrations, Mol/l		
L acid/kg calcine	20	50	100
Al+3	7.1E-01	2.9E-01	1.5E-01
B+3	6.1E-03	2.5E-03	1.3E-03
Ca+2	3.6E-02	1.5E-02	7.3E-03
Cd+2	1.5E-03	6.2E-04	3.1E-04
Cl-	3.0E-03	1.2E-03	6.1E-04
Cr+3	7.5E-04	3.1E-04	1.6E-04
Fe+3	3.6E-03	1.5E-03	7.4E-04
F-	5.9E-02	2.4E-02	1.2E-02
Gd+3	3.6E-07	1.5E-07	7.3E-08
Hg+2	3.8E-04	1.6E-04	7.9E-05
K+	1.5E-02	6.2E-03	3.1E-03
Mg+2	4.6E-03	1.9E-03	9.6E-04
Mn+2	1.2E-03	4.7E-04	2.4E-04
Mo+6	6.5E-05	2.7E-05	1.3E-05
Na+	1.6E-01	6.4E-02	3.2E-02
Ni+2	3.1E-04	1.3E-04	6.4E-05
PO4-3	3.0E-03	1.2E-03	6.1E-04
Pb+2	1.1E-04	4.4E-05	2.2E-05
Sn+4	3.8E-05	1.5E-05	7.8E-06
SO4-2	1.5E-02	6.1E-03	3.1E-03
U+4	3.7E-06	1.5E-06	7.6E-07
Zr+4	5.5E-03	2.2E-03	1.1E-03
H+, 4 M acid	2.4	3.3	3.7
NO3-, 4 M acid	3.9	3.9	4.0
H+, 8 M acid	6.2	7.3	7.6
NO3-, 8 M acid	7.7	7.9	7.9

Table 19. Estimated Radionuclide Concentrations in Bin Set 1 Flush Effluent (Alumina Calcine, Risk-Based Residual Calcine Volume)

L Acid/kg Calcine	**20**	**50**	**100**		**20**	**50**	**100**
	Ci/Liter	Ci/Liter	Ci/Liter		Ci/Liter	Ci/Liter	Ci/Liter
Am-241	2.6E-05	1.1E-05	5.4E-06	**U-237**	9.2E-10	3.7E-10	1.9E-10
Am-243	4.8E-10	2.0E-10	9.9E-11	**U-238**	2.8E-10	1.1E-10	5.8E-11
Cm-242	7.2E-10	3.0E-10	1.5E-10	**Ba-137m**	1.6E-01	6.5E-02	3.3E-02
Cm-244	1.4E-09	5.9E-10	3.0E-10	**Ce-144**	2.2E-21	8.9E-22	4.5E-22
Np-237	2.4E-07	9.9E-08	5.0E-08	**Cs-134**	8.7E-10	3.5E-10	1.8E-10
Pa-233	2.4E-07	9.9E-08	5.0E-08	**Cs-135**	2.2E-06	9.1E-07	4.6E-07
Pu-238	9.2E-05	3.7E-05	1.9E-05	**Cs-137**	1.7E-01	6.9E-02	3.5E-02
Pu-239	1.2E-05	4.7E-06	2.4E-06	**Eu-152**	1.4E-06	5.9E-07	3.0E-07
Pu-240	3.8E-06	1.6E-06	7.8E-07	**Eu-154**	7.7E-05	3.2E-05	1.6E-05
Pu-241	4.1E-05	1.7E-05	8.3E-06	**Eu-155**	4.7E-06	1.9E-06	9.6E-07
Pu-242	3.5E-10	1.4E-10	7.1E-11	**Pm-147**	6.3E-07	2.6E-07	1.3E-07
Th-230	2.4E-08	9.7E-09	4.9E-09	**Ru-106**	1.3E-17	5.1E-18	2.6E-18
Th-231	4.8E-09	2.0E-09	9.9E-10	**Sb-125**	2.6E-08	1.0E-08	5.3E-09
U-232	3.2E-11	1.3E-11	6.7E-12	**Sm-151**	3.4E-03	1.4E-03	7.0E-04
U-233	3.4E-11	1.4E-11	7.0E-12	**Sr-90**	1.5E-01	6.3E-02	3.2E-02
U-234	7.2E-07	3.0E-07	1.5E-07	**Tc-99**	8.7E-05	3.5E-05	1.8E-05
U-235	4.8E-09	2.0E-09	9.9E-10	**Y-90**	1.5E-01	6.3E-02	3.2E-02
U-236	1.2E-08	4.7E-09	2.4E-09	**I-129**	1.4E-07	5.9E-08	3.0E-08

Table 20. Estimated Radionuclide Concentrations in Bin Set 4 Flush Effluent (Zirconia Calcine, Risk-Based Residual Calcine Volume).

L Acid/kg Calcine	**20**	**50**	**100**		**20**	**50**	**100**
	Ci/Liter	Ci/Liter	Ci/Liter		Ci/Liter	Ci/Liter	Ci/Liter
Am-241	8.2E-05	3.4E-05	1.7E-05	**U-237**	8.2E-09	3.4E-09	1.7E-09
Am-243	1.4E-12	5.7E-13	2.9E-13	**U-238**	1.8E-10	7.3E-11	3.7E-11
Cm-242	1.8E-11	7.3E-12	3.7E-12	**Ba-137m**	4.5E-02	1.9E-02	9.3E-03
Cm-244	3.1E-12	1.3E-12	6.5E-13	**Co-60**	2.8E-06	1.1E-06	5.7E-07
Np-237	1.8E-08	7.5E-09	3.8E-09	**Cs-134**	1.4E-07	5.7E-08	2.9E-08
Pa-233	1.8E-08	7.5E-09	3.8E-09	**Cs-135**	9.2E-07	3.7E-07	1.9E-07
Pu-238	7.2E-04	3.0E-04	1.5E-04	**Cs-137**	4.8E-02	2.0E-02	9.8E-03
Pu-239	1.2E-05	4.7E-06	2.4E-06	**Eu-152**	2.3E-06	9.5E-07	4.8E-07
Pu-240	1.1E-05	4.3E-06	2.2E-06	**Eu-154**	1.9E-04	7.7E-05	3.9E-05
Pu-241	3.4E-04	1.4E-04	7.0E-05	**Eu-155**	2.7E-07	1.1E-07	5.6E-08
Pu-242	2.4E-08	9.9E-09	5.0E-09	**Pm-147**	2.8E-05	1.2E-05	5.9E-06
Th-230	1.4E-10	5.7E-11	2.9E-11	**Sb-125**	8.7E-07	3.5E-07	1.8E-07
Th-231	3.7E-09	1.5E-09	7.5E-10	**Sm-151**	1.1E-03	4.3E-04	2.2E-04
U-232	3.6E-11	1.5E-11	7.3E-12	**Sr-90**	6.3E-02	2.6E-02	1.3E-02
U-233	2.3E-12	9.3E-13	4.7E-13	**Tc-99**	1.5E-05	6.1E-06	3.1E-06
U-234	5.8E-07	2.4E-07	1.2E-07	**Y-90**	6.3E-02	2.6E-02	1.3E-02
U-235	3.7E-09	1.5E-09	7.5E-10	**I-129**	2.5E-08	1.0E-08	5.1E-09
U-236	9.7E-09	3.9E-09	2.0E-09				

Table 21. Estimated Radionuclide Concentrations in Bin Set 6 Flush Effluent (Sodium Bearing Waste Calcine, Risk-Based Residual Calcine Volume).

L Acid/kg Calcine	**20**	**50**	**100**		**20**	**50**	**100**
	Ci/Liter	Ci/Liter	Ci/Liter		Ci/Liter	Ci/Liter	Ci/Liter
Am-241	1.5E-05	6.1E-06	3.1E-06	**U-238**	5.9E-09	2.4E-09	1.2E-09
Am-243	5.9E-09	2.4E-09	1.2E-09	**Ba-137m**	1.0E-02	4.1E-03	2.1E-03
Cm-242	3.4E-09	1.4E-09	7.0E-10	**Ce-144**	1.7E-12	6.8E-13	3.4E-13
Cm-244	2.9E-07	1.2E-07	6.1E-08	**Cs-134**	7.5E-08	3.1E-08	1.5E-08
Np-237	8.2E-07	3.3E-07	1.7E-07	**Cs-135**	2.5E-07	1.0E-07	5.1E-08
Pa-233	8.2E-07	3.3E-07	1.7E-07	**Cs-137**	1.0E-02	4.3E-03	2.1E-03
Pu-238	9.5E-05	3.9E-05	2.0E-05	**Eu-152**	3.6E-07	1.5E-07	7.5E-08
Pu-239	1.5E-05	6.2E-06	3.1E-06	**Eu-154**	1.6E-05	6.5E-06	3.3E-06
Pu-240	2.9E-06	1.2E-06	6.1E-07	**Eu-155**	7.5E-06	3.1E-06	1.5E-06
Pu-241	3.9E-05	1.6E-05	7.9E-06	**Pm-147**	1.5E-06	6.3E-07	3.2E-07
Pu-242	2.2E-09	9.1E-10	4.6E-10	**Pr-144**	1.7E-12	6.8E-13	3.4E-13
Th-230	2.5E-10	1.0E-10	5.1E-11	**Ru-106**	3.4E-11	1.4E-11	7.0E-12
Th-231	5.9E-09	2.4E-09	1.2E-09	**Sb-125**	1.4E-07	5.7E-08	2.9E-08
U-232	5.2E-10	2.1E-10	1.1E-10	**Sm-151**	8.6E-05	3.5E-05	1.8E-05
U-233	6.8E-11	2.8E-11	1.4E-11	**Sr-90**	1.1E-02	4.4E-03	2.2E-03
U-234	2.3E-07	9.3E-08	4.7E-08	**Tc-99**	2.7E-06	1.1E-06	5.6E-07
U-235	5.9E-09	2.4E-09	1.2E-09	**Y-90**	1.1E-02	4.4E-03	2.2E-03
U-236	9.3E-09	3.8E-09	1.9E-09	**I-129**	2.3E-06	9.3E-07	4.7E-07
U-237	9.8E-10	4.0E-10	2.0E-10				

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ENGINEERING DESIGN FILE

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Project File Number 015720

Project/Task Bin Set Closure Study

Subtask Estimated Radionuclide Release Rates

Title: CSSF Radionuclide Release Rates

Summary:

The following identifies the amount or radioactive contamination expected to be released during the closure of the bin sets. The release rate, in Ci/yr, were determined for each of the closure options. The contaminant sources used for this analysis are based on inventories reported in the Waste Inventories/Characterization Study (Garcia 1997). Conservative assumptions were made based on the four different closure options that have been proposed for the deactivation of the facility. The results show that the release rate for the two options where the walls will be cleaned is 1.2E+00 Ci/yr. The release rate for the two options where wall cleaning is not done is 7.2E-02 Ci/y. Attached are the assumptions and calculations that were performed to reach these conclusions.

Distribution (complete package): M. M. Dahlmeir, R. A. Gavalya, D. J. Harrell, B. R. Helm,
B. C. Spaulding, LMITCO; WTP EIS Studies Library, Bin Set Closure Library

Distribution (summary package only):

Author I. E. Stepan	Dept. 3170 1/14/98	Reviewed R. G. Peatross	Date 1/14/98 1/14/98	Approved	Date 1/29/98
		LMITCO Review Rick A. George	Date 1.29.98	LMITCO Approval	Date

The following assumptions were made in developing the Bin Set source term:

- It is assumed that 5% of the calcine remains in the bins before the closure operations begin.
- The inventories from the Waste Inventories/Characterization Study (Garcia 1997) were used as a basis for the source term.
- Only data for Bin Sets 1 through 6 are included in the referenced study (Garcia 1997). Bin Set 7 will be assumed to have the same source term as that of Bin Set 6.
- An offgas system containing at least 1 HEPA filter will be in place to remove 99% of any material which may be released via the airborne pathway.
- It is assumed 10% of the material becomes airborne during the bin set wall cleaning activity.
- It is assumed that 0.2% of the calcine becomes airborne during the grouting operations.

Shown in Table 1 is the total activity (Ci) in each of the bin sets. This data was derived from Table 1 from the Waste Inventories/Characterization Study (Garcia 1997). Five percent of the total calcine is assumed to remain in the bins before the closure operations begin. These values are given in the second column of Table 2. The amount of material on the bin walls was obtained from EDF-BSC-001 and is listed in the third column of Table 2.

Two different release rates are calculated for the bin set closure options. One release rate for the two options where the cleaning of the bin walls is included, and one release rate for the two options where the bin walls are not cleaned. During the cleaning operations it is assumed that 10% of the material becomes airborne. This is a conservative value since the cleaning is going to be done with CO_2. CO_2 is heavier than air it will force any material coming off the walls of the bins to drop to the bottom. 95% of the material on the wall is assumed to be removed. During grouting operations, as with the Tank Farm it is assumed that a 0.2 % of the material becomes airborne and is released. Again, only 1% of all airborne material released will be released to the atmosphere because it first goes through a HEPA filter where 99% of the airborne material will be removed. Multiplying the total amount of each radionuclide in the bin set bottoms by the release fraction (0.002) and the HEPA fraction (0.01) and adding this value to the 1% release during the cleaning operations (99% of which is also removed by the HEPA filter) yields the amount released to the atmosphere during the cleaning and grouting operations. These values are listed in the fourth column in Table 2. Finally, it is assumed that the cleaning and grouting operations for all 7 bin sets will occur over a span of 14 years. Therefore, the yearly release rate of material is found by dividing this number into the amount of material released. The release rates for the two options including wall cleaning are given in the fifth column of Table 5 with the total release rate being 1.23E+00 Ci/yr.

For the other two options (no bin wall cleaning) the total release is found by multiplying the total amount of each radionuclide in the bin set bottoms by the release fraction (0.002) and the HEPA fraction (0.01). These values are listed in the sixth column in Table 2. Again, it is assumed that the grouting operations for all 7 bin sets will occur over a span of 14 years. Therefore, the yearly release rate of material is found by dividing this number into the amount of material released. The release rates for the two options excluding wall cleaning are given in the last column of Table 2 with the total release rate being 7.20E-02 Ci/yr.

Table 1. Total curies contained in the bin sets[a].

Contaminant	Bin 1	Bin 2	Bin 3	Bin 4	Bin 5	Bin 6	Bin 7	Total
Am-241	2.21E+02	4.52E+02	3.67E+02	1.67E+02	3.89E+02	3.64E+02	3.64E+02	2.32E+03
Am-243	2.02E+00	4.12E+00	3.35E+00	1.52E+00	3.54E+00	3.32E+00	3.32E+00	2.12E+01
Ce-144	0.00E+00	0.00E+00	0.00E+00	1.50E+01	2.78E-01	2.99E+01	2.99E+01	7.51E+01
Cm-242	1.58E+02	3.23E+02	2.62E+02	1.19E+02	2.78E+02	2.60E+02	2.60E+02	1.66E+03
Cm-244	1.26E+02	2.58E+02	2.10E+02	9.55E+01	2.22E+02	2.08E+02	2.08E+02	1.33E+03
Cs-134	1.32E+00	2.63E+00	1.53E+02	4.22E+02	1.22E+03	2.82E+03	2.82E+03	7.43E+03
Cs-137	1.04E+06	2.31E+06	2.45E+06	1.38E+06	2.08E+06	4.05E+05	4.05E+05	1.01E+07
Eu-154	2.23E+03	5.52E+03	5.04E+03	1.13E+04	2.15E+04	7.48E+03	7.48E+03	6.06E+04
Eu-155	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.99E+04	2.25E+02	2.25E+02	2.03E+04
Np-237	8.62E-01	1.76E+00	1.43E+00	1.30E-01	1.52E+00	1.42E+00	1.42E+00	8.54E+00
Pm-147	7.77E+01	1.55E+02	1.10E+03	6.94E+03	4.29E+03	0.00E+00	0.00E+00	1.26E+04
Pu-238	1.70E+04	3.48E+04	2.82E+04	1.29E+04	2.99E+04	2.80E+04	2.80E+04	1.79E+05
Pu-239	1.70E+02	3.48E+02	2.82E+02	1.29E+02	2.99E+02	2.80E+02	2.80E+02	1.79E+03
Pu-240	1.58E+02	3.23E+02	2.62E+02	1.19E+02	2.78E+02	2.60E+02	2.60E+02	1.66E+03
Pu-241	3.89E+04	7.95E+04	6.45E+04	2.94E+04	6.83E+04	6.40E+04	6.40E+04	4.09E+05
Pu-242	4.37E-01	8.95E-01	7.26E-01	3.30E-01	7.69E-01	7.20E-01	7.20E-01	4.60E+00
Ru-106	0.00E+00	0.00E+00	1.52E-02	1.23E-01	6.80E-01	2.40E+01	2.40E+01	4.89E+01
Sb-125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.58E+01	7.86E+01	7.86E+01	2.03E+02
Sr-90	9.54E+05	2.07E+06	2.27E+06	1.35E+06	1.96E+06	3.89E+05	3.89E+05	9.39E+06
U-233	2.91E-07	5.96E-07	4.84E-07	2.20E-07	5.12E-07	4.80E-07	4.80E-07	3.06E-06
U-234	2.72E+00	1.29E+01	1.81E+01	6.09E+00	1.60E+01	1.49E+01	1.49E+01	8.57E+01
U-235	1.90E-02	8.99E-02	1.27E-01	3.43E-02	1.11E-01	1.04E-01	1.04E-01	5.90E-01
U-236	4.42E-02	2.09E-01	2.95E-01	9.77E-02	2.59E-01	2.43E-01	2.43E-01	1.39E+00
U-237	5.36E-07	2.54E-06	3.57E-06	1.61E-06	3.14E-06	2.94E-06	2.94E-06	1.73E-05
U-238	1.08E-03	5.09E-03	7.16E-03	1.94E-03	6.30E-03	5.90E-03	5.90E-03	3.34E-02

a. This is the total inventory assuming 5% of the calcine remains in the bins.

Table 2. Release rates of radionuclides from the bin sets.[a]

Contaminant	Bin Bottoms (Ci)	Bin Walls (Ci)	Release[b] (Ci)	Release Rate[b] (Ci/yr)	Release[c] (Ci)	Release Rate[c] (Ci/yr)
Am-241	1.16E+02	2.18E+00	1.86E-03	1.33E-04	1.16E-04	8.30E-06
Am-243	1.06E+00	1.99E-02	1.70E-05	1.21E-06	1.06E-06	7.57E-08
Ce-144	3.76E+00	5.97E-02	5.15E-05	3.68E-06	3.76E-06	2.68E-07
Cm-242	8.30E+01	1.56E+00	1.33E-03	9.51E-05	8.30E-05	5.93E-06
Cm-244	6.64E+01	1.25E+00	1.07E-03	7.61E-05	6.64E-05	4.74E-06
Cs-134	3.72E+02	6.49E+00	5.57E-03	3.98E-04	3.72E-04	2.65E-05
Cs-137	5.03E+05	1.01E+04	8.58E+00	6.13E-01	5.03E-01	3.60E-02
Eu-154	3.03E+03	6.38E+01	5.41E-02	3.86E-03	3.03E-03	2.16E-04
Eu-155	1.02E+03	2.82E+01	2.36E-02	1.68E-03	1.02E-03	7.26E-05
Np-237	4.27E-01	8.02E-03	6.85E-06	4.89E-07	4.27E-07	3.05E-08
Pm-147	6.28E+02	1.39E+01	1.18E-02	8.41E-04	6.28E-04	4.49E-05
Pu-238	8.94E+03	1.68E+02	1.43E-01	1.02E-02	8.94E-03	6.38E-04
Pu-239	8.94E+01	1.68E+00	1.43E-03	1.02E-04	8.94E-05	6.38E-06
Pu-240	8.30E+01	1.56E+00	1.33E-03	9.51E-05	8.30E-05	5.93E-06
Pu-241	2.04E+04	3.84E+02	3.28E-01	2.34E-02	2.04E-02	1.46E-03
Pu-242	2.30E-01	4.32E-03	3.69E-06	2.63E-07	2.30E-07	1.64E-08
Ru-106	2.44E+00	3.71E-02	3.22E-05	2.30E-06	2.44E-06	1.75E-07
Sb-125	1.01E+01	1.82E-01	1.56E-04	1.11E-05	1.01E-05	7.25E-07
Sr-90	4.70E+05	9.42E+03	8.01E+00	5.72E-01	4.70E-01	3.35E-02
U-233	1.53E-07	2.88E-09	2.46E-12	1.76E-13	1.53E-13	1.09E-14
U-234	4.28E+00	8.18E-02	6.97E-05	4.98E-06	4.28E-06	3.06E-07
U-235	2.95E-02	5.63E-04	4.80E-07	3.43E-08	2.95E-08	2.11E-09
U-236	6.95E-02	1.33E-03	1.13E-06	8.09E-08	6.95E-08	4.97E-09
U-237	8.64E-07	1.65E-08	1.41E-11	1.00E-12	8.64E-13	6.17E-14
U-238	1.67E-03	3.19E-05	2.72E-08	1.94E-09	1.67E-09	1.19E-10
Total	[redacted]	[redacted]	1.72E+01	1.23E+00	1.01E+00	7.20E-02

a. These results based on 5% of the calcine remaining the bins before closure.
b. Data for options which include cleaning off the bin set walls.
c. Data for options which do not include cleaning off the bin set walls.

EDF-BSC-014

CANCELLED

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ENGINEERING DESIGN FILE

Form L-0431.2#
(05-96-Rev.#02)

Project File Number 015720

EDF Serial Number EDF-BSC-015

Functional File Number C-04

Project/Task ICPP Bin Set Closure Feasibility Study

Sub task Methodology for CSSF Radiation Calculations

TITLE: Methodology for CSSF Radiation Calculations

SUMMARY

This Engineering Design File presents the methodology that will be utilized for estimating personnel exposure during closure activities at the Calcined Solids Storage Facility (CSSF).

Calculations for personnel exposure will be accomplished by using the man-hours that have been estimated for retrieval activities in the Calcined Solids Storage Facility Closure Study Cost Estimate. The man-hours will be multiplied by a correction factor of .3 (30%) to adjust the total time estimated for a task to the actual time spent in the exposure areas.

An initial dose rate of 25 mrem/hr will be assumed for exposure to personnel while working above a bin set and around grouting equipment. It is assumed that the transfer lines and equipment can be shielded to this predetermined level. The primary source of the radiation exposure will be due to open risers, piping containing calcine residue, and transfer piping for grout delivery. A set dose rate of .5 mrem/hr will be assumed for exposure due to background radiation; this is a conservative estimate and is used for bounding purposes.

Using the adjusted man-hours required to complete a task, along with the initial set dose rate, the number of personnel required to complete the activities can be estimated (based on the allowable INEEL occupational dose rate of 1,000 mrem/year). Should the number of required personnel be too high, additional shielding may be added to lower the dose rate. Considerations will be made for structural integrity of the bin sets.

Structural considerations may limit the amount of shielding that can be installed on the bins. As such, to limit personnel yearly exposure, additional personnel may be added to help distribute the exposure.

This methodology is an iterative process and will require further investigation.

Distribution: D. J. Harrell, MS 3211; B. R. Helm, MS 3765; B. C. Spaulding, MS 3765; G. C. McCoy, MS 5209; M. M. Dahlmeir, MS 3765; S. P. Swanson, MS 3765; Project File (Original +1)

Authors	Department	Reviewed	Approved
Steven Swanson		G.C McCoy	
S. P. Swanson	MC&IE/4130	Date 2/2/98	Date 2/2/98

INEL Idaho National Engineering Laboratory

ENGINEERING DESIGN FILE

Form L-0431.2#
(05-96-Rev.#02)

Project File Number 015720
EDF Serial Number EDF-BSC-016
Functional File Number CB-02

Project/Task Bin Set Closure Study
Sub task Cost Estimates

TITLE: Cost Estimate for RBCC; NRC Class A Landfill

SUMMARY

Cost estimates were prepared for closing the Calcined Solids Storage Facility to either Risk-Based Clean Closure (RBCC) or Closure to Landfill Standards (CLFS) and subsequently filling the bin voids with Class A type waste. These cost estimates are attached to this Engineering Design File (EDF). Further analysis has shown, however, that the radionuclide concentrations in the bins following CLFS and subsequently filling the bin voids with Class A grout would exceed the Class A concentration limits. The concentration limits were also exceeded assuming three iterative decontamination cycles in RBCC. The original cost estimates for RBCC with a Class A fill included only three decontamination cycles.

This EDF was thus prepared to estimate the cost to close the CSSF to RBCC (with additional decontamination cycles) and subsequently fill the bin voids with Class A type waste. If it is determined that creating an NRC Class A landfill following RBCC is a viable option, these cost estimates should be analyzed further, as rough estimates were done to account for the increasing difficulty in cleaning the bins.

The estimated costs are summarized below:

Activity	Unescalated Cost	Escalated Cost
Regulatory Compliance	$ 19.5M	$ 31.6M
Fill Vaults with Clean Grout	12.4M	23.3M
Clean Bins with Robots		
Floor	216.1M	421.4M
Walls	34.6M	65.7M
Piping	16.6M	33.5M
Fill Bins with NRC Class A Grout	23.7M	51.9M
D & D of Equipment	17.0M	50.6M
Total	$339.9M	$678.0M

These estimates are based on 13 additional decontamination cycles for the walls and pipes, and 6 additional decontamination cycles for the floor.

Distribution: B. C. Spaulding, MS 3765; B. R. Helm, MS 3765; D. J. Harrell, MS 3211; M. M. Dahlmeir, MS 3765; Project File (Original + 1)

Authors Department	Reviewed	Approved
2-4-98		
M. M. Dahlmeir **MC&IE/4130**	Date 2/4/98	Date 2/4/98

The following discussion presents the methodology by which the final cost for RBCC; NRC Class A Landfill, can be estimated based on the original cost estimate.

In order to determine the added costs due to the additional decontamination cycles required, it is assumed that the percent of calcine removed during each decontamination cycle, or pass, is consistent. In addition, it is assumed the cost of each pass will not increase as the total volume of calcine remaining decreases.

The additional number of cleaning passes needed for Bin Set 1 to meet Class A concentration limits will be calculated, as this Bin Set represents the worst case scenario[1] in regards to the level of cleanliness required to meet Class A concentration limits. The number of passes required for Bin Set 1 will thus be used for all of the Bin Sets.

Note: The following calculations are approximations. Volumes have been rounded to the nearest whole number, and the cleaning of the walls, pipes, and floors is considered independently. During actual cleaning operations, the bin walls would be cleaned first, which would result in additional calcine falling to the floor.

Derive the formula for calculating the fraction of calcine removed from the bins per pass:

(1) $V_o (1 - X) = V_1$ Where: V_o = Original volume of calcine in bin

V_1 = Calcine volume remaining following first pass

X = Fraction of volume removed per pass

(2) $V_1 (1 - X) = V_2$ V_2 = Calcine volume remaining following second pass

(2a) $V_1 = V_2/(1-X)$

Substitute Equation 2a for V_1 in Equation 1

(3) $V_o (1 - X) = V_2/(1-X)$

(3a) $V_o (1 - X)^2 = V_2$

(4) $V_2 (1 - X) = V_3$ V_3 = Calcine volume remaining following third pass

Substitute Equation 3a into Equation 4 for V_2

(5) $V_3 = V_o (1 - X)^2 (1 - X)$

(5a) $V_3 = V_o (1 - X)^3$

(5b) $V_3/V_o = (1 - X)^3$

Substitute "i" for "3" in Equation 5b to make a general equation

(5c) $V_i/V_o = (1 - X)^i$

Calculate the volume of calcine removed from the walls and pipes per pass assuming 80% removal after 3 passes[a]:

Using Equation 5b, and substituting "X_{wall}" for "X", where X_{wall} is the percent volume removed from the walls and pipes per pass, solve for X_{wall}:

$V_3/V_o = (1 - X_{wall})^3$ $\qquad$ $V_3 = 20\%$ of $V_0{}^b = 0.20\ V_o$

$$\frac{0.20\ V_o}{V_o} = (1 - X_{wall})^3$$

$0.20 = (1 - X_{wall})^3$

$(0.20)^{1/3} = 1 - X_{wall}$

$X_{wall} = 1 - (0.20)^{1/3} = 0.42$, or 42%

Calculate the number of passes required to clean the walls of Bin Set 1 sufficiently to meet Class A concentration limits when filled with Class A grout:

Using Equation 5c, substitute "P_{wall}" for "i", X_{wall} for X, and V_{ow} for V_o, where P_{wall} represents the number of passes required to clean the walls and pipes sufficiently to meet the Class A concentration limits, X_{wall} represents the fraction of calcine removed from the walls each pass (calculated above), and V_{ow} represents the original volume of calcine on the walls, solve for P_{wall}:

$V_i/V_{ow} = (1 - X_{wall})^i$

$V_{Pwall}/V_{ow} = (1 - X_{wall})^{Pwall}$

$V_{Pwall} = V_{ow}\ (1 - X_{wall})^{Pwall}$

$V_{Pwall}/V_{ow} = (1 - X_{wall})^{Pwall}$

$\mathrm{Log}\ (V_{Pwall}/V_{ow}) = P_{wall} \log (1 - X_{wall})$

$P_{wall} = [\mathrm{Log}\ (V_{Pwall}/V_{ow})]/[\log (1 - X_{wall})]$ $\qquad$ V_{ow} = Original calcine volume on walls

= 50.8 cubic feet[2]

V_{Pwall} = Final calcine volume on walls and pipes

= 12% of 0.086 cubic feet[c] = 0.01 cubic feet

$P_{wall} = [\mathrm{Log}\ (0.01/50.8)]/[\log (1 - 0.42)]$

$P_{wall} = 15.7 = 16$ passes required to clean the walls and pipes sufficiently for Class A limits

---

[a] It has been assumed that 80% of the calcine remaining on the walls of the bins following CRTP will be removed by the LDUA during RBCC[2]. It is assumed that a minimum of three decontamination cycles will be required to meet RBCC. For the purposes of these calculations, it is thus assumed that three decontamination cycles will remove 80% of the calcine remaining on the walls of the bins following CRTP.

[b] It has been assumed that 80% of the calcine would be removed from the walls following three decontamination cycles[2]. It follows that the volume remaining after three decontamination cycles would be 20% of the original volume of calcine on the walls.

[c] It is assumed that because 12% of the residual calcine volume following CRTP is on the walls, the wall should account for 12% of the final volume allowed to remain in the Bin Set and still meet Class A concentration limits, or 12% of 0.086 cubic feet[1, 2].

Calculate the volume of calcine removed from the floor per pass assuming 95% removal after 3 passes[a]:

Using Equation 5b, and substituting "X_{floor}" for "X", where X_{floor} is the percent volume removed from the floors per pass, solve for X_{floor}:

$V_3/V_o = (1 - X_{floor})^3$ $\qquad$ $V_3 = 5\%$ of $V_0^{b} = 0.05\ V_o$

$$\frac{0.05\ V_o}{V_o} = (1 - X_{floor})^3$$

$0.05 = (1 - X_{floor})^3$

$(0.05)^{1/3} = 1 - X_{floor}$

$X_{floor} = 1 - (0.05)^{1/3} = 0.63 = 63\%$

Calculate the number of passes required to clean the floors of Bin Set 1 sufficiently to meet Class A concentration limits when filled with Class A grout:

Using Equation 5c, substitute "P_{floor}" for "i", X_{floor} for X, and V_{of} for V_o, where P_{floor} represents the number of passes required to clean the floors sufficiently to meet the Class A concentration limits, X_{floor} represents the fraction of calcine removed from the floors each pass (calculated above), and V_{of} represents the original volume of calcine on the floors, solve for P_{floor}:

$V_i/V_{of} = (1 - X_{floor})^i$

$V_{Pfloor}/V_{of} = (1 - X_{floor})^{Pfloor}$

$V_{Pfloor} = V_{of}(1 - X_{floor})^{Pfloor}$

$V_{Pfloor}/V_{of} = (1 - X_{floor})^{Pfloor}$

$\text{Log}(V_{Pfloor}/V_{of}) = P_{floor} \log(1 - X_{floor})$

$P_{floor} = [\text{Log}(V_{Pfloor}/V_{of})]/[\log(1 - X_{floor})]$ $\qquad$ V_{of} = Original calcine volume on floors
= 392.2 cubic feet[2]

V_{Pfloor} = Final calcine volume on floors
= 88% of 0.086 cubic feet[c] = 0.076 cubic feet

$P_{floor} = [\text{Log}(0.076/392.2)]/[\log(1 - 0.63)]$

$P_{floor} = 8.6 = 9$ passes required to clean the floors sufficiently for Class A limits

---

[a] It has been assumed that 95% of the calcine remaining on the floor of the bins following CRTP will be removed by the tractor robot during RBCC. It is assumed that a minimum of three decontamination cycles will be required to meet RBCC[2]. For the purposes of these calculations, it is thus assumed that three decontamination cycles will remove 95% of the calcine remaining on the floor of the bins following CRTP.

[b] It has been assumed that 95% of the calcine would be removed from the floors following three decontamination cycles[2]. It follows that the volume remaining after three decontamination cycles would be 5% of the original volume of calcine on the floors.

[c] It is assumed that because 88% of the residual calcine volume following CRTP is on the floors, the floor should account for 88% of the final volume allowed to remain in the Bin Set and still meet Class A concentration limits, or 88% of 0.086 cubic feet[1, 2].

Determine the cost, per hour, for the additional decontamination cycles, assuming a crew of 19 full-time employees:

Assume that the cost per hour will be the same to clean the walls, pipes, and floors.

Cost/hour = Total labor cost/Unit labor hours

Cost/hour = \$21,760,223/34,590 hours[a]

Cost = \$629.09 per hour

Determine the additional cost to clean the walls to the extent necessary to create a Class A landfill:

Determine the hours required for each cleaning pass:

Hours/pass = Unit labor hours/3 passes[b]

= 828 hours/3 passes[c]

= 276 hours/pass

Determine the total cost to clean the walls:

Cost = (Additional passes required * Hours/pass * Cost/hour * Contingency[d]) + Original Estimate[e]

= [(16 passes required – 3 passes already costed)(276 hours/pass)(\$629.09/hour)(1.75)] + \$30,600,000

= \$34,550,056 = \$34.6M

Determine the additional cost to clean the pipes to the extent necessary to create a Class A landfill:

Determine the hours required for each cleaning pass:

Hours/pass = Unit labor hours/3 passes

= 515 hours/3 passes[f]

= 172 hours/pass

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[a] Taken from the "Operation of Calcine Retrieval" task in the attached Risk-Based Clean Closure, NRC Class A fill estimate for the tractor (Risk Based Estimates).

[b] The unit labor hours represents how many hours are required to clean the walls three times based on a 19 FTE crew. The cost estimates were done based on 3 decontamination cycles, thus the unit labor hours stated in the cost estimate must be divided by 3 to determine the number of hours required per pass.

[c] Taken from the "Operation of Calcine Retrieval" task in the attached Risk-Based Clean Closure, NRC Class A fill estimate for the LDUA (Risk Based Estimates).

[d] Due to the inherent difficulties in continuous decontamination cycles, it is expected that the time required for each pass will increase as the bins become cleaner and cleaner. To account for the increased time, which cannot be accurately quantified at without further in-depth analysis, a large contingency (75%) will be added to the labor cost per pass.

[e] The original cost (unescalated) shown in the Risk Based Clean Closure, NRC Class A fill cost estimate for the given task.

[f] Taken from the "Operation of Calcine Retrieval" task in the attached Risk-Based Clean Closure, NRC Class A fill estimate for the pipe crawler (Risk Based Estimates).

It is assumed that supplementary equipment will be required to clean the pipes due to the additional decontamination passes. For the purposes of these calculations, it will be assumed that one additional pipe crawler robot will be required for each one of the seven Bin Sets to be cleaned. This results in an additional 7 pipe crawler robots.

Determine the cost due to the additional robots:

Cost per robot = Design Modifications + Fabrication Costs + Installation Costs

Design Modifications = $90,000/6 robots[a] = $15,000

Fabrication Costs = $420,000/6 robots[b] = $70,000

Installation Costs = ($297,990 + $547,990)/50 times[c] = $16,920

Cost per robot = $15,000 + $70,000 + $16,920

= $101,920

Determine the total cost to clean the pipes:

Cost = (Additional passes required * Hours/pass * Cost/hour * Contingency) + Original Estimate +

(Cost per robot * 7 additional robots)

= [(16 passes required – 3 passes already costed)(172 hours/pass)($629.09/hour)(1.75)] +

$13,400,000 + ($101,920 * 7)

= $16,575,069 = $16.6M

Determine the additional cost to clean the floors to the extent necessary to create a Class A landfill:

Determine the hours required for each cleaning pass:

Hours/pass = Unit labor hours/3 passes

= 34,590 hours/3 passes[d]

= 11,530 hours/pass

It is assumed that supplementary equipment will be required to clean the floors due to the additional decontamination passes. For the purposes of these calculations, it will be assumed that approximately half of the tractor robots will have to be replaced during the course of the additional cleaning due to the high radiation fields present in the bins. The original cost estimates assumed that 52 robots, in addition to the prototype, would be required. For the purposes of these calculations, then, it will be assumed that 26 additional robots will be needed for the added decontamination passes.

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[a] Taken from the "Design of Modifications for add'l units" task in the attached Risk-Based Clean Closure, NRC Class A fill estimate for the pipe crawler (Risk Based Estimates). This number was divided by six to determine the per unit cost, as the cost estimate was done for 6 robotic units.

[b] Taken from the "Fabrication of Additional units" task in the attached Risk-Based Clean Closure, NRC Class A fill estimate for the pipe crawler (Risk Based Estimates). This number was divided by six to determine the per unit cost, as the cost estimate was done for 6 robotic units.

[c] Taken from the "Install Robotic Units" and "Install and Shield Unit Hose/Tubes" tasks in the attached Risk-Based Clean Closure, NRC Class A fill estimate for the pipe crawler (Risk Based Estimates). This number was divided by 50 to determine the installation cost per robot in each bin.

[d] Taken from the "Operation of Calcine Retrieval" task in the attached Risk-Based Clean Closure, NRC Class A fill estimate for the tractor (Risk Based Estimates).

Determine the cost due to the additional robots:

Cost per robot = Design Modifications + Fabrication Costs + Installation Costs

Design Modifications = \$1,300,000/52 robots[a] = \$25,000

Fabrication Costs = \$13,000,000/52 robots[b] = \$250,000

Installation Costs = (\$264,880 + \$514,880)/50 times[c] = \$15,595

Cost per robot = \$25,000 + \$250,000 + \$15,595

= \$290,595

Determine the total cost to clean the floors:

Cost = (Additional passes required * Hours/pass * Cost/hour * Contingency) + Original Estimate + (Cost per robot * 26 additional robots)

= [(9 passes required – 3 passes already costed)(11,530 hours/pass)(\$629.09/hour)(1.75)] + \$132,400,000 + (\$290,595 * 26)

= \$216,116,251 = \$216.1M

The original, unescalated cost for each major activity and the new, calculated unescalated cost are summarized in Table 1.

Table 1: Unescalated Cost Estimate Summary for RBCC; NRC Class A Landfill (in millions)

ACTIVITY	Original Cost (in millions)	Calculated Cost for RBCC; NRC Class A Landfill with Additional Decontamination Cycles
Regulatory Compliance	\$19.5	\$19.5
Fill Vault with Clean grout	\$12.4	\$12.4
Clean Bins with Robots		
Floor	\$132.4	\$216.1
Walls	\$30.6	\$34.6
Piping	\$13.4	\$16.6
Fill Bins with NRC Class A Grout	\$23.7	\$23.7
D & D of Equipment	\$17.0	\$17.0
TOTAL	\$249.0	\$339.9

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[a] Taken from the "Design of Development of Modifications to add'l units" task in the attached Risk-Based Clean Closure, NRC Class A fill estimate for the tractor (Risk Based Estimates). This number was divided by 52 to determine the per unit cost, as the cost estimate was done for 52 robotic units.

[b] Taken from the "Fabrication of Additional units" task in the attached Risk-Based Clean Closure, NRC Class A fill estimate for the tractor (Risk Based Estimates). This number was divided by 52 to determine the per unit cost, as the cost estimate was done for 52 robotic units.

[c] Taken from the "Install Robotic Units" and "Install and Shield Unit Hose/Tubes" tasks in the attached Risk-Based Clean Closure, NRC Class A fill estimate for the tractor (Risk Based Estimates). This number was divided by 50 to determine the installation cost per robot in each bin.

Determine the escalated costs for Risk Based Clean Closure; NRC Class A Landfill:

First, assume that the escalation costs can be calculated as a straight percent increase of the unescalated costs. Secondly, assume that the percent increase remains constant.

(6) OEC = OUC + PI (OUC)

(6a) PI = (OEC – OUC)/(OUC)

(7) CEC = CUC + PI (CUC)

Where: OEC is the Original Escalated Cost
OUC is the Original Unescalated Cost
PI is the Percent Increase
CEC is the Calculated Escalated Cost
CUC is the Calculated Unescalated Cost

Using Equations 6a and 7, calculate the escalated cost to clean the walls:

PI = (OEC – OUC)/(OUC)[a]
= ($58,200,000 - $30,600,000)/$30,600,000
= 0.90 = 90%

CEC = CUC + PI (CUC)
= $34,600,000 + 0.90($34,600,000)
= $65,740,000 = $65.7M

Using Equations 6a and 7, determine the escalated cost to clean the pipes:

PI = (OEC – OUC)/(OUC)
= ($27,100,000 - $13,400,000)/$ 13,400,000
= 1.02 = 102%

CEC = CUC + PI (CUC)
= $16,600,000 + 1.02($16,600,000)
= $33,532,000 = $33.5M

Using Equations 6a and 7, determine the escalated cost to clean the floors:

PI = (OEC – OUC)/(OUC)
= ($258,700,000 - $132,400,000)/$132,400,000
= 0.95 = 95%

CEC = CUC + PI (CUC)
= $216,100,000 + 0.95($216,100,000)
= $421,395,000 = $421.4M

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[a] Dollar amounts for the original escalated costs to clean the walls, pipes, and floors were taken from the attached Risk Based Clean Closure, Class A fill escalated cost estimate summary.

The original, escalated cost for each major activity and the new, calculated escalated cost are summarized in Table 2.

Table 2: Escalated Cost Estimate Summary for RBCC; NRC Class A Landfill (in millions)

ACTIVITY	Original Cost (in millions)	Calculated Cost for RBCC; NRC Class A Landfill with Additional Decontamination Cycles
Regulatory Compliance	$31.6	$31.6
Fill Vault with Clean grout	$23.3	$23.3
Clean Bins with Robots		
Floor	$258.7	$421.4
Walls	$58.2	$65.7
Piping	$27.1	$33.5
Fill Bins with NRC Class A Grout	$51.9	$51.9
D & D of Equipment	$50.6	$50.6
TOTAL	$501.4	$678.0

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[1] EDF-BSC-008, *Class C and Class A Assessment*, C. M. Barnes, January 1998.

[2] EDF-BSC-001, *Calcined Solids Storage Facility – Volume Calculations*, S. P. Swanson, January 1998.

COST ESTIMATE SUMMARY
UNESCALATED

ICPP BIN SET CLOSURE	Planning Estimate	1/28/98
RISK BASED CLEAN CLOSURE	Estimate #2423	
CLASS A FILL		Checked by:
Requestor: B. C. Spaulding	Prepared by: S. L. Coward	Approved by:

Regulatory Compliance		19,500,000
Fill Vaults with Clean Grout		12,400,000
Clean Bins with Robots		
Floor		132,400,000
Walls		30,600,000
Piping		13,400,000
Fill Bins with NRC Class A Grout		23,700,000
D&D of Equipment		17,000,000
TOTAL		**$249,000,000**
	USE	**$249,000,000**

RISK BASED CLEAN CLOSURE – NRC CLASS A GROUT

DESCRIPTION		**BIN SET #1**	**BIN SET #5**	**BIN SET #7**	**BIN SET #6**	**BIN SET #3**	**BIN SET #4**	**BIN SET #2**
Scheduled Completion		(1/1/14)	(4/1/18)	(12/1/22)	(11/1/26)	(8/1/28)	(2/1/31)	(5/1/31)
ASSUME: Wait 6 Months until Start of Closure								
Permitting (5 Years)	7/1/9–7/1/14							
Grout Vaults "Clean" (Assume 1 Year)								
ED&I (2 Yrs)	7/1/12–7/1/14							
Management	7/1/12–11/1/32							
Construction		7/1/14–7/1/15	10/1/18–10/1/19	6/1/23–6/1/24	5/1/27–5/1/28	2/1/29–2/1/30	8/1/31–8/1/32	11/1/31–11/1/32
Clean Bin Walls/Piping with Robot		**(3 Months)**	**(15 Months)**	**(25 Months)**	**(24 Months)**	**(17 Months)**	**(7 Months)**	**(13 Months)**
ED&I (4 Yrs)	7/1/10–7/1/14							
Management	7/1/10–12/1/32							
Construction		7/1/14–10/1/14	10/1/18–1/1/20	6/1/23–7/1/25	5/1/27–5/1/29	2/1/29–7/1/30	8/1/31–3/1/32	11/1/31–12/1/32
Clean Bin Floors with Robot		**(3 Months)**	**(15 Months)**	**(25 Months)**	**(24 Months)**	**(17 Months)**	**(7 Months)**	**(13 Months)**
ED&I (4 Yrs)	10/1/10–10/1/14							
Management	10/1/10–1/1/34							
Construction		10/1/14–1/1/15	1/1/20–4/1/21	7/1/25–8/1/27	5/1/29–5/1/31	7/1/30–12/1/31	3/1/32–10/1/32	12/1/32–1/1/34
RCRA CLOSURE								
Grout Bins "NRC Class A"		**(3 Months)**	**(11 Months)**	**(18 Months)**	**(17 Months)**	**(12 Months)**	**(6 Months)**	**(10 Months)**
ED&I (3 Yrs)	1/1/21–1/1/24							
Management	1/1/21–8/1/34							
Construction		1/1/24–4/1/24	4/1/24–3/1/25	8/1/27–2/1/29	5/1/31–10/1/32	10/1/32–10/1/33	10/1/33–4/1/34	4/1/34–2/1/35

ASSUMPTIONS:

1) Assume same schedule as options for pouring Class C grout.
2) Installation of NRC Class A Grout into bins are based on individual schedules for each bin set. These schedules assume everything is in place for pouring at start–up date, and allow no flexibility for error or downtime.
3) More than 1 crew could be utilized simultaneously for pouring the "clean" grout into the vaults.
4) Moe than 1 crew could be utilized simultaneously for cleaning the separate bins. However, cleaning of the floors will require scheduling after cleaning the walls/piping.
5) Cleaning of bin floors are based on individual bin pro–rated calcine retrieval volumes to total volume. These schedules assume mob/demob, installation of robotic units, and any modifications of bins will be completed and bins will be ready for retrieval.
6) Because of the difficulty of cleaning of bin walls/piping, it was assumed that it would take the same duration as the cleaning of the bin floors for each bin.
7) Installation of "clean" grout into vaults will average 1 year per vault.

Lockheed Martin Idaho Technologies Co.
Rev. 6-96

COST ESTIMATE SUMMARY

PROJECT NAME: Permitting/Documentation
Risk Based - NRC Class C
LOCATION 1: INEEL/ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: PLANNING
PROJECT NO: 2423-bD
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 27-Jan-1998
TIME: 19:51:07
CHECKED BY: __________
APPR'D BY: __________

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
<u>1.1</u>	<u>CONCEPTUAL</u>			>> <u>$0</u>
1.1.1	CONCEPTUAL DESIGN	0	0	0
<u>1.2</u>	<u>MANAGEMENT</u>			>> <u>$2,374,382</u>
1.2.1	PM FOR PROJECT DEVELOPMENT	1,896,534	0	1,896,534
1.2.2	PROJECT EXECUTION	477,848	0	477,848
<u>1.3</u>	<u>PERMITTING</u>			>> <u>$11,946,206</u>
1.3.1	PERMITTING	11,946,206	0	11,946,206
1.5.2	PROCUREMENT FEES	119,462	0	>> <u>$119,462</u>
	SUBTOTAL INCLUDING ESCALATION	14,440,050	0	>> $14,440,050
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $1,206,567
	CONTINGENCY			>> $3,853,383
	TOTAL ESTIMATED COST			>> $19,500,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *0.00%*

CONTINGENCY= *35.04%*

Lockheed Martin Idaho Technologies Co.
Rev 6-96

ROJECT NAME Permitting/Documentation
Risk Based - NRC Class C
OCATION 1: INEEL/ICPP
EQUESTOR Bryan Spaulding

DETAILED COST ESTIMATE SHEET

TYPE OF ESTIMATE PLANNING
PROJECT NO. 2423-bD
PREPARED BY: S. L. Coward

PAGE # 1

DATE 27-Jan-1998
TIME: 19:51:09
REPORT NAME: Detail Cost Estimate Sheet

ODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	CONCEPTUAL DESIGN											
	CONCEPTUAL DESIGN S/T						0					
1.2.1	PM FOR PROJECT DEVELOPMENT											
	G&A	1	LS		LMITCO	0.000					602,476	602,476
	PIF	1	LS		LMITCO	0.000					696,748	696,748
	PM FOR PROJECT DEVELOPMENT S/T						0				$1,299,224	$1,299,224
1.2.1.1	PROJECT ADMINISTRATION Project Admin. during Documentation (5% of Doc. Costs)	1	LOT		LMITCO	0.000					597,310	597,310
	PROJECT ADMINISTRATION S/T						0				$597,310	$597,310
1.2.2	PROJECT EXECUTION											
	PROJECT EXECUTION S/T						0					
1.2.1.2	PROJECT SUPPORT Support During permitting/Doc. (4% of doc. costs)	1	LOT		LMITCO	0.000					477,848	477,848
	PROJECT SUPPORT S/T						0				$477,848	$477,848

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

ROJECT NAME **Permitting/Documentation**
Risk Based - NRC Class C
OCATION 1 **INEEL/ICPP**
QUESTOR **Bryan Spaulding**

TYPE OF ESTIMATE **PLANNING**
PROJECT NO.: **2423-bD**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **19:51:09**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.1	**PERMITTING**											
	PERMITTING AND DOCUMENTATION	1				0.000						
	Air Monitoring Activities, Fees, etc.	1	LS		LMITCO	0.000					770,000	770,000
	RCRC Closure (Incl. Writing, Reviews, Public Comments & Issuance of Permits)	2	FTE		Z-1700 LMITCO	1440.00	2,880	186,221				186,221
	P.E. Activities	1	LS		LMITCO	0.000					60,000	60,000
	CAA Permit to Construct (Incl. Preparing, Reviews, Public comments & Issuance)	1	LS		Z-1700 LMITCO	1800.00	1,800	116,388				116,388
	CERCLA Coordinator	2	FTE		Z-1700 LMITCO	1500.00	3,000	193,980				193,980
	Regulatory Affairs Oversight	10	YR		Z-1700 LMITCO	150.000	1,500	96,990				96,990
	Other Regulatory Compliance (CWA, Storm Water, Historical, etc.)	1	LS		Z-1700 LMITCO	1000.00	1,000	64,660				64,660
	Survey Plat	1	LS		LMITCO	0.000					10,000	10,000
	SARR	1	LS		Z-3170 LMITCO	4500.00	4,500	312,255				312,255
	NRC Landfill Disposal Requirements	10	LS		Z-1710 LMITCO	9000.00	90,000	4,960,800				4,960,800
	Environmental & Hazards Analysis	2	FTE		Z-1710 LMITCO	1800.00	3,600	198,432				198,432
	Seismic Test Bores (Allowance)	20	HOLES		Z-1710 LMITCO	2700.00	54,000	2,976,480				2,976,480
	Operational Readiness Review	1	LS		LMITCO	0.000					2,000,000	2,000,000
	PERMITTING S/T						162,280	$9,106,206			$2,840,000	$11,946,206

Lockheed Martin Idaho Technologies Co.
Rev 6-96
ROJECT NAME Permitting/Documentation
Risk Based - NRC Class C
OCATION 1 INEEL/ICPP
EQUESTOR Bryan Spaulding

DETAILED COST ESTIMATE SHEET

TYPE OF ESTIMATE. PLANNING
PROJECT NO.. 2423-bD
PREPARED BY: S. L. Coward

DATE 27-Jan-1998
TIME: 19:51:09
REPORT NAME. Detail Cost Estimate Sheet

ODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
	PROJECT SUBTOTAL						162,280	$9,106,206	$0	$0	$5,214,382	$14,320,588

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: Permitting/Documentation
Risk Based - NRC Class C
LOCATION 1 INEEL/ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: PLANNING
PROJECT NO: 2423-bD
PREPARED BY: S. L. Coward

DATE: 27-Jan-1998
TIME: 19:51:03

REPORT NAME: Contingency Analysis

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o *Contingency*	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost *by Element*
				-	+	-	+				
1.1.1	CONCEPTUAL DESIGN	0	0.00	10	40	0.00	0.00	0.000%	0.00%	0	0
1.2.1	PM FOR PROJECT DEVELOPMENT	1,896,534	13.13	10	40	1.31	5.25	4.597%	13.13%	664,566	2,561,100
1.2.2	PROJECT EXECUTION	477,848	3.31	10	40	0.33	1.32	1.158%	3.31%	167,443	645,291
1.3.1	PERMITTING	11,946,206	82.73	10	40	8.27	33.09	28.955%	82.73%	4,186,080	16,132,286
1.5.2	PROCUREMENT FEES	119,462	0.83	10	40	0.08	0.33	0.290%	0.83%	41,861	161,323
	ESCALATION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
	SUBTOTAL	14,440,050	100.00					35.000%			
	CALCULATED CONTINGENCY	5,054,017									
	RESULTANT TEC	19,494,067									
	ROUNDED TEC	19,500,000									
	PROJECT CONTINGENCY	5,059,950						35.04%			
	MANAGEMENT RESERVE	1,206,567									
	CONTINGENCY	3,853,383									
	TOTAL ESTIMATED COST	19,500,000								5,059,950	19,500,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. *The Contingency Analysis* is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE

RISK BASED CLEAN CLOSURE; CLASS A FILL; UNESCALATED

REGULATORY COMPLIANCE

PROCUREMENT FEE:

CONSTRUCTION =		$11,946,206		
GFE =				
	Subtotal	$11,946,206		
FEE @ 1% =		$11,946,206	* 0.01 =	$119,462

G&A @ 23% (with a ceiling of $500,000 imposed per year, 5 yrs)

CONSTRUCTION OR CEILING * 5 YEARS =		$2,500,000		
GFE =		$0		
PROCUREMENT FEE =		$119,462		
	Subtotal	$2,619,462		
FEE @ 23% =		$2,619,462	* 0.23 =	$602,476

PIF @ 5.5%

CONSTRUCTION =		$11,946,206		
GFE =		$0		
PROCUREMENT FEE =		$119,462		
G&A =		$602,476		
	Subtotal	$12,668,144		
FEE @ 5.5% =		$12,668,144	* 0.055 =	$696,748

TOTAL PROCUREMENT FEE:	$119,462
TOTAL G&A FEE:	$602,476
TOTAL PIF:	$696,748

Lockheed Martin Idaho Technologies Co.
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COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure (EIS Stud
Place Clean Grout in Vault
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-A2
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 27-Jan-1998
TIME: 19:54:43
CHECKED BY:
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $1,589,774
1.1.1	DESIGN ENGINEERING	1,324,812	0	1,324,812
1.1.2	TITLE III INSPECTION	264,962	0	264,962
1.2	MANAGEMENT COSTS			>> $2,216,357
1.2.1	PROJECT MANAGEMENT	1,686,432	0	1,686,432
1.2.2	CONSTRUCTION MANAGEMENT	529,925	0	529,925
1.3	CONSTRUCTION			>> $5,299,250
1.3.1	GENERAL CONDITIONS	1,067,791	0	1,067,791
1.3.2	SITEWORK	0	0	0
1.3.3	CONCRETE	4,231,459	0	4,231,459
1.5.2	PROCUREMENT FEES	52,992	0	>> $52,992
	SUBTOTAL INCLUDING ESCALATION	9,158,373	0	>> $9,158,373
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $535,224
	CONTINGENCY			>> $2,706,403
	TOTAL ESTIMATED COST			>> $12,400,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *30.00%*

CONTINGENCY= *35.40%*

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DETAILED COST ESTIMATE SHEET

PAGE # 1

ROJECT NAME **ICPP Bin Set Closure (EIS Study)**
Place Clean Grout in Vault
OCATION 1. **ICPP**
EQUESTOR **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-A2**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **19:54:45**
REPORT NAME: **Detail Cost Estimate Sheet**

ODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	DESIGN ENGINEERING ENGINEERING AND DESIGN											
EMO·	Title I &II Engineering & Design @ 20% of Construction	1	LS		*LMITCO*	0.000					1,059,850	1,059,850
EMO:	Conceptual Engineering & Design @ 5% of Construction	1	LS		*LMITCO*	0.000					264,962	264,962
	DESIGN ENGINEERING S/T						0				$1,324,812	$1,324,812
1.1.2	TITLE III INSPECTION INSPECTION - TITLE III	1	LS		*LMITCO*	0.000					264,962	264,962
EMO	*Title III @ 5% of Construction*											
	TITLE III INSPECTION S/T						0				$264,962	$264,962
1.2.1	PROJECT MANAGEMENT PROJECT MANAGEMENT	1	LS		*LMITCO*	0.000					529,925	529,925
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		*LMITCO*	0.000					817,188	817,188
	PIF	1	LS		*LMITCO*	0.000					339,319	339,319
	PROJECT MANAGEMENT S/T						0				$1,686,432	$1,686,432

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DETAILED COST ESTIMATE SHEET

PAGE # 2

ROJECT NAME ICPP Bin Set Closure (EIS Study)
Place Clean Grout in Vault
OCATION 1 ICPP
EQUESTOR Bryan Spaulding

TYPE OF ESTIMATE. Planning
PROJECT NO · 2423-A2
PREPARED BY: S. L. Coward

DATE 27-Jan-1998
TIME: 19:54:46
REPORT NAME: Detail Cost Estimate Sheet

:ODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
.2.2	**CONSTRUCTION MANAGEMENT**											
	CONSTRUCTION MANAGEMENT	1	LS		*LMITCO*	0.000					529,925	529,925
IEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$529,925	$529,925
1.3.1	**GENERAL CONDITIONS**											
	SUPERVISION (Duration of Schedule - Assume 3 Years)	1	FTE		CONF *GEN*	6240.00	6,240	207,480				207,480
	TRAINING	10	FTE		CONC *GEN*	165.000	1,650	52,850				52,850
	RADCON TECHNICIAN (Duration of Schedule - Assume 3 Years)	2	FTE		Z-1342 *LMITCO*	6240.00	12,480	616,512				616,512
	GENERAL CONDITIONS S/T						20,370	$876,842				$876,842
1.3.2	**SITEWORK**											
	SITEWORK S/T						0					
1.3.3	**CONCRETE**											
	PROCURE EQUIPMENT FOR PLACEMENT OF GROUT											
	Grout Pump	1	EA		*GEN*	0.000			55,000			55,000

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DETAILED COST ESTIMATE SHEET

PAGE # 3

ROJECT NAME **ICPP Bin Set Closure (EIS Study)**
Place Clean Grout In Vault
OCATION 1. **ICPP**
EQUESTOR **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-A2**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME **19:54:45**
REPORT NAME: **Detail Cost Estimate Sheet**

:ODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.3	**CONCRETE** *Air Compressor and Miscellaneous Cleaning Equipment*	1	EA		GEN	0.000			25,000			25,000
	GROUT DELIVERY PIPING AND ACCESSORIES PURCHASE (Incl 10% Waste)	415	LF	20.00	GEN	0.000				8,300		8,300
	GROUT DELIVERY PIPING (Incl. 10% Waste)	2,905	LF		CONC GEN	0.470	1,366	43,732				43,732
MEMO:	Install, Remove & Clean Pipe after Each Vault (7 Vaults)											
	GROUT DELIVERY PIPING CLEANING BETWEEN MANIFOLDS & DROP TUBES	676	LIFTS	30.00	CONC GEN	0.500	338	10,826		20,280		31,106
MEMO:	Assume cleaning between each lift											
	GROUT MANIFOLD AND CLEANING SYSTEM	1	LOT	7,500.00	CONC GEN	254.000	254	8,136		7,500		15,636
MEMO:	Can be Reused after each Vault Set (7 times)											
	CONCRETE S/T						1,957	$62,694	$80,000	$36,080		$178,774
1.3.3.1	**VAULT GROUTING** PURCHASE GROUT DROP TUBES AND ACCESSORIES	390	LF	20.00	GEN	0.000				7,800		7,800
MEMO:	Assume 88' long for 4 Tubes per Vault Plus 10% Waste (Can be Reused)											
	INSTALL AND REMOVE DROP TUBES	2,123	LF		CONC GEN	0.500	1,062	34,000				34,000

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DETAILED COST ESTIMATE SHEET

PAGE # 4

ROJECT NAME **ICPP Bin Set Closure (EIS Study)**
Place Clean Grout in Vault
OCATION 1 **ICPP**
EQUESTOR **Bryan Spaulding**

TYPE OF ESTIMATE **Planning**
PROJECT NO : **2423-A2**
PREPARED BY **S. L. Coward**

DATE **27-Jan-1998**
TIME: **19:54:45**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.3.1	**VAULT GROUTING**											
MEMO.	Assume 4 tubes x 7 vaults plus 10% waste											
	GROUT PLACEMENT & CLEANUP (Includes 10% Waste)	22,946	CY	80.00	CONC *GEN*	0.350	8,031	257,236		1,835,680		2,092,916
	VAULT GROUTING S/T						9,093	$291,236		$1,843,480		$2,134,716
1.3.3.2	**BIN SET VAULT ACCESS HOLES**											
	CORE DRILL 18" HOLE THROUGH VAULT ROOF (4 PLACES/VAULT)	28	EA	1,000.00	CONC *GEN*	100.000	2,800	89,684		28,000		117,684
	SHIELDING AROUND VAULT HOLES	28	EA	5,000.00	CONC *GEN*	24.000	672	21,524		140,000		161,524
	CAP 18" DIAMETER HOLES	28	EA	1,800.00	CONC *GEN*	40.000	1,120	35,874		50,400		86,274
	BIN SET VAULT ACCESS HOLES S/T						4,592	$147,082		$218,400		$365,482
	PROJECT SUBTOTAL						36,012	$1,377,853	$80,000	$2,097,960	$3,806,131	$7,361,944

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: ICPP Bin Set Closure (EIS Stud
Place Clean Grout in Vault
LOCATION 1. ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-A2
PREPARED BY: S. L. Coward

DATE: 27-Jan-1998
TIME: 19:54:39

REPORT NAME: Contingency Analysis

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING	1,324,812	14.47	10	40	1.45	5.79	5.063%	14.47%	468,920	1,793,732
1.1.2	TITLE III INSPECTION	264,962	2.89	10	40	0.29	1.16	1.013%	2.89%	93,784	358,746
1.2.1	PROJECT MANAGEMENT	1,686,432	18.41	10	40	1.84	7.37	6.445%	18.41%	596,916	2,283,348
1.2.2	CONSTRUCTION MANAGEMENT	529,925	5.79	10	40	0.58	2.31	2.025%	5.79%	187,568	717,493
1.3.1	GENERAL CONDITIONS	1,067,791	11.66	10	40	1.17	4.66	4.081%	11.66%	377,947	1,445,738
1.3.2	SITEWORK	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.3.3	CONCRETE	4,231,459	46.20	10	40	4.62	18.48	16.171%	46.20%	1,497,735	5,729,194
1.5.2	PROCUREMENT FEES	52,992	0.58	10	40	0.06	0.23	0.203%	0.58%	18,757	71,749
	ESCALATION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
	SUBTOTAL	9,158,373	100.00					35.000%			
	CALCULATED CONTINGENCY	3,205,431									
	RESULTANT TEC	12,363,804									
	ROUNDED TEC	12,400,000									
	PROJECT CONTINGENCY	3,241,627						35.40%			
	MANAGEMENT RESERVE	535,224									
	CONTINGENCY	2,706,403									
	TOTAL ESTIMATED COST	12,400,000								3,241,627	12,400,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE
RISK BASED CLEAN CLOSURE; CLASS A FILL; UNESCALATED

FILL VAULTS W/ CLEAN GROUT

PROCUREMENT FEE:

CONSTRUCTION =	$5,299,250		
GFE =			
Subtotal	$5,299,250		
FEE @ 1% =	$5,299,250	* 0.01 =	$52,993

G&A @ 23% (with a ceiling of $500,000 imposed per year, 7 yrs)

CONSTRUCTION OR CEILING * 7 YEARS =	$3,500,000		
GFE =	$0		
PROCUREMENT FEE =	$52,993		
Subtotal	$3,552,993		
FEE @ 23% =	$3,552,993	* 0.23 =	$817,188

PIF @ 5.5%

CONSTRUCTION =	$5,299,250		
GFE =	$0		
PROCUREMENT FEE =	$52,993		
G&A =	$817,188		
Subtotal	$6,169,431		
FEE @ 5.5% =	$6,169,431	* 0.055 =	$339,319

TOTAL PROCUREMENT FEE:	$52,993
TOTAL G&A FEE:	$817,188
TOTAL PIF:	$339,319

Lockheed Martin Idaho Technologies Co.
Rev. 6-96

COST ESTIMATE SUMMARY

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud Tractor (Risk Based Estimates)**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-C1**
PREPARED BY: **S. L. Coward**
REPORT NAME: **Cost Estimate Summary**

DATE: **27-Jan-1998**
TIME: **20:42:03**
CHECKED BY:
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $13,200,325
1.1.1	DESIGN ENGINEERING TITLE I & II	9,900,244	0	9,900,244
1.1.2	TITLE III INSPECTION	3,300,081	0	3,300,081
1.2	MANAGEMENT COSTS			>> $18,240,120
1.2.1	PROJECT MANAGEMENT	11,639,957	0	11,639,957
1.2.2	CONSTRUCTION MANAGEMENT	6,600,163	0	6,600,163
1.3	CONSTRUCTION			>> $66,001,630
1.3.1	GENERAL CONDITIONS	6,840,414	0	6,840,414
1.3.13	SPECIAL CONSTRUCTION	59,161,216	0	59,161,216
1.5.2	PROCUREMENT FEES	660,016	0	>> $660,016
	SUBTOTAL INCLUDING ESCALATION	98,102,091	0	>> $98,102,091
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $6,666,165
	CONTINGENCY			>> $27,631,744
	TOTAL ESTIMATED COST			>> $132,400,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *20.00%*

CONTINGENCY= *34.96%*

Lockheed Martin Idaho Technologies Co.
Rev 6-96
PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Tractor (Risk Based Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

DETAILED COST ESTIMATE SHEET

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-C1**
PREPARED BY: **S. L. Coward**

PAGE # **1**
DATE **27-Jan-1998**
TIME: **20:42:05**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	**DESIGN ENGINEERING TITLE I & II** ENGINEERING AND DESIGN											
MEMO:	Title I &II Engineering & Design @ 10% of Construction	1	LS		*LMITCO*	0.000					6,600,163	6,600,163
	Conceptual Engineering & Design @ 5% of Construction	1	LS		*LMITCO*	0.000					3,300,081	3,300,081
	DESIGN ENGINEERING TITLE I & II S/T						0				$9,900,244	$9,900,244
1.1.2	**TITLE III INSPECTION** INSPECTION - TITLE III	1	LS		*LMITCO*	0.000					3,300,081	3,300,081
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$3,300,081	$3,300,081
1.2.1	**PROJECT MANAGEMENT** PROJECT MANAGEMENT	1	LOT		*LMITCO*	0.000					6,600,163	6,600,163
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		*LMITCO*	0.000					1,301,804	1,301,804
	PIF	1	LS		*LMITCO*	0.000					3,737,990	3,737,990
	PROJECT MANAGEMENT S/T						0				$*,***,***	$11,639,957

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Tractor (Risk Based Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-C1**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **20:42:05**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	**CONSTRUCTION MANAGEMENT**											
	CONSTRUCTION MANAGEMENT	1	LOT		*LMITCO*	0.000					6,600,163	6,600,163
MEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$6,600,163	$6,600,163
1.3.1	**GENERAL CONDITIONS**											
	SUPERVISION (Duration of Schedule for Installation of Robots - 10 years)	1	FTE		PIPF *GEN*	20800.0	20,800	839,696			2,841,100	3,680,796
	TRAINING	15	FTE		SKWK *GEN*	165.000	2,475	81,947				81,947
	RADCON TECHNICIAN SUPPORT (Duration of Schedule - Assume 10 Years)	2	FTE		Z-1342 *LMITCO*	20800.0	41,600	2,055,040				2,055,040
	GENERAL CONDITIONS S/T						64,875	$2,976,683			$2,841,100	$5,817,783
1.3.13	**SPECIAL CONSTRUCTION**											
	FABRICATION OF FOLDABLE TRACTOR ROBOT											
	Design & Develop 1rst Tractor Robot, Including:	1	EA		*GEN*	0.000					3,000,000	3,000,000
	Design, Approvals, Mock-up, Proof of Process, etc.											
	Fabrication of Additional Units	52	EA		*GEN*	0.000					*,***,***	13,000,000

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 3

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Tractor (Risk Based Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-C1**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **20:42:05**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	SPECIAL CONSTRUCTION Design of Development of Modifications to Add'l Units	52	EA		GEN	0.000					1,300,000	1,300,000
	INSTALLATION OF CLEANING UNIT:											
	Install Robotic Units	50	EACH		SKWK GEN	160.000	8,000	264,880				264,880
	Install and Shield Unit Hose/Tubes (Mods, Electr., etc.) - Allowance	50	EA	5,000.00	SKWK GEN	160.000	8,000	264,880		250,000		514,880
	Systems Integration	1	LS		GEN	0.000					75,000	75,000
	CAP 18" DIAMETER HOLES	100	EA	1,800.00	SKWK GEN	40.000	4,000	132,440		180,000		312,440
	CAP 6" DIAMETER HOLES	100		500.00	SKWK GEN	24.000	2,400	79,464		50,000		129,464
	OPERATION OF CALCINE RETRIEVAL -	19	FTE		SKWK GEN	34590.0	657,210	21,760,223				21,760,223
	SPECIAL CONSTRUCTION S/T						679,610	$22,501,887		$480,000	$*,***,***	$40,356,887
	PROJECT SUBTOTAL						744,486	$25,478,570	$0	$480,000	$51,656,545	$77,615,115

Lockheed Martin Idaho Technologies Co.
Rev 6-96

CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud Tractor (Risk Based Estimates)**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-C1**
PREPARED BY: **S. L. Coward**

DATE: **27-Jan-1998**
TIME: **20:42:00**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	9,900,244	10.09	10	40	1.01	4.04	3.532%	10.09%	3,461,268	13,361,512
1.1.2	TITLE III INSPECTION	3,300,081	3.36	10	40	0.34	1.35	1.177%	3.36%	1,153,756	4,453,837
1.2.1	PROJECT MANAGEMENT	11,639,957	11.87	10	40	1.19	4.75	4.153%	11.87%	4,069,497	15,709,454
1.2.2	CONSTRUCTION MANAGEMENT	6,600,163	6.73	10	40	0.67	2.69	2.355%	6.73%	2,307,512	8,907,675
1.3.1	GENERAL CONDITIONS	6,840,414	6.97	10	40	0.70	2.79	2.440%	6.97%	2,391,508	9,231,922
1.3.13	SPECIAL CONSTRUCTION	59,161,216	60.31	10	40	6.03	24.12	21.107%	60.31%	20,683,616	79,844,832
1.5.2	PROCUREMENT FEES	660,016	0.67	10	40	0.07	0.27	0.235%	0.67%	230,751	890,767
	ESCALATION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	1	1
SUBTOTAL		98,102,091	100.00					35.000%			
CALCULATED CONTINGENCY		34,335,732									
RESULTANT TEC		132,437,823									
ROUNDED TEC		132,400,000									
PROJECT CONTINGENCY		34,297,909						34.96%			
MANAGEMENT RESERVE		6,666,165									
CONTINGENCY		27,631,744									
TOTAL ESTIMATED COST		132,400,000								34,297,909	132,400,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% - 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% - 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% - 20%
TITLE II	5% - 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE

RISK BASED CLEAN CLOSURE; CLASS A FILL; UNESCALATED

CLEAN BINS W/ ROBOTS - FLOOR

PROCUREMENT FEE:

CONSTRUCTION =		$66,001,630		
GFE =				
	Subtotal	$66,001,630		
FEE @ 1% =		$66,001,630	* 0.01 =	$660,016

G&A @ 23% (with a ceiling of $500,000 imposed per year, 10 yrs)

CONSTRUCTION OR CEILING * 10 YEARS =		$5,000,000		
GFE =		$0		
PROCUREMENT FEE =		$660,016		
	Subtotal	$5,660,016		
FEE @ 23% =		$5,660,016	* 0.23 =	$1,301,804

PIF @ 5.5%

CONSTRUCTION =		$66,001,630		
GFE =		$0		
PROCUREMENT FEE =		$660,016		
G&A =		$1,301,804		
	Subtotal	$67,963,450		
FEE @ 5.5% =		$67,963,450	* 0.055 =	$3,737,990

TOTAL PROCUREMENT FEE:	$660,016
TOTAL G&A FEE:	$1,301,804
TOTAL PIF:	$3,737,990

Lockheed Martin Idaho Technologies Co.
Rev. 6-96

COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure (EIS Stud LDUA (Risk Based Estimates)
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-D
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 27-Jan-1998
TIME: 20:47:33
CHECKED BY: ______
APPR'D BY: ______

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
<u>1.1</u>	<u>ENGINEERING, DESIGN AND INSPECTION</u>			>> <u>$2,778,017</u>
1.1.1	DESIGN ENGINEERING TITLE I & II	2,083,513	0	2,083,513
1.1.2	TITLE III INSPECTION	694,504	0	694,504
<u>1.2</u>	<u>MANAGEMENT COSTS</u>			>> <u>$5,871,039</u>
1.2.1	PROJECT MANAGEMENT	3,407,558	0	3,407,558
1.2.2	CONSTRUCTION MANAGEMENT	2,463,481	0	2,463,481
<u>1.3</u>	<u>CONSTRUCTION</u>			>> <u>$13,890,099</u>
1.3.1	GENERAL CONDITIONS	1,831,085	0	1,831,085
1.3.13	SPECIAL CONSTRUCTION	12,059,014	0	12,059,014
1.5.2	PROCUREMENT FEES	138,901	0	>> <u>$138,901</u>
	SUBTOTAL INCLUDING ESCALATION	22,678,056	0	>> $22,678,056
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $1,402,900
	CONTINGENCY			>> $6,519,044
	TOTAL ESTIMATED COST			>> $30,600,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *20.00%*

CONTINGENCY= *34.93%*

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
LDUA (Risk Based Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-D**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **20:47:35**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	DESIGN ENGINEERING TITLE I & II ENGINEERING AND DESIGN											
MEMO:	Title I &II Engineering & Design @ 10% of Construction	1	LS		*LMITCO*	0.000					1,389,009	1,389,009
	Conceptual Engineering & Design @ 5% of Construction	1	LS		*LMITCO*	0.000					694,504	694,504
	DESIGN ENGINEERING TITLE I & II S/T						0				$2,083,513	$2,083,513
1.1.2	TITLE III INSPECTION INSPECTION - TITLE III	1	LS		*LMITCO*	0.000					694,504	694,504
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$694,504	$694,504
1.2.1	PROJECT MANAGEMENT PROJECT MANAGEMENT	1	LOT		*LMITCO*	0.000					1,389,009	1,389,009
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		*LMITCO*	0.000					1,181,947	1,181,947
	PIF	1	LS		*LMITCO*	0.000					836,602	836,602
	PROJECT MANAGEMENT S/T						0				$3,407,558	$3,407,558

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
LDUA (Risk Based Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-D**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **20:47:35**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	**CONSTRUCTION MANAGEMENT** CONSTRUCTION MANAGEMENT	1	LOT		*LMITCO*	0.000					2,463,481	2,463,481
MEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$2,463,481	$2,463,481
1.3.1	**GENERAL CONDITIONS** SUPERVISION (Assume Share with Piping Est. (10 Yrs/2) - Duration of Schedule)	1	FTE		PIPF *GEN*	10400.0	10,400	419,848				419,848
	TRAINING	8	FTE		SKWK *GEN*	165.000	1,320	43,705				43,705
	RADCON TECHNICIAN SUPPORT (Assume Share with Piping Est (10 Yrs/2) - Duration)	2	FTE		Z-1342 *LMITCO*	10400.0	20,800	1,027,520				1,027,520
	GENERAL CONDITIONS S/T						32,520	$1,491,073				$1,491,073
1.3.13	**SPECIAL CONSTRUCTION**											
	DESIGN AND DEVELOPMENT OF LDUA											
	Design and Fabricate 1rst LDUA, Including:	1	EA		*GEN*	0.000					5,000,000	5,000,000
	Design, Approvals, Mock-up, Proof of Process, etc.											
	Fabrication of Add'l Units	6	EA		*GEN*	0.000					2,550,000	2,550,000

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
LDUA (Risk Based Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-D**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **20:47:35**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	**SPECIAL CONSTRUCTION** Design of Modifications for add'l Units	6	EA		GEN	0.000					450,000	450,000
	INSTALLATION OF CLEANING UNIT:											
	Install Robotic Units	50	EACH		SKWK GEN	200.000	10,000	331,100				331,100
	Install and Shield Unit Hose/Tubes (Mods, Electr., etc.) - Allowance	50	EA	5,000.00	SKWK GEN	200.000	10,000	331,100		250,000		581,100
	Systems Integration	1	LS		GEN	0.000					100,000	100,000
	Shielding and Retrieval Area	7	EA		GEN	0.000					350,000	350,000
	CAP 18" DIA. HOLES - ASSUME Holes were capped in Floor Estimate	50	EA		SKWK GEN	40.000	2,000	66,220				66,220
	CAP 6" DIAMETER HOLES - Assume Holes were capped in Floor Estimate	50	EA		SKWK GEN	24.000	1,200	39,732				39,732
	OPERATION OF CALCINE RETRIEVAL	19	FTE		SKWK GEN	828.000	15,732	520,887				520,887
	SPECIAL CONSTRUCTION S/T						38,932	$1,289,039		$250,000	$8,450,000	$9,989,039
	PROJECT SUBTOTAL						71,452	$2,780,112	$0	$250,000	$17,099,056	$20,129,168

Lockheed Martin Idaho Technologies Co.
Rev 6-96

CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud LDUA (Risk Based Estimates)**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-D**
PREPARED BY: **S. L. Coward**

DATE: **27-Jan-1998**
TIME: **20:47:30**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	2,083,513	9.19	10	40	0.92	3.67	3.216%	9.19%	727,817	2,811,330
1.1.2	TITLE III INSPECTION	694,504	3.06	10	40	0.31	1.22	1.072%	3.06%	242,606	937,110
1.2.1	PROJECT MANAGEMENT	3,407,558	15.03	10	40	1.50	6.01	5.259%	15.03%	1,190,335	4,597,893
1.2.2	CONSTRUCTION MANAGEMENT	2,463,481	10.86	10	40	1.09	4.35	3.802%	10.86%	860,548	3,324,029
1.3.1	GENERAL CONDITIONS	1,831,085	8.07	10	40	0.81	3.23	2.826%	8.07%	639,638	2,470,723
1.3.13	SPECIAL CONSTRUCTION	12,059,014	53.17	10	40	5.32	21.27	18.611%	53.17%	4,212,479	16,271,493
1.5.2	PROCUREMENT FEES	138,901	0.61	10	40	0.06	0.24	0.214%	0.61%	48,521	187,422
	ESCALATION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
	SUBTOTAL	22,678,056	100.00					35.000%			
	CALCULATED CONTINGENCY	7,937,320									
	RESULTANT TEC	30,615,376									
	ROUNDED TEC	30,600,000									
	PROJECT CONTINGENCY	7,921,944						34.93%			
	MANAGEMENT RESERVE	1,402,900									
	CONTINGENCY	6,519,044									
	TOTAL ESTIMATED COST	30,600,000								7,921,944	30,600,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE
RISK BASED CLEAN CLOSURE; CLASS A FILL; UNESCALATED

CLEAN BINS W/ ROBOTS - WALLS

PROCUREMENT FEE:

CONSTRUCTION = $13,890,099
GFE =
Subtotal $13,890,099

FEE @ 1% = $13,890,099 * 0.01 = $138,901

G&A @ 23% (with a ceiling of $500,000 imposed per year, 10 yrs)

CONSTRUCTION OR
CEILING • 10 YEARS = $5,000,000
GFE = $0
PROCUREMENT FEE = $138,901
Subtotal $5,138,901

FEE @ 23% = $5,138,901 * 0.23 = $1,181,947

PIF @ 5.5%

CONSTRUCTION = $13,890,099
GFE = $0
PROCUREMENT FEE = $138,901
G&A = $1,181,947
Subtotal $15,210,947

FEE @ 5.5% = $15,210,947 • 0.055 = $836,602

TOTAL PROCUREMENT FEE: $138,901

TOTAL G&A FEE: $1,181,947

TOTAL PIF: $836,602

Lockheed Martin Idaho Technologies Co.
Rev. 6-96

COST ESTIMATE SUMMARY

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud Pipe Crawler (Risk Based Estim**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-E**
PREPARED BY: **S. L. Coward**
REPORT NAME: **Cost Estimate Summary**

DATE: **27-Jan-1998**
TIME: **20:52:33**
CHECKED BY: ____________________
APPR'D BY: ____________________

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $1,185,557
1.1.1	DESIGN ENGINEERING	889,168	0	889,168
1.1.2	TITLE III INSPECTION	296,389	0	296,389
1.2	MANAGEMENT COSTS			>> $2,742,481
1.2.1	PROJECT MANAGEMENT	2,149,702	0	2,149,702
1.2.2	CONSTRUCTION MANAGEMENT	592,779	0	592,779
1.3	CONSTRUCTION			>> $5,927,794
1.3.1	GENERAL CONDITIONS	1,831,085	0	1,831,085
1.3.13	SPECIAL CONSTRUCTION	4,096,709	0	4,096,709
1.5.2	PROCUREMENT FEES	59,278	0	>> $59,278
	SUBTOTAL INCLUDING ESCALATION	**9,915,110**	**0**	**>> $9,915,110**
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $598,707
	CONTINGENCY			>> $2,886,183
	TOTAL ESTIMATED COST			>> $13,400,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *20.00%*

CONTINGENCY= *35.15%*

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # **1**

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Pipe Crawler (Risk Based Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-E**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **20:52:35**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	**DESIGN ENGINEERING** ENGINEERING AND DESIGN											
MEMO:	Title I &II Engineering & Design @ 10% of Construction	1	LS		*LMITCO*	0.000					592,779	592,779
	Conceptual Engineering & Design @ 5% of Construction	1	LS		*LMITCO*	0.000					296,389	296,389
	DESIGN ENGINEERING S/T						0				$889,168	$889,168
1.1.2	**TITLE III INSPECTION** INSPECTION - TITLE III	1	LS		*LMITCO*	0.000					296,389	296,389
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$296,389	$296,389
1.2.1	**PROJECT MANAGEMENT** PROJECT MANAGEMENT	1	LOT		*LMITCO*	0.000					592,779	592,779
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		*LMITCO*	0.000					1,163,634	1,163,634
	PIF	1	LS		*LMITCO*	0.000					393,289	393,289
	PROJECT MANAGEMENT S/T						0				$2,149,702	$2,149,702

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Pipe Crawler (Risk Based Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-E**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **20:52:35**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	**CONSTRUCTION MANAGEMENT** CONSTRUCTION MANAGEMENT	1	LOT		*LMITCO*	0.000					592,779	592,779
MEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$592,779	$592,779
1.3.1	**GENERAL CONDITIONS** SUPERVISION (Share with Wall Est. (10 yrs/2) - Duration)	1	FTE		PIPF *GEN*	10400.0	10,400	419,848				419,848
	TRAINING	8	FTE		SKWK *GEN*	165.000	1,320	43,705				43,705
	RADCON TECHNICIAN SUPPORT (Share with Wall Est (10 yrs/2) - Duration)	2	FTE		Z-1342 *LMITCO*	10400.0	20,800	1,027,520				1,027,520
	GENERAL CONDITIONS S/T						32,520	$1,491,073				$1,491,073
1.3.13	**SPECIAL CONSTRUCTION**											
	DESIGN AND DEVELOPMENT OF PIPE CRAWLER											
	Design and Development of 1rst Unit, Including:	1	LS		*GEN*	0.000					800,000	800,000
	Design, Approvals, Mock-ups, Proof of Process, etc.											
	Fabrication of Additional units	6	EA		*GEN*	0.000					420,000	420,000

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 3

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Pipe Crawler (Risk Based Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-E**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **20:52:35**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	SPECIAL CONSTRUCTION Design of Modifications for add'l units	6	EA		GEN	0.000					90,000	90,000
	INSTALLATION OF PIPE CRAWLER											
	Install Robotic Units	50	EACH		SKWK GEN	180.000	9,000	297,990				297,990
	Install and Shield Unit Hose/Tubes (Mods, Electr., etc.) - Allowance	50	EA	5,000.00	SKWK GEN	180.000	9,000	297,990		250,000		547,990
	Systems Integration	1	LS		GEN	0.000					100,000	100,000
	Shielding and Retrieval Area	7			GEN	0.000					350,000	350,000
	CAP 18" DIAMETER HOLES - ASSUME Holes Capped In Floor Estimate	50	EA		SKWK GEN	40.000	2,000	66,220				66,220
	CAP 6" DIAMETER HOLES - ASSUME Holes Capped In Floor Estimate	50	EA		SKWK GEN	24.000	1,200	39,732				39,732
	OPERATION OF CALCINE RETRIEVAL	19	FTE		SKWK GEN	515.000	9,785	323,981				323,981
	SPECIAL CONSTRUCTION S/T						30,985	$1,025,913		$250,000	$1,760,000	$3,035,913
	PROJECT SUBTOTAL						63,505	$2,516,987	$0	$250,000	$5,688,038	$8,455,026

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud**
Pipe Crawler (Risk Based Estim
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-E**
PREPARED BY: **S. L. Coward**

DATE: **27-Jan-1998**
TIME: **20:52:30**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING	889,168	8.97	10	40	0.90	3.59	3.139%	8.97%	312,518	1,201,686
1.1.2	TITLE III INSPECTION	296,389	2.99	10	40	0.30	1.20	1.046%	2.99%	104,173	400,562
1.2.1	PROJECT MANAGEMENT	2,149,702	21.68	10	40	2.17	8.67	7.588%	21.68%	755,561	2,905,263
1.2.2	CONSTRUCTION MANAGEMENT	592,779	5.98	10	40	0.60	2.39	2.092%	5.98%	208,346	801,125
1.3.1	GENERAL CONDITIONS	1,831,085	18.47	10	40	1.85	7.39	6.464%	18.47%	643,576	2,474,661
1.3.13	SPECIAL CONSTRUCTION	4,096,709	41.32	10	40	4.13	16.53	14.461%	41.32%	1,439,881	5,536,590
1.5.2	PROCUREMENT FEES	59,278	0.60	10	40	0.06	0.24	0.209%	0.60%	20,835	80,113
	ESCALATION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
	SUBTOTAL	9,915,110	100.00					35.000%			
	CALCULATED CONTINGENCY	3,470,289									
	RESULTANT TEC	13,385,399									
	ROUNDED TEC	13,400,000									
	PROJECT CONTINGENCY	3,484,890						35.15%			
	MANAGEMENT RESERVE	598,707									
	CONTINGENCY	2,886,183									
	TOTAL ESTIMATED COST	13,400,000								3,484,890	13,400,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE
RISK BASED CLEAN CLOSURE; CLASS A FILL; UNESCALATED

CLEAN BINS W/ ROBOTS - PIPING

PROCUREMENT FEE:

CONSTRUCTION =	$5,927,794		
GFE =			
Subtotal	$5,927,794		
FEE @ 1% =	$5,927,794	• 0.01 =	$59,278

G&A @ 23% (with a ceiling of $500,000 imposed per year, 10 yrs)

CONSTRUCTION OR CEILING * 10 YEARS =	$5,000,000		
GFE =	$0		
PROCUREMENT FEE =	$59,278		
Subtotal	$5,059,278		
FEE @ 23% =	$5,059,278	* 0.23 =	$1,163,634

PIF @ 5.5%

CONSTRUCTION =	$5,927,794		
GFE =	$0		
PROCUREMENT FEE =	$59,278		
G&A =	$1,163,634		
Subtotal	$7,150,706		
FEE @ 5.5% =	$7,150,706	• 0.055 =	$393,289

TOTAL PROCUREMENT FEE:	$59,278
TOTAL G&A FEE:	$1,163,634
TOTAL PIF:	$393,289

Lockheed Martin Idaho Technologies Co.
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COST ESTIMATE SUMMARY

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud Place NRC Class A Grout**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-B1**
PREPARED BY: **S. L. Coward**
REPORT NAME: **Cost Estimate Summary**

DATE: **27-Jan-1998**
TIME: **20:07:18**
CHECKED BY:
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	**ENGINEERING, DESIGN AND INSPECTION**			>> $3,192,222
1.1.1	DESIGN ENGINEERING TITLE I & II	2,660,185	0	2,660,185
1.1.2	TITLE III INSPECTION	532,037	0	532,037
1.2	**MANAGEMENT COSTS**			>> $3,594,336
1.2.1	PROJECT MANAGEMENT	2,530,262	0	2,530,262
1.2.2	CONSTRUCTION MANAGEMENT	1,064,074	0	1,064,074
1.3	**CONSTRUCTION**			>> $10,640,741
1.3.1	GENERAL CONDITIONS	3,437,150	0	3,437,150
1.3.2	SITEWORK	0	0	0
1.3.3	CONCRETE	1,387,185	0	1,387,185
1.3.15	MECHANICAL	3,365,584	0	3,365,584
1.3.16	ELECTRICAL	2,450,822	0	2,450,822
1.5.2	PROCUREMENT FEES	106,407	0	>> $106,407
	SUBTOTAL INCLUDING ESCALATION	17,533,706	0	>> $17,533,706
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $1,074,715
	CONTINGENCY			>> $5,091,579
	TOTAL ESTIMATED COST			>> $23,700,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *30.00%*

CONTINGENCY= *35.17%*

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: ICPP Bin Set Closure (EIS Study)
Place NRC Class A Grout
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423-B1
PREPARED BY: S. L. Coward

DATE 27-Jan-1998
TIME: 20:07:20
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	DESIGN ENGINEERING TITLE I & II ENGINEERING AND DESIGN											
MEMO:	Title I &II Engineering & Design @ 20% of Construction	1	LS		*LMITCO*	0.000					2,128,148	2,128,148
MEMO:	Conceptual Design @ 5% of Construction	1	LS		*LMITCO*	0.000					532,037	532,037
	DESIGN ENGINEERING TITLE I & II S/T						0				$2,660,185	$2,660,185
1.1.2	TITLE III INSPECTION INSPECTION - TITLE III	1	LS		*LMITCO*	0.000					532,037	532,037
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$532,037	$532,037
1.2.1	PROJECT MANAGEMENT PROJECT MANAGEMENT	1	LS		*LMITCO*	0.000					1,064,074	1,064,074
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		*LMITCO*	0.000					829,474	829,474
	PIF	1	LS		*LMITCO*	0.000					636,714	636,714
	PROJECT MANAGEMENT S/T						0				$2,530,262	$2,530,262

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 2

PROJECT NAME: ICPP Bin Set Closure (EIS Study)
Place NRC Class A Grout
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423-B1
PREPARED BY: S. L. Coward

DATE 27-Jan-1998
TIME: 20:07:20
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	CONSTRUCTION MANAGEMENT											
	CONSTRUCTION MANAGEMENT	1	LS		LMITCO	0.000					1,064,074	1,064,074
MEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$1,064,074	$1,064,074
1.3.1	GENERAL CONDITIONS											
	SUPERVISION (Duration of Project - Assume 10 Years)	1	FTE		CONF GEN	20800.0	20,800	691,600				691,600
	TRAINING	20	FTE		CONC GEN	165.000	3,300	105,699				105,699
	RADCON TECHNICIAN SUPPORT (Duration of Project - Assume 10 Years)	2	FTE		Z-1342 LMITCO	20800.0	41,600	2,055,040				2,055,040
	GENERAL CONDITIONS S/T						65,700	$2,852,339				$2,852,339
1.3.2	SITEWORK											
	ASSUME NO EXCAVATION WILL BE REQUIRED FOR MONITORS											
	SITEWORK S/T						0					
1.3.3	CONCRETE											

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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place NRC Class A Grout
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-B1**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **20:07:20**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.3	CONCRETE PROCURE EQUIPMENT FOR PLACEMENT OF GROUT											
	Grout Booster Pump	1	EA	55,000.00	GEN	0.000				55,000		55,000
	Air Compressor and Miscellaneous Cleaning Equipment	1	LS	25,000.00	GEN	0.000				25,000		25,000
	"A" FRAME HOIST FOR LIFTING OF FILL PIPE	100	EA	2,000.00	CONC GEN	40.000	4,000	128,120		200,000		328,120
	POUR CLASS A GROUT AND CLEAN PIPE (Includes 10% Waste)	10,406	CY	0.28	CONC GEN	0.800	8,325	266,643		2,914		269,557
	CLEANING OF PIPING AFTER EACH LIFT	666	LIFTS	30.00	CONC GEN	0.500	333	10,666		19,980		30,646
	6" CAPS FOR PENETRATIONS (Assume 2 per bin)	100	EA	500.00	CONC GEN	24.000	2,400	76,872		50,000		126,872
	CONCRETE S/T						15,058	$482,301		$352,894		$835,195
1.3.15	MECHANICAL											
	DOUBLE CONTAINED GROUT DELIVERY PIPE (Includes 10% Waste)	3,367	LF	47.00	CONC GEN	1.200	4,040	129,414	10,101	158,249	13,468	311,232
	VALVE MANIFOLD ASSEMBLY (7 Vaults plus 1 Extra)	8	EA	100,000.00	CONC GEN	80.000	640	20,499		800,000		820,499
MEMO:	Self-Contained Sealed Unit to Mitigate Leakage during Grout Placement											
	REMOVAL OF RETR.TUBES (2 per Bin) Add'l labor for removal)	7,300	LF	0.20	CONC GEN	0.250	1,825	58,455		1,460		59,915

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place NRC Class A Grout
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-B1**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **20:07:20**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.15	**MECHANICAL** REMOVAL AND DISPOSAL OF GROUT DELIVERY PIPE AND RETR. TUBES	10,667	LF	1.50	CONC *GEN*	1.740	18,561	594,495		16,001	160,005	770,501
MEMO:	Incl. Glovebag, Cuts to Rad Box, Handl., Rad Box Purch. & Disposal											
	VALVE/MANIFOLD REMOVAL	8	EA	2,000.00	CONC *GEN*	480.000	3,840	122,995		16,000	5,600	144,595
MEMO:	Incl. Rad Tent, Disconnect from Piping &Pump, Rad Boxes & Disposal											
	MECHANICAL S/T						28,906	$925,859	$10,101	$991,710	$179,073	$2,106,742
1.3.16	**ELECTRICAL**											
	RAD MONITORS IN EXISTING LANCES	42	EA	30,000.00	CONC *GEN*	150.000	6,300	201,789		1,260,000		1,461,789
	MONITOR TANKS DURING CLASS A GROUT POUR	1	LS		CONC *GEN*	2400.00	2,400	76,872				76,872
MEMO;	Assume Readings take 2 Days Once per Month for 10 Yrs											
	CERCLA tp Monitor after Leaks are Filled with Class A Grout											
	ELECTRICAL S/T						8,700	$278,661		$1,260,000		$1,538,661
	PROJECT SUBTOTAL						118,364	$4,639,160	$10,101	$2,604,603	$6,965,631	$14,119,495

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: ICPP Bin Set Closure (EIS Stud
Place NRC Class A Grout
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-B1
PREPARED BY: S. L. Coward

DATE: 27-Jan-1998
TIME: 20:07:15

REPORT NAME: Contingency Analysis

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	2,660,185	15.17	10	40	1.52	6.07	5.310%	15.17%	935,540	3,595,725
1.1.2	TITLE III INSPECTION	532,037	3.03	10	40	0.30	1.21	1.062%	3.03%	187,108	719,145
1.2.1	PROJECT MANAGEMENT	2,530,262	14.43	10	40	1.44	5.77	5.051%	14.43%	889,848	3,420,110
1.2.2	CONSTRUCTION MANAGEMENT	1,064,074	6.07	10	40	0.61	2.43	2.124%	6.07%	374,216	1,438,290
1.3.1	GENERAL CONDITIONS	3,437,150	19.60	10	40	1.96	7.84	6.861%	19.60%	1,208,785	4,645,935
1.3.2	SITEWORK	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.3.3	CONCRETE	1,387,185	7.91	10	40	0.79	3.16	2.769%	7.91%	487,848	1,875,033
1.3.15	MECHANICAL	3,365,584	19.19	10	40	1.92	7.68	6.718%	19.19%	1,183,616	4,549,200
1.3.16	ELECTRICAL	2,450,822	13.98	10	40	1.40	5.59	4.892%	13.98%	861,911	3,312,733
1.5.2	PROCUREMENT FEES	106,407	0.61	10	40	0.06	0.24	0.212%	0.61%	37,421	143,828
	ESCALATION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	1	1
	SUBTOTAL	17,533,706	100.00					35.000%			
	CALCULATED CONTINGENCY	6,136,797									
	RESULTANT TEC	23,670,503									
	ROUNDED TEC	23,700,000									
	PROJECT CONTINGENCY	6,166,294						35.17%			
	MANAGEMENT RESERVE	1,074,715									
	CONTINGENCY	5,091,579									
	TOTAL ESTIMATED COST	23,700,000								6,166,294	23,700,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% -- 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% -- 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% -- 20%
TITLE II	5% -- 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE
RISK BASED CLEAN CLOSURE; CLASS A FILL; UNESCALATED

FILL BINS W/ NRC CLASS A GROUT

PROCUREMENT FEE:

CONSTRUCTION =		$10,640,741		
GFE =				
	Subtotal	$10,640,741		
FEE @ 1% =		$10,640,741	* 0.01 =	$106,407

G&A @ 23% (with a ceiling of $500,000 imposed per year, 7 yrs)

CONSTRUCTION OR CEILING • 7 YEARS =		$3,500,000		
GFE =		$0		
PROCUREMENT FEE =		$106,407		
	Subtotal	$3,606,407		
FEE @ 23% =		$3,606,407	• 0.23 =	$829,474

PIF @ 5.5%

CONSTRUCTION =		$10,640,741		
GFE =		$0		
PROCUREMENT FEE =		$106,407		
G&A =		$829,474		
	Subtotal	$11,576,622		
FEE @ 5.5% =		$11,576,622	• 0.055 =	$636,714

TOTAL PROCUREMENT FEE:	$106,407
TOTAL G&A FEE:	$829,474
TOTAL PIF:	$636,714

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COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure
D&D of Equipment
LOCATION 1: INEEL / ICPP
REQUESTOR: B. C. Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423D&D
PREPARED BY: S.L.Coward/smb
REPORT NAME: Cost Estimate Summary

DATE: 27-Jan-1998
TIME: 19:33:11
CHECKED BY:
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $0
1.1.1	DESIGN ENGINEERING TITLE I & II	0	0	0
1.1.2	TITLE III INSPECTION	0	0	0
1.2	MANAGEMENT COSTS			>> $800,213
1.2.1	PROJECT MANAGEMENT	800,213	0	800,213
1.2.2	CONSTRUCTION MANAGEMENT	0	0	0
1.3	CONSTRUCTION			>> $11,709,711
1.3.13	SPECIAL CONSTRUCTION	11,709,711	0	11,709,711
1.5.2	PROCUREMENT FEES	117,097	0	>> $117,097
	SUBTOTAL INCLUDING ESCALATION	12,627,021	0	>> $12,627,021
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $0
	CONTINGENCY			>> $4,372,979
	TOTAL ESTIMATED COST			>> $17,000,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *0.00%*

CONTINGENCY= *34.63%*

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DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: ICPP Bin Set Closure
D&D of Equipment
LOCATION 1: INEEL / ICPP
REQUESTOR B. C. Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423D&D
PREPARED BY: S.L.Coward/smb

DATE 27-Jan-1998
TIME: 19:30:57
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	DESIGN ENGINEERING TITLE I & II											
	Costs for Design activities included in Special Construction											
	DESIGN ENGINEERING TITLE I & II S/T						0					
1.1.2	TITLE III INSPECTION											
	Costs for inspection activities included in Special Construction											
	TITLE III INSPECTION S/T						0					
1.2.1	PROJECT MANAGEMENT											
	Costs for Project Management activities included in Special Construction											
	G&A	1	LS		LMITCO	0.000					141,932	141,932
	PIF	1	LS		LMITCO	0.000					658,281	658,281
	PROJECT MANAGEMENT S/T						0				$800,213	$800,213
1.2.2	CONSTRUCTION MANAGEMENT											

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PROJECT NAME: **ICPP Bin Set Closure**
D&D of Equipment
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

DETAILED COST ESTIMATE SHEET

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423D&D**
PREPARED BY: **S.L.Coward/smb**

DATE **27-Jan-1998**
TIME: **19:30:57**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	CONSTRUCTION MANAGEMENT Costs for Construction Management activities included in Special Construction											
	CONSTRUCTION MANAGEMENT S/T						0					
1.3.13	SPECIAL CONSTRUCTION											
	Ventilation, Instrument and Control Building (VIC) - 7 ea @ 2400 sf	1	lot			0.000					969,133	969,133
	- Assume facility will have low levels of hazardous material											
	- Assume facility will have no rad contamination											
	- Assume facility will have no asbestos											
	Confinement Enclosures (top of Bin Sets) - 7 ea @ 1600 sf	1	lot			0.000					1,248,126	1,248,126
	Bridge Crane - 7 ea @ 300 sf	1	lot			0.000					369,376	369,376
	- Assume bridge 40' across x 45' high x 2' wide for rails											
	- Assume trolley @ 5' x 5' x 5'											
	HVAC Equipment/System - 1 ea @ 5800 sf	1	lot			0.000					449,044	449,044
	- Assume 7 air handlers @ 5'x5'x6'											
	- Assume 3 exhaust fans @ 4'x4'x3'											

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DETAILED COST ESTIMATE SHEET

PAGE # 3

PROJECT NAME ICPP Bin Set Closure
D&D of Equipment
LOCATION 1 INEEL / ICPP
REQUESTOR: B. C. Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423D&D
PREPARED BY: S.L.Coward/smb

DATE 27-Jan-1998
TIME: 19:30:57
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	**SPECIAL CONSTRUCTION** - Assume 63 HEPA filters @ 6'x6'x2'											
	Jumper Retrieval Piping (Shielded) - 1 ea @ 420 sf	1	lot			0.000					109,494	109,494
	- Assume 210' long x 2' wide concrete											
	Remote Core Drilling Platform/Saw, etc. - 1 ea @ 250 sf	1	lot			0.000					55,966	55,966
	- Assume platform @ 5' x 5' x 6' and saw is 100 sf											
	Remote Welding and Cutting Equipment - Allowance - 1 ea @ 500 sf	1	lot			0.000					111,932	111,932
	Vertical Deployment Apparlus - 7 ea @ 150 sf	1	lot			0.000					235,057	235,057
	- Assume 5' x 5' x 6'											
	Shielding & Riser Plugs - 100 ea @ 4 sf	1	lot			0.000					116,794	116,794
	- Assume 2' x 2'											
	CO2 Blasting Equipment - Allowance - 2 ea @ 500 sf	1	lot			0.000					223,864	223,864
	Retrieval Lines - 1 ea @ 2310 sf	1	lot			0.000					373,116	373,116
	- Assume 2310' long x 1' wide											
	Control Consoles, Cameras, Lighting - Allowance - 1 ea @ 1000 sf	1	lot			0.000					107,934	107,934
	Grouting Manifolds - Clean - Allowance - 8 ea @ 300 sf	1	lot			0.000					259,043	259,043

DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure**
D&D of Equipment
LOCATION 1: **INEEL / ICPP**
REQUESTOR **B. C. Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423D&D**
PREPARED BY: **S.L.Coward/smb**

DATE **27-Jan-1998**
TIME: **19:30:57**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	SPECIAL CONSTRUCTION											
	Grouting Manifolds - Class C - Allowance - 8 ea @ 300 sf	1	lot			0.000					537,274	537,274
	LDUA's - Allowance - 7 ea @ 150 sf	1	lot			0.000					209,873	209,873
	Pipe Crawler Robots - Allowance - 7 ea @ 150 sf	1	lot			0.000					209,873	209,873
	Tractor Robots - Allowance - 53 ea @ 250 sf	1	lot			0.000					2,648,393	2,648,393
	Misc Robot Wire and Hose Lines - Allowance - 1 ea @ 1000 sf	1	lot			0.000					199,879	199,879
	Waste Disposal - quantities as stated in EDF											
	- Solid Waste	500	cf			0.000					540	540
	- Radioactive Waste	10,000	cf			0.000					3,000,000	3,000,000
	- Mixed Waste	2,200	cf			0.000					275,000	275,000
	SPECIAL CONSTRUCTION S/T						0				$*,***,***	$11,709,711
	PROJECT SUBTOTAL						0	$0	$0	$0	$12,509,924	$12,509,924

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CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure D&D of Equipment**
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423D&D**
PREPARED BY: **S.L.Coward/smb**

DATE: **27-Jan-1998**
TIME: **19:33:04**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.1.2	TITLE III INSPECTION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.2.1	PROJECT MANAGEMENT	800,213	6.34	10	40	0.63	2.53	2.218%	6.34%	277,129	1,077,342
1.2.2	CONSTRUCTION MANAGEMENT	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.3.13	SPECIAL CONSTRUCTION	11,709,711	92.74	10	40	9.27	37.09	32.457%	92.74%	4,055,297	15,765,008
1.5.2	PROCUREMENT FEES	117,097	0.93	10	40	0.09	0.37	0.325%	0.93%	40,553	157,650
	ESCALATION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
	SUBTOTAL	12,627,021	100.00					35.000%			
	CALCULATED CONTINGENCY	4,419,457									
	RESULTANT TEC	17,046,478									
	ROUNDED TEC	17,000,000									
	PROJECT CONTINGENCY	4,372,979						34.63%			
	MANAGEMENT RESERVE	0									
	CONTINGENCY	4,372,979									
	TOTAL ESTIMATED COST	17,000,000								4,372,979	17,000,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

INEL RAD Contaminated Surplus Facilities Cost Model ==> D&D Cost

CPP Bin Set Closure

Project File #015720
Prepared by Sherry Coward

Qty (ea.)	*ID Number*	*Facility Description*	*Total Usable Floor Space Square Feet*	*Bldg Lvls*	*Facility Rating*						*D&D ROM Cost ($)*
					ACM	*HAZ*	*RAD*	*SYS*	*Bldg*	*CHRTZ*	
	[illegible]										
7	See Note 1	Ventilation, Instr. & Control Bldg (VIC)	2,400	1	NA	L	NA	L	S	L	969,133
7		Confinement Enclosures (top of Bin Sets)	1,600	1	NA	A	A	L	S	L	1,248,126
7	See Note 2	Bridge Crane	300	1	NA	L	H	L	S	L	369,376
1	See Note 3	HVAC Equipment/System	5,800	1	NA	L	A	L	S	L	449,044
1	See Note 4	Jumper Retrieval Piping (Shielded)	420	1	NA	A	H	L	C	L	109,494
1	See Note 5	Remote Core Drilling Platform/Saw, etc.	250	1	NA	H	H	L	S	L	55,968
1	Allowance	Remote Welding and Cutting Equipment	500	1	NA	H	H	L	S	L	111,932
7	See Note 6	Vertical Deployment Apparatus	150	1	NA	H	H	L	S	L	235,057
100	See Note 7	Shielding and Riser Plugs	4	1	NA	H	H	L	C	L	116,794
2	Allowance	CO2 Blasting Equipment	600	1	NA	H	H	L	S	L	223,884
1	See Note 8	Retrieval Lines	2,310	1	NA	H	H	L	S	L	373,116
1	Allowance	Control Consoles, Cameras & Lighting	1,000	1	NA	L	L	L	S	L	107,934
8	Allowance	Grouting Manifolds - Clean	300	1	NA	L	L	L	S	L	259,043
8	Allowance	Grouting Manifolds - Class C	300	1	NA	H	H	L	S	L	537,274
7	Allowance	LDUA's	150	1	NA	A	H	L	S	L	209,873
7	Allowance	Pipe Crawler Robots	150	1	NA	A	H	L	S	L	209,873
63	Allowance	Tractor Robots	250	1	NA	A	H	L	S	L	2,648,393
1	Allowance	Misc Robot wire and hose lines	1,000	1	NA	A	H	L	S	L	199,879
	See Note 9	Waste Disposal									
		Solid Waste (in CF)	500								.540
		Radioactive Waste (in CF)	10,000								3,000,000
		Mixed Waste (in CF)	2,200								275,000
		Subtotal ICPP BIN SET CLOSURE									11,709,711

NOTES:

1 - Assumed that facility will have low levels of hazardous material, no rad contamination, and no asbestos
2 - Assume 40' across by 45' high x 2' w for rails plus trolley (5' x 5' x 5')
3 - Assume 7 Air handlers (5' x 5' x 6'), 3 Exhaust Fans (4' x 4' x 3'), and 63 HEPA filters (6' x 6' x 2')
4 - Assume 210 LF x 2' wide concrete
5 - Assume platform (5' x 5' x 6) plus saw (100 sf)
6 - Assume 5' x 5' x 6'
7 - Assume 2' x 2' plugs
8 - Assume 2310' x 1' wide
9 - Waste Disposal Quantities were provided by EDF
Assume the following Waste Disposal Unit Costs:

Industrial Landfill	$1.08/cf
Low Level Waste Repository	$125/cf
Rad Waste	$300/cf

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE
RISK BASED CLEAN CLOSURE; CLASS A FILL; UNESCALATED

D&D OF EQUIPMENT

PROCUREMENT FEE:

CONSTRUCTION =	$11,709,711		
GFE =			
Subtotal	$11,709,711		
FEE @ 1% =	$11,709,711	* 0.01 =	$117,097

G&A @ 23% (with a ceiling of $500,000 imposed per year, 1 yr)

CONSTRUCTION OR CEILING * 1 YEARS =	$500,000		
GFE =	$0		
PROCUREMENT FEE =	$117,097		
Subtotal	$617,097		
FEE @ 23% =	$617,097	* 0.23 =	$141,932

PIF @ 5.5%

CONSTRUCTION =	$11,709,711		
GFE =	$0		
PROCUREMENT FEE =	$117,097		
G&A =	$141,932		
Subtotal	$11,968,740		
FEE @ 5.5% =	$11,968,740	* 0.055 =	$658,281

TOTAL PROCUREMENT FEE:	$117,097
TOTAL G&A FEE:	$141,932
TOTAL PIF:	$658,281

COST ESTIMATE SUMMARY
ESCALATED

ICPP BIN SET CLOSURE **RISK BASED CLEAN CLOSURE** **CLASS A FILL** **Requestor: B. C. Spaulding**	Planning Estimate Estimate #2423 Prepared by: S. L. Coward	1/28/98 Checked by: Approved by:

Regulatory Compliance		31,600,000
Fill Vaults with Clean Grout		23,300,000
Clean Bins with Robots		
Floor		258,700,000
Walls		58,200,000
Piping		27,100,000
Fill Bins with NRC Class A Grout		51,900,000
D&D of Equipment		50,600,000
TOTAL		**$501,400,000**
	USE	**$501,000,000**

Lockheed Martin Idaho Technologies Co.
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COST ESTIMATE SUMMARY

PROJECT NAME: Permitting/Documentation Risk Based - NRC Class C
LOCATION 1: INEEL/ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: PLANNING
PROJECT NO: 2423-BD-E
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 28-Jan-1998
TIME: 11:02:58
CHECKED BY:
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	CONCEPTUAL			>> $0
1.1.1	CONCEPTUAL DESIGN	0	0	0
1.2	MANAGEMENT			>> $3,800,720
1.2.1	PM FOR PROJECT DEVELOPMENT	1,942,993	1,107,506	3,050,499
1.2.2	PROJECT EXECUTION	477,848	272,373	750,221
1.3	PERMITTING			>> $19,444,616
1.3.1	PERMITTING	12,385,106	7,059,510	19,444,616
1.5.2	PROCUREMENT FEES	123,851	70,595	>> $194,446
	SUBTOTAL INCLUDING ESCALATION	14,929,798	8,509,984	>> $23,439,782
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $1,963,906
	CONTINGENCY			>> $6,196,312
	TOTAL ESTIMATED COST			>> $31,600,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *0.00%*
CONTINGENCY= *34.81%*

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DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: **Permitting/Documentation**
Risk Based - NRC Class C
LOCATION 1: **INEEL/ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **PLANNING**
PROJECT NO.: **2423-BD-E**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **11:03:00**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	CONCEPTUAL DESIGN											
	CONCEPTUAL DESIGN S/T						0					
1.2.1	PM FOR PROJECT DEVELOPMENT											
	G&A	1	LS		*LMITCO*	0.000					619,723	619,723
	PIF	1	LS		*LMITCO*	0.000					725,960	725,960
	PM FOR PROJECT DEVELOPMENT S/T						0				$1,345,683	$1,345,683
1.2.1.1	PROJECT ADMINISTRATION Project Admin. during Documentation (5% of Doc. Costs)	1	LOT		*LMITCO*	0.000					597,310	597,310
	PROJECT ADMINISTRATION S/T						0				$597,310	$597,310
1.2.2	PROJECT EXECUTION											
	PROJECT EXECUTION S/T						0					
1.2.1.2	PROJECT SUPPORT Support During permitting/Doc. (4% of doc. costs)	1	LOT		*LMITCO*	0.000					477,848	477,848
	PROJECT SUPPORT S/T						0				$477,848	$477,848

DETAILED COST ESTIMATE SHEET

PROJECT NAME: **Permitting/Documentation**
Risk Based - NRC Class C
LOCATION 1: **INEEL/ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **PLANNING**
PROJECT NO.: **2423-BD-E**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **11:03:00**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.1	PERMITTING											
	RCRC Closure (Incl. Writing, Reviews, Public Comments & Issuance of Permits)	2	FTE		Z-1700 *LMITCO*	1440.00	2,880	186,221				186,221
	Air Monitoring Activities, Fees, etc.	2	LS		*LMITCO*	0.000					1,208,900	1,208,900
	P.E. Activities	1	LS		*LMITCO*	0.000					60,000	60,000
	CAA Permit to Construct (Incl. Preparing, Reviews, Public comments & Issuance)	1	LS		Z-1700 *LMITCO*	1800.00	1,800	116,388				116,388
	CERCLA Coordinator	2	FTE		Z-1700 *LMITCO*	1500.00	3,000	193,980				193,980
	Regulatory Affairs Oversight	10	YR		Z-1700 *LMITCO*	150.000	1,500	96,990				96,990
	Other Regulatory Compliance (CWA, Storm Water, Historical, etc.)	1	LS		Z-1700 *LMITCO*	1000.00	1,000	64,660				64,660
	Survey Plat	1	LS		*LMITCO*	0.000					10,000	10,000
	SARR	1	LS		Z-3170 *LMITCO*	4500.00	4,500	312,255				312,255
	NRC Landfill Disposal Requirements	10	LS		Z-1710 *LMITCO*	9000.00	90,000	4,960,800				4,960,800
	Environmental & Hazards Analysis	2	FTE		Z-1710 *LMITCO*	1800.00	3,600	198,432				198,432
	Seismic Test Bores (Allowance)	20	HOLES		Z-1710 *LMITCO*	2700.00	54,000	2,976,480				2,976,480
	Operational Readiness Review	1	LS		*LMITCO*	0.000					2,000,000	2,000,000
	PERMITTING S/T						162,280	$9,106,206			$3,278,900	$12,385,106
	PROJECT SUBTOTAL						162,280	$9,106,206	$0	$0	$5,699,741	$14,805,947

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CONTINGENCY ANALYSIS

PROJECT NAME: **Permitting/Documentation Risk Based - NRC Class C**
LOCATION 1: **INEEL/ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **PLANNING**
PROJECT NO: **2423-BD-E**
PREPARED BY: **S. L. Coward**

DATE: **28-Jan-1998**
TIME: **11:02:47**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	CONCEPTUAL DESIGN	0	0.00	10	40	0.00	0.00	0.000%	0.00%	0	0
1.2.1	PM FOR PROJECT DEVELOPMENT	1,942,993	8.29	10	40	0.83	3.32	2.901%	8.29%	676,425	2,619,418
1.2.2	PROJECT EXECUTION	477,848	2.04	10	40	0.20	0.82	0.714%	2.04%	166,356	644,204
1.3.1	PERMITTING	12,385,106	52.84	10	40	5.28	21.14	18.493%	52.84%	4,311,694	16,696,800
1.5.2	PROCUREMENT FEES	123,851	0.53	10	40	0.05	0.21	0.185%	0.53%	43,117	166,968
	ESCALATION	8,509,984	36.31	10	40	3.63	14.52	12.707%	36.31%	2,962,626	11,472,610
	SUBTOTAL	23,439,782	100.00					35.000%			
	CALCULATED CONTINGENCY	8,203,924									
	RESULTANT TEC	31,643,706									
	ROUNDED TEC	31,600,000									
	PROJECT CONTINGENCY	8,160,218						34.81%			
	MANAGEMENT RESERVE	1,963,906									
	CONTINGENCY	6,196,312									
	TOTAL ESTIMATED COST	31,600,000								8,160,218	31,600,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE
RISK BASED CLEAN CLOSURE; CLASS A FILL; ESCALATED

REGULATORY COMPLIANCE

PROCUREMENT FEE:

CONSTRUCTION =		$19,444,616		
GFE =				
	Subtotal	$19,444,616		
FEE @ 1% =		$19,444,616	* 0.01 =	$194,446

G&A @ 23% (with a ceiling of $500,000 imposed per year, 5 yrs)

CONSTRUCTION OR CEILING * 5 YEARS =		$2,500,000		
GFE =		$0		
PROCUREMENT FEE =		$194,446		
	Subtotal	$2,694,446		
FEE @ 23% =		$2,694,446	* 0.23 =	$619,723

PIF @ 5.5%

CONSTRUCTION =		$12,385,106		
GFE =		$0		
PROCUREMENT FEE =		$194,446		
G&A =		$619,723		
	Subtotal	$13,199,275		
FEE @ 5.5% =		$13,199,275	* 0.055 =	$725,960

TOTAL PROCUREMENT FEE:	$194,446
TOTAL G&A FEE:	$619,723
TOTAL PIF:	$725,960

Lockheed Martin Idaho Technologies Co.
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COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure (EIS Stud
Place Clean Grout in Vault
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-A2-E1
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 28-Jan-1998
TIME: 10:21:14
CHECKED BY: SMB
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $2,493,296
1.1.1	DESIGN ENGINEERING	1,324,812	649,158	1,973,970
1.1.2	TITLE III INSPECTION	264,962	254,364	519,326
1.2	MANAGEMENT COSTS			>> $4,288,659
1.2.1	PROJECT MANAGEMENT	1,701,574	1,548,432	3,250,006
1.2.2	CONSTRUCTION MANAGEMENT	529,925	508,728	1,038,653
1.3	CONSTRUCTION			>> $10,386,530
1.3.1	GENERAL CONDITIONS	1,067,791	1,025,079	2,092,870
1.3.2	SITEWORK	0	0	0
1.3.3	CONCRETE	4,231,459	4,062,201	8,293,660
1.5.2	PROCUREMENT FEES	52,992	50,873	>> $103,865
	SUBTOTAL INCLUDING ESCALATION	9,173,515	8,098,835	>> $17,272,350
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $1,049,039
	CONTINGENCY			>> $4,978,611
	TOTAL ESTIMATED COST			>> $23,300,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *24.00%*

CONTINGENCY= *34.90%*

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE #. 1

PROJECT NAME: ICPP Bin Set Closure (EIS Study)
Place Clean Grout in Vault
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423-A2-E1
PREPARED BY: S. L. Coward

DATE 28-Jan-1998
TIME: 10:21:16
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	**DESIGN ENGINEERING** ENGINEERING AND DESIGN											
MEMO:	Title I &II Engineering & Design @ 20% of Construction	1	LS		*LMITCO*	0.000					1,059,850	1,059,850
MEMO:	Conceptual Engineering & Design @ 5% of Construction	1	LS		*LMITCO*	0.000					264,962	264,962
	DESIGN ENGINEERING S/T						0				**$1,324,812**	**$1,324,812**
1.1.2	**TITLE III INSPECTION** INSPECTION - TITLE III	1	LS		*LMITCO*	0.000					264,962	264,962
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				**$264,962**	**$264,962**
1.2.1	**PROJECT MANAGEMENT** PROJECT MANAGEMENT	1	LS		*LMITCO*	0.000					529,925	529,925
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		*LMITCO*	0.000					828,889	828,889
	PIF	1	LS		*LMITCO*	0.000					342,760	342,760
	PROJECT MANAGEMENT S/T						0				**$1,701,574**	**$1,701,574**

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 2

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place Clean Grout In Vault
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-A2-E1**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **10:21:16**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	CONSTRUCTION MANAGEMENT CONSTRUCTION MANAGEMENT	1	LS		*LMITCO*	0.000					529,925	529,925
MEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$529,925	$529,925
1.3.1	GENERAL CONDITIONS SUPERVISION (Duration of Schedule - Assume 3 Years)	1	FTE		CONF *GEN*	6240.00	6,240	207,480				207,480
	TRAINING	10	FTE		CONC *GEN*	165.000	1,650	52,850				52,850
	RADCON TECHNICIAN (Duration of Schedule - Assume 3 Years)	2	FTE		Z-1342 *LMITCO*	6240.00	12,480	616,512				616,512
	GENERAL CONDITIONS S/T						20,370	$876,842				$876,842
1.3.2	SITEWORK											
	SITEWORK S/T						0					
1.3.3	CONCRETE											
	PROCURE EQUIPMENT FOR PLACEMENT OF GROUT											
	Grout Pump	1	EA		*GEN*	0.000			55,000			55,000

DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place Clean Grout In Vault
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-A2-E1**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **10:21:16**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.3	CONCRETE Air Compressor and Miscellaneous Cleaning Equipment	1	EA		GEN	0.000			25,000			25,000
	GROUT DELIVERY PIPING AND ACCESSORIES PURCHASE (Incl. 10% Waste)	415	LF	20.00	GEN	0.000				8,300		8,300
	GROUT DELIVERY PIPING (Incl. 10% Waste)	2,905	LF		CONC GEN	0.470	1,365	43,732				43,732
MEMO:	Install, Remove & Clean Pipe after Each Vault (7 Vaults)											
	GROUT DELIVERY PIPING CLEANING BETWEEN MANIFOLDS & DROP TUBES	676	LIFTS	30.00	CONC GEN	0.500	338	10,826		20,280		31,106
MEMO:	Assume cleaning between each lift											
	GROUT MANIFOLD AND CLEANING SYSTEM	1	LOT	7,500.00	CONC GEN	254.000	254	8,136		7,500		15,636
MEMO:	Can be Reused after each Vault Set (7 times)											
	CONCRETE S/T						1,957	$62,694	$80,000	$36,080		$178,774
1.3.3.1	VAULT GROUTING PURCHASE GROUT DROP TUBES AND ACCESSORIES	390	LF	20.00	GEN	0.000				7,800		7,800
MEMO:	Assume 88' long for 4 Tubes per Vault Plus 10% Waste (Can be Reused)											
	INSTALL AND REMOVE DROP TUBES	2,123	LF		CONC GEN	0.500	1,062	34,000				34,000

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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place Clean Grout In Vault
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-A2-E1**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **10:21:16**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.3.1	**VAULT GROUTING**											
MEMO:	Assume 4 tubes x 7 vaults plus 10% waste											
	GROUT PLACEMENT & CLEANUP (Includes 10% Waste)	22,946	CY	80.00	CONC GEN	0.350	8,031	257,236		1,835,680		2,092,916
	VAULT GROUTING S/T						9,093	$291,236		$1,843,480		$2,134,716
1.3.3.2	**BIN SET VAULT ACCESS HOLES**											
	CORE DRILL 18" HOLE THROUGH VAULT ROOF (4 PLACES/VAULT)	28	EA	1,000.00	CONC GEN	100.000	2,800	89,684		28,000		117,684
	SHIELDING AROUND VAULT HOLES	28	EA	5,000.00	CONC GEN	24.000	672	21,524		140,000		161,524
	CAP 18" DIAMETER HOLES	28	EA	1,800.00	CONC GEN	40.000	1,120	35,874		50,400		86,274
	BIN SET VAULT ACCESS HOLES S/T						4,592	$147,082		$218,400		$366,482
	PROJECT SUBTOTAL						36,012	$1,377,853	$80,000	$2,097,960	$3,821,273	$7,377,086

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CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud Place Clean Grout in Vault**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-A2-E1**
PREPARED BY: **S. L. Coward**

DATE: **28-Jan-1998**
TIME: **10:20:01**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING	1,324,812	7.67	10	40	0.77	3.07	2.685%	7.67%	462,329	1,787,141
1.1.2	TITLE III INSPECTION	264,962	1.53	10	40	0.15	0.61	0.537%	1.53%	92,466	357,428
1.2.1	PROJECT MANAGEMENT	1,701,574	9.85	10	40	0.99	3.94	3.448%	9.85%	593,810	2,295,384
1.2.2	CONSTRUCTION MANAGEMENT	529,925	3.07	10	40	0.31	1.23	1.074%	3.07%	184,932	714,857
1.3.1	GENERAL CONDITIONS	1,067,791	6.18	10	40	0.62	2.47	2.164%	6.18%	372,634	1,440,425
1.3.2	SITEWORK	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.3.3	CONCRETE	4,231,459	24.50	10	40	2.45	9.80	8.574%	24.50%	1,476,681	5,708,140
1.5.2	PROCUREMENT FEES	52,992	0.31	10	40	0.03	0.12	0.107%	0.31%	18,493	71,485
	ESCALATION	8,098,835	46.89	10	40	4.69	18.76	16.411%	46.89%	2,826,305	10,925,140
	SUBTOTAL	17,272,350	100.00					35.000%			
	CALCULATED CONTINGENCY	6,045,323									
	RESULTANT TEC	23,317,673									
	ROUNDED TEC	23,300,000									
	PROJECT CONTINGENCY	6,027,650						34.90%			
	MANAGEMENT RESERVE	1,049,039									
	CONTINGENCY	4,978,611									
	TOTAL ESTIMATED COST	23,300,000								6,027,650	23,300,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE
RISK BASED CLEAN CLOSURE; CLASS A FILL; ESCALATED

FILL VAULTS W/ CLEAN GROUT

PROCUREMENT FEE:

CONSTRUCTION =		$10,386,530		
GFE =				
	Subtotal	$10,386,530		
FEE @ 1% =		$10,386,530	* 0.01 =	$103,865

G&A @ 23% (with a ceiling of $500,000 imposed per year, 7 yrs)

CONSTRUCTION OR CEILING • 7 YEARS =		$3,500,000		
GFE =		$0		
PROCUREMENT FEE =		$103,865		
	Subtotal	$3,603,865		
FEE @ 23% =		$3,603,865	* 0.23 =	$828,889

PIF @ 5.5%

CONSTRUCTION =		$5,299,250		
GFE =		$0		
PROCUREMENT FEE =		$103,865		
G&A =		$828,889		
	Subtotal	$6,232,004		
FEE @ 5.5% =		$6,232,004	* 0.055 =	$342,760

TOTAL PROCUREMENT FEE:	$103,865
TOTAL G&A FEE:	$828,889
TOTAL PIF:	$342,760

Lockheed Martin Idaho Technologies Co.
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COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure (EIS Stud Tractor (Risk Based Estimates)
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-C1-E4
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 28-Jan-1998
TIME: 11:50:05
CHECKED BY: SMB
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $21,021,518
1.1.1	DESIGN ENGINEERING TITLE I & II	9,900,244	4,455,110	14,355,354
1.1.2	TITLE III INSPECTION	3,300,081	3,366,083	6,666,164
1.2	MANAGEMENT COSTS			>> $35,947,378
1.2.1	PROJECT MANAGEMENT	11,840,340	10,774,709	22,615,049
1.2.2	CONSTRUCTION MANAGEMENT	6,600,163	6,732,166	13,332,329
1.3	CONSTRUCTION			>> $133,323,293
1.3.1	GENERAL CONDITIONS	6,840,414	6,977,222	13,817,636
1.3.13	SPECIAL CONSTRUCTION	59,161,216	60,344,441	119,505,657
1.5.2	PROCUREMENT FEES	660,016	673,217	>> $1,333,233
	SUBTOTAL INCLUDING ESCALATION	98,302,474	93,322,948	>>$191,625,422
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $13,465,653
	CONTINGENCY			>> $53,608,925
	TOTAL ESTIMATED COST			>> $258,700,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *16.00%*
CONTINGENCY= *35.00%*

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: ICPP Bin Set Closure (EIS Study)
Tractor (Risk Based Estimates)
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423-C1-E4
PREPARED BY: S. L. Coward

DATE 28-Jan-1998
TIME: 11:50:08
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	**DESIGN ENGINEERING TITLE I & II** ENGINEERING AND DESIGN											
MEMO:	Title I &II Engineering & Design @ 10% of Construction	1	LS		*LMITCO*	0.000					6,600,163	6,600,163
	Conceptual Engineering & Design @ 5% of Construction	1	LS		*LMITCO*	0.000					3,300,081	3,300,081
	DESIGN ENGINEERING TITLE I & II S/T						0				$9,900,244	$9,900,244
1.1.2	**TITLE III INSPECTION** INSPECTION - TITLE III	1	LS		*LMITCO*	0.000					3,300,081	3,300,081
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$3,300,081	$3,300,081
1.2.1	**PROJECT MANAGEMENT** PROJECT MANAGEMENT	1	LOT		*LMITCO*	0.000					6,600,163	6,600,163
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		*LMITCO*	0.000					1,456,644	1,456,644
	PIF	1	LS		*LMITCO*	0.000					3,783,533	3,783,533
	PROJECT MANAGEMENT S/T						0				$*,***,***	$11,840,340

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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Tractor (Risk Based Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-C1-E4**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **11:50:08**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	CONSTRUCTION MANAGEMENT CONSTRUCTION MANAGEMENT	1	LOT		*LMITCO*	0.000					6,600,163	6,600,163
MEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$6,600,163	$6,600,163
1.3.1	GENERAL CONDITIONS SUPERVISION (Duration of Schedule for Installation of Robots - 10 years)	1	FTE		PIPF *GEN*	20800.0	20,800	839,696			2,841,100	3,680,796
	TRAINING	15	FTE		SKWK *GEN*	165.000	2,475	81,947				81,947
	RADCON TECHNICIAN SUPPORT (Duration of Schedule - Assume 10 Years)	2	FTE		Z-1342 *LMITCO*	20800.0	41,600	2,055,040				2,055,040
	GENERAL CONDITIONS S/T						64,875	$2,976,683			$2,841,100	$5,817,783
1.3.13	SPECIAL CONSTRUCTION											
	FABRICATION OF FOLDABLE TRACTOR ROBOT											
	Design & Develop 1rst Tractor Robot, Including:	1	EA		*GEN*	0.000					3,000,000	3,000,000
	Design, Approvals, Mock-up, Proof of Process, etc.											
	Fabrication of Additional Units	52	EA		*GEN*	0.000					*,***,***	13,000,000

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DETAILED COST ESTIMATE SHEET

PAGE # 3

PROJECT NAME: ICPP Bin Set Closure (EIS Study)
Tractor (Risk Based Estimates)
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423-C1-E4
PREPARED BY: S. L. Coward

DATE 28-Jan-1998
TIME: 11:50:08
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	**SPECIAL CONSTRUCTION** Design of Development of Modifications to Add'l Units	52	EA		GEN	0.000					1,300,000	1,300,000
	INSTALLATION OF CLEANING UNIT:											
	Install Robotic Units	50	EACH		SKWK GEN	160.000	8,000	264,880				264,880
	Install and Shield Unit Hose/Tubes (Mods, Electr., etc.) - Allowance	50	EA	5,000.00	SKWK GEN	160.000	8,000	264,880		250,000		514,880
	Systems Integration	1	LS		GEN	0.000					75,000	75,000
	CAP 18" DIAMETER HOLES	100	EA	1,800.00	SKWK GEN	40.000	4,000	132,440		180,000		312,440
	CAP 6" DIAMETER HOLES	100		500.00	SKWK GEN	24.000	2,400	79,464		50,000		129,464
	OPERATION OF CALCINE RETRIEVAL -	19	FTE		SKWK GEN	34590.0	657,210	21,760,223				21,760,223
	SPECIAL CONSTRUCTION S/T						679,610	$22,501,887		$480,000	$*,***,***	$40,356,887
	PROJECT SUBTOTAL						744,485	$25,478,570	$0	$480,000	$51,856,928	$77,815,498

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud Tractor (Risk Based Estimates)**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-C1-E4**
PREPARED BY: **S. L. Coward**

DATE: **28-Jan-1998**
TIME: **11:50:02**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	9,900,244	5.17	10	40	0.52	2.07	1.808%	5.17%	3,465,379	13,365,623
1.1.2	TITLE III INSPECTION	3,300,081	1.72	10	40	0.17	0.69	0.603%	1.72%	1,155,126	4,455,207
1.2.1	PROJECT MANAGEMENT	11,840,340	6.18	10	40	0.62	2.47	2.163%	6.18%	4,144,470	15,984,810
1.2.2	CONSTRUCTION MANAGEMENT	6,600,163	3.44	10	40	0.34	1.38	1.206%	3.44%	2,310,253	8,910,416
1.3.1	GENERAL CONDITIONS	6,840,414	3.57	10	40	0.36	1.43	1.249%	3.57%	2,394,348	9,234,762
1.3.13	SPECIAL CONSTRUCTION	59,161,216	30.87	10	40	3.09	12.35	10.806%	30.87%	20,708,179	79,869,395
1.5.2	PROCUREMENT FEES	660,016	0.34	10	40	0.03	0.14	0.121%	0.34%	231,025	891,041
	ESCALATION	93,322,948	48.70	10	40	4.87	19.48	17.045%	48.70%	32,665,798	125,988,746
	SUBTOTAL	191,625,422	100.00					35.000%			
	CALCULATED CONTINGENCY	67,068,898									
	RESULTANT TEC	258,694,320									
	ROUNDED TEC	258,700,000									
	PROJECT CONTINGENCY	67,074,578						35.00%			
	MANAGEMENT RESERVE	13,465,653									
	CONTINGENCY	53,608,925									
	TOTAL ESTIMATED COST	258,700,000								67,074,578	258,700,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE
RISK BASED CLEAN CLOSURE; CLASS A FILL; ESCALATED

CLEAN BINS W/ ROBOTS - FLOOR

PROCUREMENT FEE:

CONSTRUCTION =		$133,323,293		
GFE =				
	Subtotal	$133,323,293		
FEE @ 1% =		$133,323,293	* 0.01 =	$1,333,233

G&A @ 23% (with a ceiling of $500,000 imposed per year, 10 yrs)

CONSTRUCTION OR CEILING * 10 YEARS =		$5,000,000		
GFE =		$0		
PROCUREMENT FEE =		$1,333,233		
	Subtotal	$6,333,233		
FEE @ 23% =		$6,333,233	* 0.23 =	$1,456,644

PIF @ 5.5%

CONSTRUCTION =		$66,001,630		
GFE =		$0		
PROCUREMENT FEE =		$1,333,233		
G&A =		$1,456,644		
	Subtotal	$68,791,507		
FEE @ 5.5% =		$68,791,507	* 0.055 =	$3,783,533

TOTAL PROCUREMENT FEE:	$1,333,233
TOTAL G&A FEE:	$1,456,644
TOTAL PIF:	$3,783,533

Lockheed Martin Idaho Technologies Co.
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COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure (EIS Stud LDUA (Risk Based Estimates)
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-D-E1
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 28-Jan-1998
TIME: 11:25:28
CHECKED BY: SMB
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $4,382,322
1.1.1	DESIGN ENGINEERING TITLE I & II	2,083,513	937,581	3,021,094
1.1.2	TITLE III INSPECTION	694,504	666,724	1,361,228
1.2	MANAGEMENT COSTS			>> $11,240,306
1.2.1	PROJECT MANAGEMENT	3,447,249	2,964,634	6,411,883
1.2.2	CONSTRUCTION MANAGEMENT	2,463,481	2,364,942	4,828,423
1.3	CONSTRUCTION			>> $27,224,593
1.3.1	GENERAL CONDITIONS	1,831,085	1,757,841	3,588,926
1.3.13	SPECIAL CONSTRUCTION	12,059,014	11,576,653	23,635,667
1.5.2	PROCUREMENT FEES	138,901	133,345	>> $272,246
	SUBTOTAL INCLUDING ESCALATION	22,717,747	20,401,720	>> $43,119,467
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $2,749,684
	CONTINGENCY			>> $12,330,849
	TOTAL ESTIMATED COST			>> $58,200,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *16.00%*
CONTINGENCY= *34.97%*

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: ICPP Bin Set Closure (EIS Study)
LDUA (Risk Based Estimates)
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423-D-E1
PREPARED BY: S. L. Coward

DATE 28-Jan-1998
TIME: 11:25:30
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	DESIGN ENGINEERING TITLE I & II											
MEMO:	Title I &II Engineering & Design @ 10% of Construction	1	LS		*LMITCO*	0.000					1,389,009	1,389,009
	Conceptual Engineering & Design @ 5% of Construction	1	LS		*LMITCO*	0.000					694,504	694,504
	DESIGN ENGINEERING TITLE I & II S/T						0				$2,083,513	$2,083,513
1.1.2	TITLE III INSPECTION											
	INSPECTION - TITLE III	1	LS		*LMITCO*	0.000					694,504	694,504
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$694,504	$694,504
1.2.1	PROJECT MANAGEMENT											
	PROJECT MANAGEMENT	1	LOT		*LMITCO*	0.000					1,389,009	1,389,009
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		*LMITCO*	0.000					1,212,617	1,212,617
	PIF	1	LS		*LMITCO*	0.000					845,623	845,623
	PROJECT MANAGEMENT S/T						0				$3,447,249	$3,447,249
1.2.2	CONSTRUCTION MANAGEMENT											
	CONSTRUCTION MANAGEMENT	1	LOT		*LMITCO*	0.000					2,463,481	2,463,481

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 2

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
LDUA (Risk Based Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-D-E1**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **11:25:30**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2 MEMO:	CONSTRUCTION MANAGEMENT CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$2,463,481	$2,463,481
1.3.1	GENERAL CONDITIONS											
	SUPERVISION (Assume Share with Piping Est. (10 Yrs/2) - Duration of Schedule)	1	FTE		PIPF *GEN*	10400.0	10,400	419,848				419,848
	TRAINING	8	FTE		SKWK *GEN*	165.000	1,320	43,705				43,705
	RADCON TECHNICIAN SUPPORT (Assume Share with Piping Est (10 Yrs/2) - Duration)	2	FTE		Z-1342 *LMITCO*	10400.0	20,800	1,027,520				1,027,520
	GENERAL CONDITIONS S/T						32,520	$1,491,073				$1,491,073
1.3.13	SPECIAL CONSTRUCTION											
	DESIGN AND DEVELOPMENT OF LDUA											
	Design and Fabricate 1rst LDUA, including:	1	EA		*GEN*	0.000					5,000,000	5,000,000
	Design, Approvals, Mock-up, Proof of Process, etc.											
	Fabrication of Add'l Units	6	EA		*GEN*	0.000					2,550,000	2,550,000

Lockheed Martin Idaho Technologies Co.
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PROJECT NAME: ICPP Bin Set Closure (EIS Study)
LDUA (Risk Based Estimates)
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

DETAILED COST ESTIMATE SHEET

TYPE OF ESTIMATE. Planning
PROJECT NO.: 2423-D-E1
PREPARED BY: S. L. Coward

PAGE # 3

DATE 28-Jan-1998
TIME: 11:25:30
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	SPECIAL CONSTRUCTION Design of Modifications for add'l Units	6	EA		GEN	0.000					450,000	450,000
	INSTALLATION OF CLEANING UNIT:											
	Install Robotic Units	50	EACH		SKWK GEN	200.000	10,000	331,100				331,100
	Install and Shield Unit Hose/Tubes (Mods, Electr., etc.) - Allowance	50	EA	5,000.00	SKWK GEN	200.000	10,000	331,100		250,000		581,100
	Systems Integration	1	LS		GEN	0.000					100,000	100,000
	Shielding and Retrieval Area	7	EA		GEN	0.000					350,000	350,000
	CAP 18" DIA. HOLES - ASSUME Holes were capped in Floor Estimate	50	EA		SKWK GEN	40.000	2,000	66,220				66,220
	CAP 6" DIAMETER HOLES - Assume Holes were capped in Floor Estimate	50	EA		SKWK GEN	24.000	1,200	39,732				39,732
	OPERATION OF CALCINE RETRIEVAL	19	FTE		SKWK GEN	828.000	15,732	520,887				520,887
	SPECIAL CONSTRUCTION S/T						38,932	$1,289,039		$250,000	$8,450,000	$9,989,039
	PROJECT SUBTOTAL						71,452	$2,780,112	$0	$250,000	$17,138,747	$20,168,859

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud LDUA (Risk Based Estimates)**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-D-E1**
PREPARED BY: **S. L. Coward**

DATE: **28-Jan-1998**
TIME: **11:25:25**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	2,083,513	4.83	10	40	0.48	1.93	1.691%	4.83%	728,684	2,812,197
1.1.2	TITLE III INSPECTION	694,504	1.61	10	40	0.16	0.64	0.564%	1.61%	242,895	937,399
1.2.1	PROJECT MANAGEMENT	3,447,249	7.99	10	40	0.80	3.20	2.798%	7.99%	1,205,635	4,652,884
1.2.2	CONSTRUCTION MANAGEMENT	2,463,481	5.71	10	40	0.57	2.29	2.000%	5.71%	861,574	3,325,055
1.3.1	GENERAL CONDITIONS	1,831,085	4.25	10	40	0.42	1.70	1.486%	4.25%	640,401	2,471,486
1.3.13	SPECIAL CONSTRUCTION	12,059,014	27.97	10	40	2.80	11.19	9.788%	27.97%	4,217,500	16,276,514
1.5.2	PROCUREMENT FEES	138,901	0.32	10	40	0.03	0.13	0.113%	0.32%	48,579	187,480
	ESCALATION	20,401,720	47.31	10	40	4.73	18.93	16.560%	47.31%	7,135,265	27,536,985
SUBTOTAL		43,119,467	100.00					35.000%			
CALCULATED CONTINGENCY		15,091,813									
RESULTANT TEC		58,211,280									
ROUNDED TEC		58,200,000									
PROJECT CONTINGENCY		15,080,533						34.97%			
MANAGEMENT RESERVE		2,749,684									
CONTINGENCY		12,330,849									
TOTAL ESTIMATED COST		58,200,000								15,080,533	58,200,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE

RISK BASED CLEAN CLOSURE; CLASS A FILL; ESCALATED

CLEAN BINS W/ ROBOTS - WALLS

PROCUREMENT FEE:

CONSTRUCTION =		$27,224,593		
GFE =				
	Subtotal	$27,224,593		
FEE @ 1% =		$27,224,593	* 0.01 =	$272,246

G&A @ 23% (with a ceiling of $500,000 imposed per year, 10 yrs)

CONSTRUCTION OR CEILING • 10 YEARS =		$5,000,000		
GFE =		$0		
PROCUREMENT FEE =		$272,246		
	Subtotal	$5,272,246		
FEE @ 23% =		$5,272,246	• 0.23 =	$1,212,617

PIF @ 5.5%

CONSTRUCTION =		$13,890,099		
GFE =		$0		
PROCUREMENT FEE =		$272,246		
G&A =		$1,212,617		
	Subtotal	$15,374,961		
FEE @ 5.5% =		$15,374,961	• 0.055 =	$845,623

TOTAL PROCUREMENT FEE:	$272,246
TOTAL G&A FEE:	$1,212,617
TOTAL PIF:	$845,623

Lockheed Martin Idaho Technologies Co.
Rev. 6-96

COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure (EIS Stud Pipe Crawler (Risk Based Estim
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-E-E1
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 28-Jan-1998
TIME: 11:28:25
CHECKED BY: SMB
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $3,159,509
1.1.1	DESIGN ENGINEERING	1,778,336	800,251	2,578,587
1.1.2	TITLE III INSPECTION	296,389	284,533	580,922
1.2	MANAGEMENT COSTS			>> $5,191,797
1.2.1	PROJECT MANAGEMENT	2,166,640	1,863,310	4,029,950
1.2.2	CONSTRUCTION MANAGEMENT	592,779	569,068	1,161,847
1.3	CONSTRUCTION			>> $11,618,475
1.3.1	GENERAL CONDITIONS	1,831,085	1,757,841	3,588,926
1.3.13	SPECIAL CONSTRUCTION	4,096,709	3,932,840	8,029,549
1.5.2	PROCUREMENT FEES	59,278	56,907	>> $116,185
	SUBTOTAL INCLUDING ESCALATION	10,821,216	9,264,750	>> $20,085,966
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $1,173,466
	CONTINGENCY			>> $5,840,568
	TOTAL ESTIMATED COST			>> $27,100,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *27.00%*

CONTINGENCY= *34.92%*

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: ICPP Bin Set Closure (EIS Study)
Pipe Crawler (Risk Based Estimates)
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423-E-E1
PREPARED BY: S. L. Coward

DATE 28-Jan-1998
TIME: 11:28:28
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	**DESIGN ENGINEERING**											
MEMO:	Title I &II Engineering & Design @ 10% of Construction	1	LS		*LMITCO*	0.000					592,779	592,779
	Conceptual Engineering & Design @ 5% of Construction	1	LS		*LMITCO*	0.000					296,389	296,389
MEMO:	Title I &II Engineering & Design @ 10% of Construction	1	LS		*LMITCO*	0.000					592,779	592,779
	Conceptual Engineering & Design @ 5% of Construction	1	LS		*LMITCO*	0.000					296,389	296,389
	DESIGN ENGINEERING S/T						0				$1,778,336	$1,778,336
1.1.2	**TITLE III INSPECTION**											
	INSPECTION - TITLE III	1	LS		*LMITCO*	0.000					296,389	296,389
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$296,389	$296,389
1.2.1	**PROJECT MANAGEMENT**											
	PROJECT MANAGEMENT	1	LOT		*LMITCO*	0.000					592,779	592,779
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		*LMITCO*	0.000					1,176,722	1,176,722
	PIF	1	LS		*LMITCO*	0.000					397,139	397,139

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 2

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Pipe Crawler (Risk Based Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-E-E1**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **11:28:28**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.1	PROJECT MANAGEMENT											
	PROJECT MANAGEMENT S/T						0				$2,166,640	$2,166,640
1.2.2	CONSTRUCTION MANAGEMENT											
	CONSTRUCTION MANAGEMENT	1	LOT		LMITCO	0.000					592,779	592,779
MEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$592,779	$592,779
1.3.1	GENERAL CONDITIONS											
	SUPERVISION (Share with Wall Est. (10 yrs/2) - Duration)	1	FTE		PIPF GEN	10400.0	10,400	419,848				419,848
	TRAINING	8	FTE		SKWK GEN	165.000	1,320	43,705				43,705
	RADCON TECHNICIAN SUPPORT (Share with Wall Est (10 yrs/2) - Duration)	2	FTE		Z-1342 LMITCO	10400.0	20,800	1,027,520				1,027,520
	GENERAL CONDITIONS S/T						32,520	$1,491,073				$1,491,073
1.3.13	SPECIAL CONSTRUCTION											
	DESIGN AND DEVELOPMENT OF PIPE CRAWLER											
	Design and Development of 1rst Unit, Including:	1	LS		GEN	0.000					800,000	800,000

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Pipe Crawler (Risk Based Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-E-E1**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **11:28:28**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	**SPECIAL CONSTRUCTION** Design, Approvals, Mock-ups, Proof of Process, etc.											
	Fabrication of Additional units	6	EA		GEN	0.000					420,000	420,000
	Design of Modifications for add'l units	6	EA		GEN	0.000					90,000	90,000
	INSTALLATION OF PIPE CRAWLER											
	Install Robotic Units	50	EACH		SKWK GEN	180.000	9,000	297,990				297,990
	Install and Shield Unit Hose/Tubes (Mods, Electr., etc.) - Allowance	50	EA	5,000.00	SKWK GEN	180.000	9,000	297,990		250,000		547,990
	Systems Integration	1	LS		GEN	0.000					100,000	100,000
	Shielding and Retrieval Area	7			GEN	0.000					350,000	350,000
	CAP 18" DIAMETER HOLES - ASSUME Holes Capped in Floor Estimate	50	EA		SKWK GEN	40.000	2,000	66,220				66,220
	CAP 6" DIAMETER HOLES - ASSUME Holes Capped in Floor Estimate	50	EA		SKWK GEN	24.000	1,200	39,732				39,732
	OPERATION OF CALCINE RETRIEVAL	19	FTE		SKWK GEN	515.000	9,785	323,981				323,981
	SPECIAL CONSTRUCTION S/T						30,985	$1,025,913		$250,000	$1,760,000	$3,035,913
	PROJECT SUBTOTAL						63,505	$2,516,987	$0	$250,000	$6,594,144	$9,361,131

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud Pipe Crawler (Risk Based Estim**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-E-E1**
PREPARED BY: **S. L. Coward**

DATE: **28-Jan-1998**
TIME: **11:28:22**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING	1,778,336	8.85	10	40	0.89	3.54	3.099%	8.85%	620,996	2,399,332
1.1.2	TITLE III INSPECTION	296,389	1.48	10	40	0.15	0.59	0.516%	1.48%	103,499	399,888
1.2.1	PROJECT MANAGEMENT	2,166,640	10.79	10	40	1.08	4.31	3.775%	10.79%	756,592	2,923,232
1.2.2	CONSTRUCTION MANAGEMENT	592,779	2.95	10	40	0.30	1.18	1.033%	2.95%	206,999	799,778
1.3.1	GENERAL CONDITIONS	1,831,085	9.12	10	40	0.91	3.65	3.191%	9.12%	639,416	2,470,501
1.3.13	SPECIAL CONSTRUCTION	4,096,709	20.40	10	40	2.04	8.16	7.139%	20.40%	1,430,574	5,527,283
1.5.2	PROCUREMENT FEES	59,278	0.30	10	40	0.03	0.12	0.103%	0.30%	20,700	79,978
	ESCALATION	9,264,750	46.13	10	40	4.61	18.45	16.144%	46.13%	3,235,258	12,500,008
	SUBTOTAL	20,085,966	100.00					35.000%			
	CALCULATED CONTINGENCY	7,030,088									
	RESULTANT TEC	27,116,054									
	ROUNDED TEC	27,100,000									
	PROJECT CONTINGENCY	7,014,034						34.92%			
	MANAGEMENT RESERVE	1,173,466									
	CONTINGENCY	5,840,568									
	TOTAL ESTIMATED COST	27,100,000								7,014,034	27,100,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE
RISK BASED CLEAN CLOSURE; CLASS A FILL; ESCALATED

CLEAN BINS W/ ROBOTS - PIPING

PROCUREMENT FEE:

CONSTRUCTION =	$11,618,475		
GFE =			
Subtotal	$11,618,475		
FEE @ 1% =	$11,618,475	* 0.01 =	$116,185

G&A @ 23% (with a ceiling of $500,000 imposed per year, 10 yrs)

CONSTRUCTION OR CEILING * 10 YEARS =	$5,000,000		
GFE =	$0		
PROCUREMENT FEE =	$116,185		
Subtotal	$5,116,185		
FEE @ 23% =	$5,116,185	* 0.23 =	$1,176,722

PIF @ 5.5%

CONSTRUCTION =	$5,927,794		
GFE =	$0		
PROCUREMENT FEE =	$116,185		
G&A =	$1,176,722		
Subtotal	$7,220,701		
FEE @ 5.5% =	$7,220,701	* 0.055 =	$397,139

TOTAL PROCUREMENT FEE:	$116,185
TOTAL G&A FEE:	$1,176,722
TOTAL PIF:	$397,139

Lockheed Martin Idaho Technologies Co.
Rev. 6-96

COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure (EIS Stud Place NRC Class A Grout
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-B1-E1
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 28-Jan-1998
TIME: 12:25:03
CHECKED BY: SMB
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $6,278,036
1.1.1	DESIGN ENGINEERING TITLE I & II	2,660,185	2,420,768	5,080,953
1.1.2	TITLE III INSPECTION	532,037	665,046	1,197,083
1.2	MANAGEMENT COSTS			>> $8,022,143
1.2.1	PROJECT MANAGEMENT	2,569,852	3,058,124	5,627,976
1.2.2	CONSTRUCTION MANAGEMENT	1,064,074	1,330,093	2,394,167
1.3	CONSTRUCTION			>> $23,941,667
1.3.1	GENERAL CONDITIONS	3,437,150	4,296,437	7,733,587
1.3.2	SITEWORK	0	0	0
1.3.3	CONCRETE	1,387,185	1,733,982	3,121,167
1.3.15	MECHANICAL	3,365,584	4,206,980	7,572,564
1.3.16	ELECTRICAL	2,450,822	3,063,527	5,514,349
1.5.2	PROCUREMENT FEES	106,407	133,009	>> $239,416
	SUBTOTAL INCLUDING ESCALATION	17,573,296	20,907,966	>> $38,481,262
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $2,418,108
	CONTINGENCY			>> $11,000,630
	TOTAL ESTIMATED COST			>> $51,900,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *26.00%*

CONTINGENCY= *34.87%*

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: ICPP Bin Set Closure (EIS Study)
Place NRC Class A Grout
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423-B1-E1
PREPARED BY: S. L. Coward

DATE 28-Jan-1998
TIME: 12:25:06
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	DESIGN ENGINEERING TITLE I & II ENGINEERING AND DESIGN											
MEMO:	Title I &II Engineering & Design @ 20% of Construction	1	LS		*LMITCO*	0.000					2,128,148	2,128,148
MEMO:	Conceptual Design @ 5% of Construction	1	LS		*LMITCO*	0.000					532,037	532,037
	DESIGN ENGINEERING TITLE I & II S/T						0				$2,660,185	$2,660,185
1.1.2	TITLE III INSPECTION INSPECTION - TITLE III	1	LS		*LMITCO*	0.000					532,037	532,037
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$532,037	$532,037
1.2.1	PROJECT MANAGEMENT PROJECT MANAGEMENT	1	LS		*LMITCO*	0.000					1,064,074	1,064,074
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		*LMITCO*	0.000					860,066	860,066
	PIF	1	LS		*LMITCO*	0.000					645,712	645,712
	PROJECT MANAGEMENT S/T						0				$2,569,852	$2,569,852

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place NRC Class A Grout
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-B1-E1**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **12:25:06**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	CONSTRUCTION MANAGEMENT											
	CONSTRUCTION MANAGEMENT	1	LS		LMITCO	0.000					1,064,074	1,064,074
MEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$1,064,074	$1,064,074
1.3.1	GENERAL CONDITIONS											
	SUPERVISION (Duration of Project - Assume 10 Years)	1	FTE		CONF GEN	20800.0	20,800	691,600				691,600
	TRAINING	20	FTE		CONC GEN	165.000	3,300	105,699				105,699
	RADCON TECHNICIAN SUPPORT (Duration of Project - Assume 10 Years)	2	FTE		Z-1342 LMITCO	20800.0	41,600	2,055,040				2,055,040
	GENERAL CONDITIONS S/T						65,700	$2,852,339				$2,852,339
1.3.2	SITEWORK											
	ASSUME NO EXCAVATION WILL BE REQUIRED FOR MONITORS											
	SITEWORK S/T						0					
1.3.3	CONCRETE											

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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place NRC Class A Grout
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-B1-E1**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **12:25:06**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.3	**CONCRETE** PROCURE EQUIPMENT FOR PLACEMENT OF GROUT											
	Grout Booster Pump	1	EA	55,000.00	GEN	0.000				55,000		55,000
	Air Compressor and Miscellaneous Cleaning Equipment	1	LS	25,000.00	GEN	0.000				25,000		25,000
	"A" FRAME HOIST FOR LIFTING OF FILL PIPE	100	EA	2,000.00	CONC GEN	40.000	4,000	128,120		200,000		328,120
	POUR CLASS A GROUT AND CLEAN PIPE (Includes 10% Waste)	10,406	CY	0.28	CONC GEN	0.800	8,325	266,643		2,914		269,557
	CLEANING OF PIPING AFTER EACH LIFT	666	LIFTS	30.00	CONC GEN	0.500	333	10,666		19,980		30,646
	6" CAPS FOR PENETRATIONS (Assume 2 per bin)	100	EA	500.00	CONC GEN	24.000	2,400	76,872		50,000		126,872
	CONCRETE S/T						15,058	$482,301		$352,894		$835,195
1.3.15	**MECHANICAL**											
	DOUBLE CONTAINED GROUT DELIVERY PIPE (Includes 10% Waste)	3,367	LF	47.00	CONC GEN	1.200	4,040	129,414	10,101	158,249	13,468	311,232
	VALVE MANIFOLD ASSEMBLY (7 Vaults plus 1 Extra)	8	EA	100,000.00	CONC GEN	80.000	640	20,499		800,000		820,499
MEMO:	Self-Contained Sealed Unit to Mitigate Leakage during Grout Placement											
	REMOVAL OF RETR.TUBES (2 per Bin) Add'l labor for removal)	7,300	LF	0.20	CONC GEN	0.250	1,825	58,455		1,460		59,915

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 4

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place NRC Class A Grout
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-B1-E1**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **12:25:06**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.15	**MECHANICAL** REMOVAL AND DISPOSAL OF GROUT DELIVERY PIPE AND RETR. TUBES	10,667	LF	1.50	CONC *GEN*	1.740	18,561	594,495		16,001	160,005	770,501
MEMO:	Incl. Glovebag, Cuts to Rad Box, Handl., Rad Box Purch. & Disposal											
	VALVE/MANIFOLD REMOVAL	8	EA	2,000.00	CONC *GEN*	480.000	3,840	122,995		16,000	5,600	144,595
MEMO:	Incl. Rad Tent, Disconnect from Piping &Pump, Rad Boxes & Disposal											
	MECHANICAL S/T						28,906	$925,859	$10,101	$991,710	$179,073	$2,106,742
1.3.16	**ELECTRICAL**											
	RAD MONITORS IN EXISTING LANCES	42	EA	30,000.00	CONC *GEN*	150.000	6,300	201,789		1,260,000		1,461,789
	MONITOR TANKS DURING CLASS A GROUT POUR	1	LS		CONC *GEN*	2400.00	2,400	76,872				76,872
MEMO;	Assume Readings take 2 Days Once per Month for 10 Yrs											
	CERCLA tp Monitor after Leaks are Filled with Class A Grout											
	ELECTRICAL S/T						8,700	$278,661		$1,260,000		$1,538,661
	PROJECT SUBTOTAL						118,364	$4,539,160	$10,101	$2,604,603	$7,005,221	$14,159,085

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CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud Place NRC Class A Grout**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-B1-E1**
PREPARED BY: **S. L. Coward**

DATE: **28-Jan-1998**
TIME: **12:27:49**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	2,660,185	6.91	10	40	0.69	2.77	2.420%	6.91%	927,629	3,587,814
1.1.2	TITLE III INSPECTION	532,037	1.38	10	40	0.14	0.55	0.484%	1.38%	185,526	717,563
1.2.1	PROJECT MANAGEMENT	2,569,852	6.68	10	40	0.67	2.67	2.337%	6.68%	896,129	3,465,981
1.2.2	CONSTRUCTION MANAGEMENT	1,064,074	2.77	10	40	0.28	1.11	0.968%	2.77%	371,052	1,435,126
1.3.1	GENERAL CONDITIONS	3,437,150	8.93	10	40	0.89	3.57	3.126%	8.93%	1,198,563	4,635,713
1.3.2	SITEWORK	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.3.3	CONCRETE	1,387,185	3.60	10	40	0.36	1.44	1.262%	3.60%	483,723	1,870,908
1.3.15	MECHANICAL	3,365,584	8.75	10	40	0.87	3.50	3.061%	8.75%	1,173,607	4,539,191
1.3.16	ELECTRICAL	2,450,822	6.37	10	40	0.64	2.55	2.229%	6.37%	854,622	3,305,444
1.5.2	PROCUREMENT FEES	106,407	0.28	10	40	0.03	0.11	0.097%	0.28%	37,105	143,512
	ESCALATION	20,907,966	54.33	10	40	5.43	21.73	19.016%	54.33%	7,290,782	28,198,748
SUBTOTAL		38,481,262	100.00					35.000%			
CALCULATED CONTINGENCY		13,468,442									
RESULTANT TEC		51,949,704									
ROUNDED TEC		51,900,000									
PROJECT CONTINGENCY		13,418,738						34.87%			
MANAGEMENT RESERVE		2,418,108									
CONTINGENCY		11,000,630									
TOTAL ESTIMATED COST		51,900,000								13,418,738	51,900,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. *The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.*

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............Up to 50%	
Conceptual	*15% – 25%*
Experimental/Special Conditions............Up to 40%	
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE
RISK BASED CLEAN CLOSURE; CLASS A FILL; ESCALATED

FILL BINS W/ NRC CLASS A GROUT

PROCUREMENT FEE:

CONSTRUCTION =		$23,941,667		
GFE =				
	Subtotal	$23,941,667		
FEE @ 1% =		$23,941,667	• 0.01 =	$239,417

G&A @ 23% (with a ceiling of $500,000 imposed per year, 7 yrs)

CONSTRUCTION OR CEILING • 7 YEARS =		$3,500,000		
GFE =		$0		
PROCUREMENT FEE =		$239,417		
	Subtotal	$3,739,417		
FEE @ 23% =		$3,739,417	• 0.23 =	$860,066

PIF @ 5.5%

CONSTRUCTION =		$10,640,741		
GFE =		$0		
PROCUREMENT FEE =		$239,417		
G&A =		$860,066		
	Subtotal	$11,740,224		
FEE @ 5.5% =		$11,740,224	• 0.055 =	$645,712

TOTAL PROCUREMENT FEE:	$239,417
TOTAL G&A FEE:	$860,066
TOTAL PIF:	$645,712

Lockheed Martin Idaho Technologies Co.
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COST ESTIMATE SUMMARY

PROJECT NAME: **ICPP Bin Set Closure**
D&D of Equipment
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423D&D
PREPARED BY: S.L.Coward/smb
REPORT NAME: Cost Estimate Summary

DATE: 28-Jan-1998
TIME: 09:58:46
CHECKED BY: SMB
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $0
1.1.1	DESIGN ENGINEERING TITLE I & II	0	0	0
1.1.2	TITLE III INSPECTION	0	0	0
1.2	MANAGEMENT COSTS			>> $2,561,125
1.2.1	PROJECT MANAGEMENT	868,178	1,692,947	2,561,125
1.2.2	CONSTRUCTION MANAGEMENT	0	0	0
1.3	CONSTRUCTION			>> $34,543,647
1.3.13	SPECIAL CONSTRUCTION	11,709,711	22,833,936	34,543,647
1.5.2	PROCUREMENT FEES	117,097	228,339	>> $345,436
	SUBTOTAL INCLUDING ESCALATION	12,694,986	24,755,222	>> $37,450,208
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $0
	CONTINGENCY			>> $13,149,792
	TOTAL ESTIMATED COST			>> $50,600,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *0.00%*

CONTINGENCY= *35.11%*

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: ICPP Bin Set Closure
D&D of Equipment
LOCATION 1: INEEL / ICPP
REQUESTOR: B. C. Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423D&D
PREPARED BY: S.L.Coward/smb

DATE 28-Jan-1998
TIME: 10:13:24
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	DESIGN ENGINEERING TITLE I & II											
	Costs for Design activities included in Special Construction											
	DESIGN ENGINEERING TITLE I & II S/T						0					
1.1.2	TITLE III INSPECTION											
	Costs for inspection activities included in Special Construction											
	TITLE III INSPECTION S/T						0					
1.2.1	PROJECT MANAGEMENT											
	Costs for Project Management activities included in Special Construction											
	G&A	1	LS		*LMITCO*	0.000					194,450	194,450
	PIF	1	LS		*LMITCO*	0.000					673,728	673,728
	PROJECT MANAGEMENT S/T						0				$868,178	$868,178
1.2.2	CONSTRUCTION MANAGEMENT											

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DETAILED COST ESTIMATE SHEET

PAGE # 2

PROJECT NAME: **ICPP Bin Set Closure**
D&D of Equipment
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423D&D**
PREPARED BY: **S.L.Coward/smb**

DATE **28-Jan-1998**
TIME: **10:13:24**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	**CONSTRUCTION MANAGEMENT** Costs for Construction Management activities included in Special Construction											
	CONSTRUCTION MANAGEMENT S/T						0					
1.3.13	**SPECIAL CONSTRUCTION**											
	Ventilation, Instrument and Control Building (VIC) - 7 ea @ 2400 sf	1	lot			0.000					969,133	969,133
	- Assume facility will have low levels of hazardous material											
	- Assume facility will have no rad contamination											
	- Assume facility will have no asbestos											
	Confinement Enclosures (top of Bin Sets) - 7 ea @ 1600 sf	1	lot			0.000					1,248,126	1,248,126
	Bridge Crane - 7 ea @ 300 sf	1	lot			0.000					369,376	369,376
	- Assume bridge 40' across x 45' high x 2' wide for rails											
	- Assume trolley @ 5' x 5' x 5'											
	HVAC Equipment/System - 1 ea @ 5800 sf	1	lot			0.000					449,044	449,044
	- Assume 7 air handlers @ 5'x5'x6'											
	- Assume 3 exhaust fans @ 4'x4'x3'											

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DETAILED COST ESTIMATE SHEET

PROJECT NAME: ICPP Bin Set Closure
D&D of Equipment
LOCATION 1: INEEL / ICPP
REQUESTOR: B. C. Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423D&D
PREPARED BY: S.L.Coward/smb

DATE 28-Jan-1998
TIME: 10:13:24
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	SPECIAL CONSTRUCTION - Assume 63 HEPA filters @ 6'x6'x2'											
	Jumper Retrieval Piping (Shielded) - 1 ea @ 420 sf	1	lot			0.000					109,494	109,494
	- Assume 210' long x 2' wide concrete											
	Remote Core Drilling Platform/Saw, etc. - 1 ea @ 250 sf	1	lot			0.000					55,966	55,966
	- Assume platform @ 5' x 5' x 6' and saw is 100 sf											
	Remote Welding and Cutting Equipment - Allowance - 1 ea @ 500 sf	1	lot			0.000					111,932	111,932
	Vertical Deployment Appartus - 7 ea @ 150 sf	1	lot			0.000					235,057	235,057
	- Assume 5' x 5' x 6'											
	Shielding & Riser Plugs - 100 ea @ 4 sf	1	lot			0.000					116,794	116,794
	- Assume 2' x 2'											
	CO2 Blasting Equipment - Allowance - 2 ea @ 500 sf	1	lot			0.000					223,864	223,864
	Retrieval Lines - 1 ea @ 2310 sf	1	lot			0.000					373,116	373,116
	- Assume 2310' long x 1' wide											
	Control Consoles, Cameras, Lighting - Allowance - 1 ea @ 1000 sf	1	lot			0.000					107,934	107,934
	Grouting Manifolds - Clean - Allowance - 8 ea @ 300 sf	1	lot			0.000					259,043	259,043

Lockheed Martin Idaho Technologies Co.
Rev 6-96
PROJECT NAME: ICPP Bin Set Closure
D&D of Equipment
LOCATION 1: INEEL / ICPP
REQUESTOR: B. C. Spaulding

DETAILED COST ESTIMATE SHEET

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423D&D
PREPARED BY: S.L.Coward/smb

DATE 28-Jan-1998
TIME: 10:13:24
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	**SPECIAL CONSTRUCTION**											
	Grouting Manifolds - Class C - Allowance - 8 ea @ 300 sf	1	lot			0.000					537,274	537,274
	LDUA's - Allowance - 7 ea @ 150 sf	1	lot			0.000					209,873	209,873
	Pipe Crawler Robots - Allowance - 7 ea @ 150 sf	1	lot			0.000					209,873	209,873
	Tractor Robots - Allowance - 53 ea @ 250 sf	1	lot			0.000					2,648,393	2,648,393
	Misc Robot Wire and Hose Lines - Allowance - 1 ea @ 1000 sf	1	lot			0.000					199,879	199,879
	Waste Disposal - quantities as stated in EDF											
	- Solid Waste	500	cf			0.000					540	540
	- Radioactive Waste	10,000	cf			0.000					3,000,000	3,000,000
	- Mixed Waste	2,200	cf			0.000					275,000	275,000
	SPECIAL CONSTRUCTION S/T						0				$*,***,***	$11,709,711
	PROJECT SUBTOTAL						0	$0	$0	$0	$12,577,889	$12,577,889

Lockheed Martin Idaho Technologies Co.
Rev 6-96

CONTINGENCY ANALYSIS

PROJECT NAME: ICPP Bin Set Closure
D&D of Equipment
LOCATION 1: INEEL / ICPP
REQUESTOR: B. C. Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423D&D
PREPARED BY: S.L.Coward/smb

DATE: 28-Jan-1998
TIME: 09:58:43

REPORT NAME: Contingency Analysis

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.1.2	TITLE III INSPECTION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.2.1	PROJECT MANAGEMENT	868,178	2.32	10	40	0.23	0.93	0.811%	2.32%	304,841	1,173,019
1.2.2	CONSTRUCTION MANAGEMENT	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.3.13	SPECIAL CONSTRUCTION	11,709,711	31.27	10	40	3.13	12.51	10.944%	31.27%	4,111,600	15,821,311
1.5.2	PROCUREMENT FEES	117,097	0.31	10	40	0.03	0.13	0.109%	0.31%	41,116	158,213
	ESCALATION	24,755,222	66.10	10	40	6.61	26.44	23.136%	66.10%	8,692,235	33,447,457
	SUBTOTAL	37,450,208	100.00					35.000%			
	CALCULATED CONTINGENCY	13,107,573									
	RESULTANT TEC	50,557,781									
	ROUNDED TEC	50,600,000									
	PROJECT CONTINGENCY	13,149,792						35.11%			
	MANAGEMENT RESERVE	0									
	CONTINGENCY	13,149,792									
	TOTAL ESTIMATED COST	50,600,000								13,149,792	50,600,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE
RISK BASED CLEAN CLOSURE; CLASS A FILL; ESCALATED

D&D OF EQUIPMENT

PROCUREMENT FEE:

CONSTRUCTION =	$34,543,647		
GFE =			
Subtotal	$34,543,647		
FEE @ 1% =	$34,543,647	* 0.01 =	$345,436

G&A @ 23% (with a ceiling of $500,000 imposed per year, 1 yr)

CONSTRUCTION OR CEILING * 1 YEARS =	$500,000		
GFE =	$0		
PROCUREMENT FEE =	$345,436		
Subtotal	$845,436		
FEE @ 23% =	$845,436	* 0.23 =	$194,450

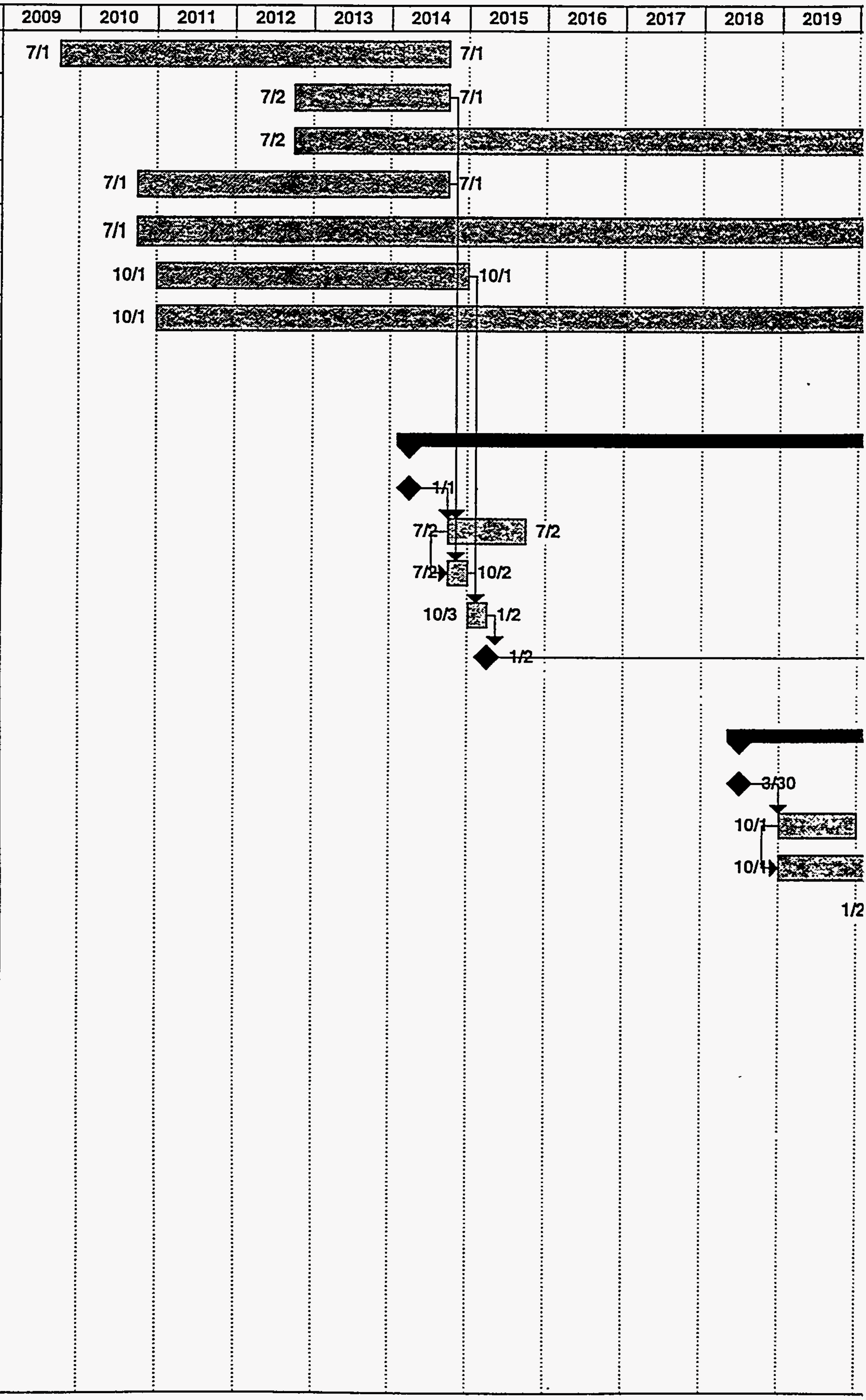
PIF @ 5.5%

CONSTRUCTION =	$11,709,711		
GFE =	$0		
PROCUREMENT FEE =	$345,436		
G&A =	$194,450		
Subtotal	$12,249,598		
FEE @ 5.5% =	$12,249,598	* 0.055 =	$673,728

TOTAL PROCUREMENT FEE:	$345,436
TOTAL G&A FEE:	$194,450
TOTAL PIF:	$673,728

RISK BASED CLE
NRC CLASS

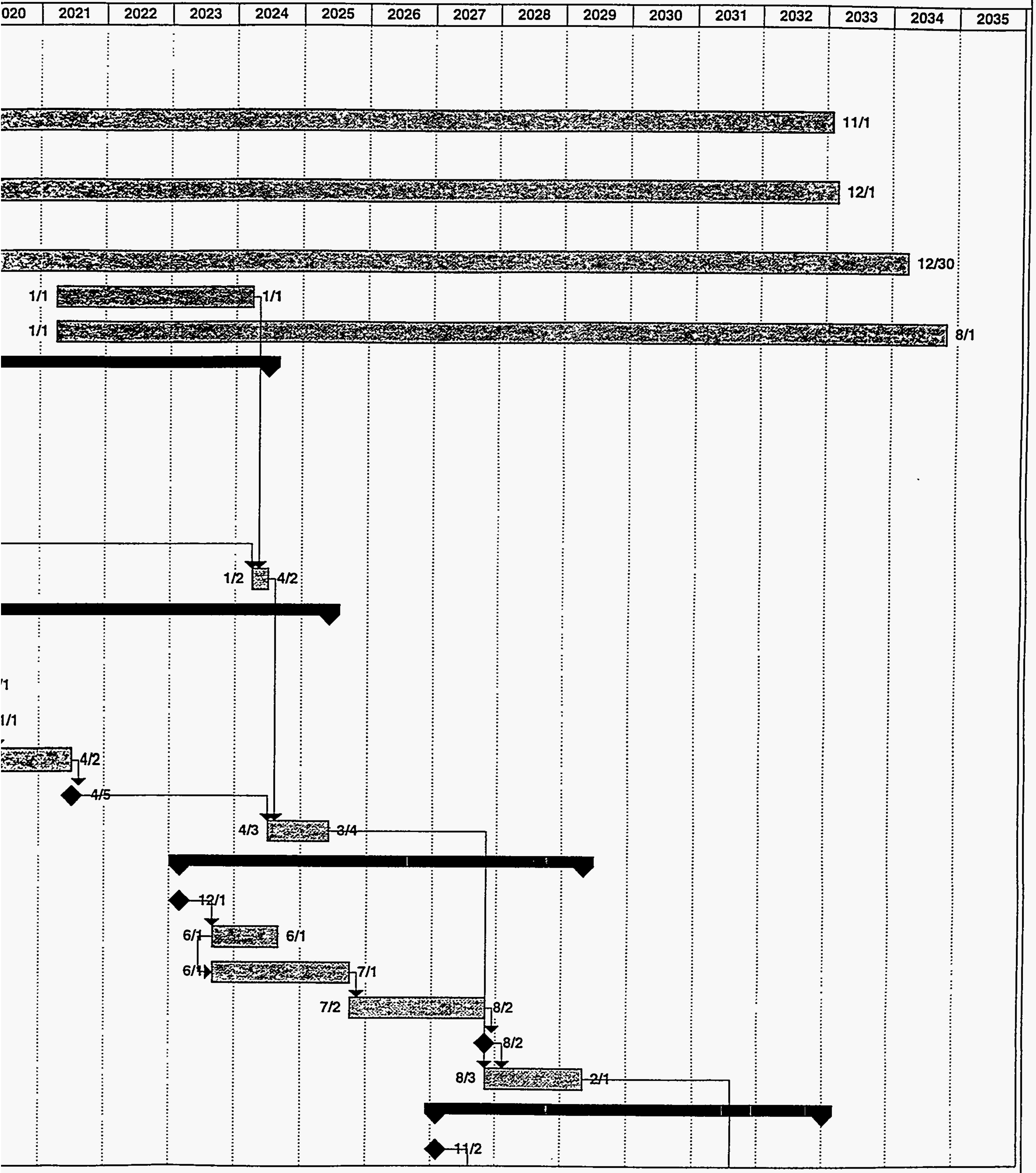
ID	Task Name
1	PERMITTING
2	DESIGN - GROUT VAULTS
3	MANAGEMENT - GROUT VAULTS
4	DESIGN - CLEAN BIN WALLS/PIPING
5	MANAGEMENT - CLEAN WALLS/PIPING
6	DESIGN - CLEAN BIN FLOORS
7	MANAGEMENT - CLEAN BIN FLOORS
8	DESIGN - GROUT BINS
9	MANAGEMENT - GROUT BINS
10	BIN SET #1
11	RETRIEVAL COMPLETE
12	GROUT VAULTS
13	CLEAN BIN WALLS/PIPING
14	CLEAN BIN FLOORS
15	RCRA CLOSURE
16	GROUT BINS
17	BIN SET #5
18	RETRIEVAL COMPLETE
19	GROUT VAULTS
20	CLEAN BIN WALLS/PIPING
21	CLEAN BIN FLOORS
22	RCRA CLOSURE
23	GROUT BINS
24	BIN SET #7
25	RETRIEVAL COMPLETE
26	GROUT VAULTS
27	CLEAN BIN WALLS/PIPING
28	CLEAN BIN FLOORS
29	RCRA CLOSURE
30	GROUT BINS
31	BIN SET #6
32	RETRIEVAL COMPLETE



Project: 2423-2.MPP
Date: Tue 1/6/98

Task	▨	Milestone	●	Rolled Up Task	▨
Progress	■	Summary	▬	Rolled Up Milestone	◇

CLOSURE -
GROUT



▨ Rolled Up Progress ▬

COST ESTIMATE SUMMARY
UNESCALATED

ICPP BIN SET CLOSURE CLOSURE TO RCRA LANDFILL STANDARDS; CLASS A FILL Requestor: B. C. Spaulding	Planning Estimate Estimate #2423 Prepared by: S. L. Coward	1/28/98 Checked by: Approved by:

Regulatory Compliance		19,500,000
Fill Vaults with Clean Grout		12,400,000
Clean Bins with Robots		
Floor		82,600,000
Fill Bins with NRC Class A Grout		23,700,000
D&D of Equipment		17,000,000
TOTAL		**$155,200,000**
	USE	**$155,000,000**

RCRA CLOSURE TO LANDFILL STANDARDS – NRC CLASS A GROUT

DESCRIPTION		BIN SET #1	BIN SET #5	BIN SET #7	BIN SET #6	BIN SET #3	BIN SET #4	BIN SET #2
Scheduled Completion		(1/1/14)	(4/1/18)	(12/1/22)	(11/1/26)	(8/1/28)	(2/1/31)	(5/1/31)
ASSUME: Wait 6 Months until Start of Closure								
Permitting (5 Years)	7/1/9–7/1/14							
Grout Vaults "Clean" (Assume 1 Year)								
ED&I (2 Yrs)	7/1/12–7/1/14							
Management	7/1/12–11/1/32							
Construction		7/1/14–7/1/15	10/1/18–10/1/19	6/1/23–6/1/24	5/1/27–5/1/28	2/1/29–2/1/30	8/1/31–8/1/32	11/1/31–11/1/32
Clean Bin Floors with Robot		(3 Months)	(15 Months)	(25 Months)	(24 Months)	(17 Months)	(7 Months)	(13 Months)
ED&I (4 Yrs)	7/1/10–7/1/14							
Management	7/1/10–12/1/32							
Construction		7/1/14–10/1/14	10/1/18–1/1/20	6/1/23–7/1/25	5/1/27–5/1/29	2/1/29–7/1/30	8/1/31–3/1/32	11/1/31–12/1/32
RCRA CLOSURE								
Grout Bins "NRC Class A"		(3 Months)	(11 Months)	(18 Months)	(17 Months)	(12 Months)	(6 Months)	(10 Months)
ED&I (3 Yrs)	1/1/21–1/1/24							
Management	1/1/21–10/1/33							
Construction		1/1/24–4/1/24	4/1/24–3/1/25	7/1/25–1/1/27	5/1/29–10/1/30	10/1/30–10/1/31	3/1/32–9/1/32	12/1/32–10/1/33

ASSUMPTIONS:

1) Assume same schedule as options for pouring Class C grout.
2) Installation of NRC Class A Grout into bins are based on individual schedules for each bin set. These schedules assume everything is in place at start–up date for pouring, and allows no flexibility for error or downtime.
3) More than 1 crew could be utilized simultaneously for pouring the "clean" grout into the vaults.
4) More than 1 crew could be utilized simultaneously for cleaning the separate bins.
5) Installation of "clean" grout into vaults will average 1 year per vault.
6) Cleaning of bin floors are based on individual bin pro–rated calcine retrieval volumes to total volume. These schedules assume mob/demob, installation of robotic units, and any modifications of bins will be completed and bins will be ready for retrieval.

Lockheed Martin Idaho Technologies Co.
Rev. 6-96

COST ESTIMATE SUMMARY

PROJECT NAME: Permitting/Documentation
Risk Based - NRC Class C
LOCATION 1: INEEL/ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: PLANNING
PROJECT NO: 2423-bD
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 27-Jan-1998
TIME: 19:51:07
CHECKED BY: SMB
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	CONCEPTUAL			>> $0
1.1.1	CONCEPTUAL DESIGN	0	0	0
1.2	MANAGEMENT			>> $2,374,382
1.2.1	PM FOR PROJECT DEVELOPMENT	1,896,534	0	1,896,534
1.2.2	PROJECT EXECUTION	477,848	0	477,848
1.3	PERMITTING			>> $11,946,206
1.3.1	PERMITTING	11,946,206	0	11,946,206
1.5.2	PROCUREMENT FEES	119,462	0	>> $119,462
	SUBTOTAL INCLUDING ESCALATION	14,440,050	0	>> $14,440,050
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $1,206,567
	CONTINGENCY			>> $3,853,383
	TOTAL ESTIMATED COST			>> $19,500,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *0.00%*

CONTINGENCY= *35.04%*

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PROJECT NAME: **Permitting/Documentation**
Risk Based - NRC Class C
LOCATION 1: **INEEL/ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **PLANNING**
PROJECT NO.: **2423-bD**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **19:51:09**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	**CONCEPTUAL DESIGN**											
	CONCEPTUAL DESIGN S/T						0					
1.2.1	**PM FOR PROJECT DEVELOPMENT**											
	G&A	1	LS		*LMITCO*	0.000					602,476	602,476
	PIF	1	LS		*LMITCO*	0.000					696,748	696,748
	PM FOR PROJECT DEVELOPMENT S/T						0				$1,299,224	$1,299,224
1.2.1.1	**PROJECT ADMINISTRATION** Project Admin. during Documentation (5% of Doc. Costs)	1	LOT		*LMITCO*	0.000					597,310	597,310
	PROJECT ADMINISTRATION S/T						0				$597,310	$597,310
1.2.2	**PROJECT EXECUTION**											
	PROJECT EXECUTION S/T						0					
1.2.1.2	**PROJECT SUPPORT** Support During permitting/Doc. (4% of doc. costs)	1	LOT		*LMITCO*	0.000					477,848	477,848
	PROJECT SUPPORT S/T						0				$477,848	$477,848

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PAGE # 2

PROJECT NAME: **Permitting/Documentation**
Risk Based - NRC Class C
LOCATION 1: **INEEL/ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **PLANNING**
PROJECT NO.: **2423-bD**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **19:51:09**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.1	**PERMITTING** PERMITTING AND DOCUMENTATION	1				0.000						
	Air Monitoring Activities, Fees, etc.	1	LS		*LMITCO*	0.000					770,000	770,000
	RCRC Closure (Incl. Writing, Reviews, Public Comments & Issuance of Permits)	2	FTE		Z-1700 *LMITCO*	1440.00	2,880	186,221				186,221
	P.E. Activities	1	LS		*LMITCO*	0.000					60,000	60,000
	CAA Permit to Construct (Incl. Preparing, Reviews, Public comments & Issuance)	1	LS		Z-1700 *LMITCO*	1800.00	1,800	116,388				116,388
	CERCLA Coordinator	2	FTE		Z-1700 *LMITCO*	1500.00	3,000	193,980				193,980
	Regulatory Affairs Oversight	10	YR		Z-1700 *LMITCO*	150.000	1,500	96,990				96,990
	Other Regulatory Compliance (CWA, Storm Water, Historical, etc.)	1	LS		Z-1700 *LMITCO*	1000.00	1,000	64,660				64,660
	Survey Plat	1	LS		*LMITCO*	0.000					10,000	10,000
	SARR	1	LS		Z-3170 *LMITCO*	4500.00	4,500	312,255				312,255
	NRC Landfill Disposal Requirements	10	LS		Z-1710 *LMITCO*	9000.00	90,000	4,960,800				4,960,800
	Environmental & Hazards Analysis	2	FTE		Z-1710 *LMITCO*	1800.00	3,600	198,432				198,432
	Seismic Test Bores (Allowance)	20	HOLES		Z-1710 *LMITCO*	2700.00	54,000	2,976,480				2,976,480
	Operational Readiness Review	1	LS		*LMITCO*	0.000					2,000,000	2,000,000
	PERMITTING S/T						162,280	$9,106,206			$2,840,000	$11,946,206

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PROJECT NAME: Permitting/Documentation
Risk Based - NRC Class C
LOCATION 1: INEEL/ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: PLANNING
PROJECT NO.: 2423-bD
PREPARED BY: S. L. Coward

DATE 27-Jan-1998
TIME: 19:51:09
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
	PROJECT SUBTOTAL						162,280	$9,106,206	$0	$0	$5,214,382	$14,320,588

Lockheed Martin Idaho Technologies Co.
Rev 6-96

CONTINGENCY ANALYSIS

PROJECT NAME: **Permitting/Documentation**
Risk Based - NRC Class C
LOCATION 1: **INEEL/ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **PLANNING**
PROJECT NO: **2423-bD**
PREPARED BY: **S. L. Coward**

DATE: **27-Jan-1998**
TIME: **19:51:03**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+	-			
1.1.1	CONCEPTUAL DESIGN	0	0.00	10	40	0.00	0.00	0.000%	0.00%	0	0
1.2.1	PM FOR PROJECT DEVELOPMENT	1,896,534	13.13	10	40	1.31	5.25	4.597%	13.13%	664,566	2,561,100
1.2.2	PROJECT EXECUTION	477,848	3.31	10	40	0.33	1.32	1.158%	3.31%	167,443	645,291
1.3.1	PERMITTING	11,946,206	82.73	10	40	8.27	33.09	28.955%	82.73%	4,186,080	16,132,286
1.5.2	PROCUREMENT FEES	119,462	0.83	10	40	0.08	0.33	0.290%	0.83%	41,861	161,323
	ESCALATION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
	SUBTOTAL	*14,440,050*	*100.00*					35.000%			
	CALCULATED CONTINGENCY	5,054,017									
	RESULTANT TEC	19,494,067									
	ROUNDED TEC	19,500,000									
	PROJECT CONTINGENCY	5,059,950						35.04%			
	MANAGEMENT RESERVE	1,206,567									
	CONTINGENCY	3,853,383									
	TOTAL ESTIMATED COST	*19,500,000*								5,059,950	19,500,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE

CLOSURE TO RCRA LANDFILL STANDARDS; CLASS A FILL; UNESCALATED

REGULATORY COMPLIANCE

PROCUREMENT FEE:

CONSTRUCTION =		$11,946,206		
GFE =				
	Subtotal	$11,946,206		
FEE @ 1% =		$11,946,206	• 0.01 =	$119,462

G&A @ 23% (with a ceiling of $500,000 imposed per year , 5 Years)

CONSTRUCTION OR CEILING • # OF YEARS =		$2,500,000		
GFE =		$0		
PROCUREMENT FEE =		$119,462		
	Subtotal	$2,619,462		
FEE @ 23% =		$2,619,462	* 0.23 =	$602,476

PIF @ 5.5%

CONSTRUCTION =		$11,946,206		
GFE =		$0		
PROCUREMENT FEE =		$119,462		
G&A =		$602,476		
	Subtotal	$12,668,144		
FEE @ 5.5% =		$12,668,144	• 0.055 =	$696,748

TOTAL PROCUREMENT FEE:	$119,462
TOTAL G&A FEE:	$602,476
TOTAL PIF:	$696,748

Lockheed Martin Idaho Technologies Co.
Rev. 6-96

COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure (EIS Stud
Place Clean Grout in Vault
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-A2
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 27-Jan-1998
TIME: 19:54:43
CHECKED BY: SmB
APPR'D BY: ______

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $1,589,774
1.1.1	DESIGN ENGINEERING	1,324,812	0	1,324,812
1.1.2	TITLE III INSPECTION	264,962	0	264,962
1.2	MANAGEMENT COSTS			>> $2,216,357
1.2.1	PROJECT MANAGEMENT	1,686,432	0	1,686,432
1.2.2	CONSTRUCTION MANAGEMENT	529,925	0	529,925
1.3	CONSTRUCTION			>> $5,299,250
1.3.1	GENERAL CONDITIONS	1,067,791	0	1,067,791
1.3.2	SITEWORK	0	0	0
1.3.3	CONCRETE	4,231,459	0	4,231,459
1.5.2	PROCUREMENT FEES	52,992	0	>> $52,992
	SUBTOTAL INCLUDING ESCALATION	9,158,373	0	>> $9,158,373
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $535,224
	CONTINGENCY			>> $2,706,403
	TOTAL ESTIMATED COST			>> $12,400,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *30.00%*

CONTINGENCY= *35.40%*

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place Clean Grout In Vault
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-A2**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **19:54:45**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	**DESIGN ENGINEERING** ENGINEERING AND DESIGN											
MEMO:	Title I &II Engineering & Design @ 20% of Construction	1	LS		*LMITCO*	0.000					1,059,850	1,059,850
MEMO:	Conceptual Engineering & Design @ 5% of Construction	1	LS		*LMITCO*	0.000					264,962	264,962
	DESIGN ENGINEERING S/T						0				$1,324,812	$1,324,812
1.1.2	**TITLE III INSPECTION** INSPECTION - TITLE III	1	LS		*LMITCO*	0.000					264,962	264,962
MEMO;	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$264,962	$264,962
1.2.1	**PROJECT MANAGEMENT** PROJECT MANAGEMENT	1	LS		*LMITCO*	0.000					529,925	529,925
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		*LMITCO*	0.000					817,188	817,188
	PIF	1	LS		*LMITCO*	0.000					339,319	339,319
	PROJECT MANAGEMENT S/T						0				$1,686,432	$1,686,432

Lockheed Martin Idaho Technologies Co.
Rov 6-96

DETAILED COST ESTIMATE SHEET

PAGE # 2

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place Clean Grout In Vault
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-A2**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **19:54:45**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	**CONSTRUCTION MANAGEMENT**											
	CONSTRUCTION MANAGEMENT	1	LS		LMITCO	0.000					529,925	529,925
MEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$529,925	$529,925
1.3.1	**GENERAL CONDITIONS**											
	SUPERVISION (Duration of Schedule - Assume 3 Years)	1	FTE		CONF GEN	6240.00	6,240	207,480				207,480
	TRAINING	10	FTE		CONC GEN	165.000	1,650	52,850				52,850
	RADCON TECHNICIAN (Duration of Schedule - Assume 3 Years)	2	FTE		Z-1342 LMITCO	6240.00	12,480	616,512				616,512
	GENERAL CONDITIONS S/T						20,370	$876,842				$876,842
1.3.2	**SITEWORK**											
	SITEWORK S/T						0					
1.3.3	**CONCRETE**											
	PROCURE EQUIPMENT FOR PLACEMENT OF GROUT											
	Grout Pump	1	EA		GEN	0.000			55,000			55,000

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place Clean Grout in Vault
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-A2**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **19:54:45**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.3	**CONCRETE** Air Compressor and Miscellaneous Cleaning Equipment	1	EA		GEN	0.000			25,000			25,000
	GROUT DELIVERY PIPING AND ACCESSORIES PURCHASE (Incl. 10% Waste)	415	LF	20.00	GEN	0.000				8,300		8,300
	GROUT DELIVERY PIPING (Incl. 10% Waste)	2,905	LF		CONC GEN	0.470	1,365	43,732				43,732
MEMO:	Install, Remove & Clean Pipe after Each Vault (7 Vaults)											
	GROUT DELIVERY PIPING CLEANING BETWEEN MANIFOLDS & DROP TUBES	676	LIFTS	30.00	CONC GEN	0.500	338	10,826		20,280		31,106
MEMO:	Assume cleaning between each lift											
	GROUT MANIFOLD AND CLEANING SYSTEM	1	LOT	7,500.00	CONC GEN	254.000	254	8,136		7,500		15,636
MEMO:	Can be Reused after each Vault Set (7 times)											
	CONCRETE S/T						1,957	$62,694	$80,000	$36,080		$178,774
1.3.3.1	**VAULT GROUTING** PURCHASE GROUT DROP TUBES AND ACCESSORIES	390	LF	20.00	GEN	0.000				7,800		7,800
MEMO:	Assume 88' long for 4 Tubes per Vault Plus 10% Waste (Can be Reused)											
	INSTALL AND REMOVE DROP TUBES	2,123	LF		CONC GEN	0.500	1,062	34,000				34,000

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place Clean Grout in Vault
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-A2**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **19:54:45**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.3.1 MEMO:	**VAULT GROUTING** Assume 4 tubes x 7 vaults plus 10% waste											
	GROUT PLACEMENT & CLEANUP (Includes 10% Waste)	22,946	CY	80.00	CONC GEN	0.350	8,031	257,236		1,835,680		2,092,916
	VAULT GROUTING S/T						9,093	$291,236		$1,843,480		$2,134,716
1.3.3.2	**BIN SET VAULT ACCESS HOLES** CORE DRILL 18" HOLE THROUGH VAULT ROOF (4 PLACES/VAULT)	28	EA	1,000.00	CONC GEN	100.000	2,800	89,684		28,000		117,684
	SHIELDING AROUND VAULT HOLES	28	EA	5,000.00	CONC GEN	24.000	672	21,524		140,000		161,524
	CAP 18" DIAMETER HOLES	28	EA	1,800.00	CONC GEN	40.000	1,120	35,874		50,400		86,274
	BIN SET VAULT ACCESS HOLES S/T						4,592	$147,082		$218,400		$365,482
	PROJECT SUBTOTAL						36,012	$1,377,853	$80,000	$2,097,960	$3,806,131	$7,361,944

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud Place Clean Grout in Vault**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-A2**
PREPARED BY: **S. L. Coward**

DATE: **27-Jan-1998**
TIME: **19:54:39**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING	1,324,812	14.47	10	40	1.45	5.79	5.063%	14.47%	468,920	1,793,732
1.1.2	TITLE III INSPECTION	264,962	2.89	10	40	0.29	1.16	1.013%	2.89%	93,784	358,746
1.2.1	PROJECT MANAGEMENT	1,686,432	18.41	10	40	1.84	7.37	6.445%	18.41%	596,916	2,283,348
1.2.2	CONSTRUCTION MANAGEMENT	529,925	5.79	10	40	0.58	2.31	2.025%	5.79%	187,568	717,493
1.3.1	GENERAL CONDITIONS	1,067,791	11.66	10	40	1.17	4.66	4.081%	11.66%	377,947	1,445,738
1.3.2	SITEWORK	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.3.3	CONCRETE	4,231,459	46.20	10	40	4.62	18.48	16.171%	46.20%	1,497,735	5,729,194
1.5.2	PROCUREMENT FEES	52,992	0.58	10	40	0.06	0.23	0.203%	0.58%	18,757	71,749
	ESCALATION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
	SUBTOTAL	9,158,373	100.00					35.000%			
	CALCULATED CONTINGENCY	3,205,431									
	RESULTANT TEC	12,363,804									
	ROUNDED TEC	12,400,000									
	PROJECT CONTINGENCY	3,241,627						35.40%			
	MANAGEMENT RESERVE	535,224									
	CONTINGENCY	2,706,403									
	TOTAL ESTIMATED COST	12,400,000								3,241,627	12,400,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE

CLOSURE TO RCRA LANDFILL STANDARDS; CLASS A FILL; UNESCALATED

FILL VAULTS W/ CLEAN GROUT

PROCUREMENT FEE:

CONSTRUCTION =		$5,299,250		
GFE =				
	Subtotal	$5,299,250		
FEE @ 1% =		$5,299,250	* 0.01 =	$52,993

G&A @ 23% (with a ceiling of $500,000 imposed per year , 7 Years)

CONSTRUCTION OR CEILING • # OF YEARS =		$3,500,000		
GFE =		$0		
PROCUREMENT FEE =		$52,993		
	Subtotal	$3,552,993		
FEE @ 23% =		$3,552,993	* 0.23 =	$817,188

PIF @ 5.5%

CONSTRUCTION =		$5,299,250		
GFE =		$0		
PROCUREMENT FEE =		$52,993		
G&A =		$817,188		
	Subtotal	$6,169,431		
FEE @ 5.5% =		$6,169,431	• 0.055 =	$339,319

TOTAL PROCUREMENT FEE:	$52,993
TOTAL G&A FEE:	$817,188
TOTAL PIF:	$339,319

Lockheed Martin Idaho Technologies Co.
Rev. 6-96

COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure (EIS Stud Tractor (RCRA Estimates)
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-C
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 27-Jan-1998
TIME: 19:21:06
CHECKED BY: JMB
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
<u>1.1</u>	<u>ENGINEERING, DESIGN AND INSPECTION</u>			>> <u>$8,170,841</u>
1.1.1	DESIGN ENGINEERING TITLE I & II	6,128,131	0	6,128,131
1.1.2	TITLE III INSPECTION	2,042,710	0	2,042,710
<u>1.2</u>	<u>MANAGEMENT COSTS</u>			>> <u>$11,752,676</u>
1.2.1	PROJECT MANAGEMENT	7,667,255	0	7,667,255
1.2.2	CONSTRUCTION MANAGEMENT	4,085,421	0	4,085,421
<u>1.3</u>	<u>CONSTRUCTION</u>			>> <u>$40,854,211</u>
1.3.1	GENERAL CONDITIONS	6,840,414	0	6,840,414
1.3.13	SPECIAL CONSTRUCTION	34,013,797	0	34,013,797
1.5.2	PROCUREMENT FEES	408,542	0	>> <u>$408,542</u>
	SUBTOTAL INCLUDING ESCALATION	61,186,270	0	>> $61,186,270
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $4,126,275
	CONTINGENCY			>> $17,287,455
	TOTAL ESTIMATED COST			>> $82,600,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *20.00%*

CONTINGENCY= *35.00%*

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: ICPP Bin Set Closure (EIS Study)
Tractor (RCRA Estimates)
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423-C
PREPARED BY: S. L. Coward

DATE 27-Jan-1998
TIME: 19:21:08
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	DESIGN ENGINEERING TITLE I & II ENGINEERING AND DESIGN											
MEMO:	Title I &II Engineering & Design @ 10% of Construction	1	LS		*LMITCO*	0.000					4,085,421	4,085,421
	Conceptual Engineering & Design @ 5% of Construction	1	LS		*LMITCO*	0.000					2,042,710	2,042,710
	DESIGN ENGINEERING TITLE I & II S/T						0				$6,128,131	$6,128,131
1.1.2	TITLE III INSPECTION INSPECTION - TITLE III	1	LS		*LMITCO*	0.000					2,042,710	2,042,710
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$2,042,710	$2,042,710
1.2.1	PROJECT MANAGEMENT PROJECT MANAGEMENT	1	LOT		*LMITCO*	0.000					4,085,421	4,085,421
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		*LMITCO*	0.000					1,243,965	1,243,965
	PIF	1	LS		*LMITCO*	0.000					2,337,869	2,337,869
	PROJECT MANAGEMENT S/T						0				$7,667,255	$7,667,255

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Tractor (RCRA Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-C**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **19:21:08**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	CONSTRUCTION MANAGEMENT											
	CONSTRUCTION MANAGEMENT	1	LOT		LMITCO	0.000					4,085,421	4,085,421
MEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$4,085,421	$4,085,421
1.3.1	GENERAL CONDITIONS											
	SUPERVISION (Duration of Schedule for Installation of Robots - 10 years)	1	FTE		PIPF GEN	20800.0	20,800	839,696			2,841,100	3,680,796
	TRAINING	15	FTE		SKWK GEN	165.000	2,475	81,947				81,947
	RADCON TECHNICIAN SUPPORT (Duration of Schedule - Assume 10 Years)	2	FTE		Z-1342 LMITCO	20800.0	41,600	2,055,040				2,055,040
	GENERAL CONDITIONS S/T						64,875	$2,976,683			$2,841,100	$5,817,783
1.3.13	SPECIAL CONSTRUCTION											
	FABRICATION OF FOLDABLE TRACTOR ROBOT											
	Design & Develop 1rst Tractor Robot, Including:	1	EA		GEN	0.000					3,000,000	3,000,000
	Design, Approvals, Mock-up, Proof of Process, etc.											
	Fabrication of Additional Units	52	EA		GEN	0.000					*,***,***	13,000,000

Lockheed Martin Idaho Technologies Co.
Rev 6-96
PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Tractor (RCRA Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

DETAILED COST ESTIMATE SHEET

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-C**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **19:21:08**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	**SPECIAL CONSTRUCTION** Design of Development of Modifications to Add'l Units	52	EA		GEN	0.000					1,300,000	1,300,000
	INSTALLATION OF CLEANING UNIT:											
	Install Robotic Units	50	EACH		SKWK GEN	160.000	8,000	264,880				264,880
	Install and Shield Unit Hose/Tubes (Mods, Electr., etc.) - Allowance	50	EA	5,000.00	SKWK GEN	160.000	8,000	264,880		250,000		514,880
	Systems Integration	1	LS		GEN	0.000					75,000	75,000
	CAP 18" DIAMETER HOLES	100	EA	1,800.00	SKWK GEN	40.000	4,000	132,440		180,000		312,440
	CAP 6" DIAMETER HOLES	100		500.00	SKWK GEN	24.000	2,400	79,464		50,000		129,464
	OPERATION OF CALCINE RETRIEVAL -	19	FTE		SKWK GEN	11530.0	219,070	7,253,408				7,253,408
	SPECIAL CONSTRUCTION S/T						241,470	$7,995,072		$480,000	$*,***,***	$25,850,072
	PROJECT SUBTOTAL						306,345	$10,971,755	$0	$480,000	$40,139,617	$51,591,372

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud Tractor (RCRA Estimates)**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-C**
PREPARED BY: **S. L. Coward**

DATE: **27-Jan-1998**
TIME: **19:21:02**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	6,128,131	10.02	10	40	1.00	4.01	3.505%	10.02%	2,144,699	8,272,830
1.1.2	TITLE III INSPECTION	2,042,710	3.34	10	40	0.33	1.34	1.168%	3.34%	714,900	2,757,610
1.2.1	PROJECT MANAGEMENT	7,667,255	12.53	10	40	1.25	5.01	4.386%	12.53%	2,683,356	10,350,611
1.2.2	CONSTRUCTION MANAGEMENT	4,085,421	6.68	10	40	0.67	2.67	2.337%	6.68%	1,429,800	5,515,221
1.3.1	GENERAL CONDITIONS	6,840,414	11.18	10	40	1.12	4.47	3.913%	11.18%	2,393,981	9,234,395
1.3.13	SPECIAL CONSTRUCTION	34,013,797	55.59	10	40	5.56	22.24	19.457%	55.59%	11,904,015	45,917,812
1.5.2	PROCUREMENT FEES	408,542	0.67	10	40	0.07	0.27	0.234%	0.67%	142,980	551,522
	ESCALATION	0	0.00	10	40	0.00	0.00	0.000%	0.00%	(1)	(1)
	SUBTOTAL	61,186,270	100.00					35.000%			
	CALCULATED CONTINGENCY	21,415,195									
	RESULTANT TEC	82,601,465									
	ROUNDED TEC	82,600,000									
	PROJECT CONTINGENCY	21,413,730						35.00%			
	MANAGEMENT RESERVE	4,126,275									
	CONTINGENCY	17,287,455									
	TOTAL ESTIMATED COST	82,600,000								21,413,730	82,600,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions	............Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions	............Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE

CLOSURE TO RCRA LANDFILL STANDARDS; CLASS A FILL; UNESCALATED

CLEAN BINS W/ ROBOTS FLOOR

PROCUREMENT FEE:

CONSTRUCTION =	$40,854,211		
GFE =			
Subtotal	$40,854,211		
FEE @ 1% =	$40,854,211	* 0.01 =	$408,542

G&A @ 23% (with a ceiling of $500,000 imposed per year , 10 Years)

CONSTRUCTION OR CEILING • # OF YEARS =	$5,000,000		
GFE =	$0		
PROCUREMENT FEE =	$408,542		
Subtotal	$5,408,542		
FEE @ 23% =	$5,408,542	• 0.23 =	$1,243,965

PIF @ 5.5%

CONSTRUCTION =	$40,854,211		
GFE =	$0		
PROCUREMENT FEE =	$408,542		
G&A =	$1,243,965		
Subtotal	$42,506,718		
FEE @ 5.5% =	$42,506,718	* 0.055 =	$2,337,869

TOTAL PROCUREMENT FEE:	$408,542
TOTAL G&A FEE:	$1,243,965
TOTAL PIF:	$2,337,869

Lockheed Martin Idaho Technologies Co.
Rev. 6-96

COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure (EIS Stud Place NRC Class A Grout
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-B1
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 27-Jan-1998
TIME: 20:07:18
CHECKED BY:
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $3,192,222
1.1.1	DESIGN ENGINEERING TITLE I & II	2,660,185	0	2,660,185
1.1.2	TITLE III INSPECTION	532,037	0	532,037
1.2	MANAGEMENT COSTS			>> $3,594,336
1.2.1	PROJECT MANAGEMENT	2,530,262	0	2,530,262
1.2.2	CONSTRUCTION MANAGEMENT	1,064,074	0	1,064,074
1.3	CONSTRUCTION			>> $10,640,741
1.3.1	GENERAL CONDITIONS	3,437,150	0	3,437,150
1.3.2	SITEWORK	0	0	0
1.3.3	CONCRETE	1,387,185	0	1,387,185
1.3.15	MECHANICAL	3,365,584	0	3,365,584
1.3.16	ELECTRICAL	2,450,822	0	2,450,822
1.5.2	PROCUREMENT FEES	106,407	0	>> $106,407
	SUBTOTAL INCLUDING ESCALATION	17,533,706	0	>> $17,533,706
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $1,074,715
	CONTINGENCY			>> $5,091,579
	TOTAL ESTIMATED COST			>> $23,700,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *30.00%*

CONTINGENCY= *35.17%*

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: ICPP Bin Set Closure (EIS Study)
Place NRC Class A Grout
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423-B1
PREPARED BY: S. L. Coward

DATE 27-Jan-1998
TIME: 20:07:20
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	**DESIGN ENGINEERING TITLE I & II** ENGINEERING AND DESIGN											
MEMO:	Title I &II Engineering & Design @ 20% of Construction	1	LS		LMITCO	0.000					2,128,148	2,128,148
MEMO:	Conceptual Design @ 5% of Construction	1	LS		LMITCO	0.000					532,037	532,037
	DESIGN ENGINEERING TITLE I & II S/T						0				$2,660,185	$2,660,185
1.1.2	**TITLE III INSPECTION** INSPECTION - TITLE III	1	LS		LMITCO	0.000					532,037	532,037
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$532,037	$532,037
1.2.1	**PROJECT MANAGEMENT** PROJECT MANAGEMENT	1	LS		LMITCO	0.000					1,064,074	1,064,074
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		LMITCO	0.000					829,474	829,474
	PIF	1	LS		LMITCO	0.000					636,714	636,714
	PROJECT MANAGEMENT S/T						0				$2,530,262	$2,530,262

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place NRC Class A Grout
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-B1**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **20:07:20**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	CONSTRUCTION MANAGEMENT											
	CONSTRUCTION MANAGEMENT	1	LS		LMITCO	0.000					1,064,074	1,064,074
MEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$1,064,074	$1,064,074
1.3.1	GENERAL CONDITIONS											
	SUPERVISION (Duration of Project - Assume 10 Years)	1	FTE		CONF GEN	20800.0	20,800	691,600				691,600
	TRAINING	20	FTE		CONC GEN	165.000	3,300	105,699				105,699
	RADCON TECHNICIAN SUPPORT (Duration of Project - Assume 10 Years)	2	FTE		Z-1342 LMITCO	20800.0	41,600	2,055,040				2,055,040
	GENERAL CONDITIONS S/T						65,700	$2,852,339				$2,852,339
1.3.2	SITEWORK											
	ASSUME NO EXCAVATION WILL BE REQUIRED FOR MONITORS											
	SITEWORK S/T						0					
1.3.3	CONCRETE											

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place NRC Class A Grout
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-B1**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **20:07:20**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.3	CONCRETE PROCURE EQUIPMENT FOR PLACEMENT OF GROUT											
	Grout Booster Pump	1	EA	55,000.00	GEN	0.000				55,000		55,000
	Air Compressor and Miscellaneous Cleaning Equipment	1	LS	25,000.00	GEN	0.000				25,000		25,000
	"A" FRAME HOIST FOR LIFTING OF FILL PIPE	100	EA	2,000.00	CONC GEN	40.000	4,000	128,120		200,000		328,120
	POUR CLASS A GROUT AND CLEAN PIPE (Includes 10% Waste)	10,406	CY	0.28	CONC GEN	0.800	8,325	266,643		2,914		269,557
	CLEANING OF PIPING AFTER EACH LIFT	666	LIFTS	30.00	CONC GEN	0.500	333	10,666		19,980		30,646
	6" CAPS FOR PENETRATIONS (Assume 2 per bin)	100	EA	500.00	CONC GEN	24.000	2,400	76,872		50,000		126,872
	CONCRETE S/T						15,058	$482,301		$352,894		$835,195
1.3.15	MECHANICAL											
	DOUBLE CONTAINED GROUT DELIVERY PIPE (Includes 10% Waste)	3,367	LF	47.00	CONC GEN	1.200	4,040	129,414	10,101	158,249	13,468	311,232
	VALVE MANIFOLD ASSEMBLY (7 Vaults plus 1 Extra)	8	EA	100,000.00	CONC GEN	80.000	640	20,499		800,000		820,499
MEMO:	Self-Contained Sealed Unit to Mitigate Leakage during Grout Placement											
	REMOVAL OF RETR.TUBES (2 per Bin) Add'l labor for removal)	7,300	LF	0.20	CONC GEN	0.250	1,825	58,455		1,460		59,915

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place NRC Class A Grout
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-B1**
PREPARED BY: **S. L. Coward**

DATE **27-Jan-1998**
TIME: **20:07:20**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.15	**MECHANICAL** REMOVAL AND DISPOSAL OF GROUT DELIVERY PIPE AND RETR. TUBES	10,667	LF	1.50	CONC *GEN*	1.740	18,561	594,495		16,001	160,005	770,501
MEMO:	Incl. Glovebag, Cuts to Rad Box, Handl., Rad Box Purch. & Disposal											
	VALVE/MANIFOLD REMOVAL	8	EA	2,000.00	CONC *GEN*	480.000	3,840	122,995		16,000	5,600	144,595
MEMO:	Incl. Rad Tent, Disconnect from Piping &Pump, Rad Boxes & Disposal											
	MECHANICAL S/T						28,906	$925,859	$10,101	$991,710	$179,073	$2,106,742
1.3.16	**ELECTRICAL**											
	RAD MONITORS IN EXISTING LANCES	42	EA	30,000.00	CONC *GEN*	150.000	6,300	201,789		1,260,000		1,461,789
	MONITOR TANKS DURING CLASS A GROUT POUR	1	LS		CONC *GEN*	2400.00	2,400	76,872				76,872
MEMO;	Assume Readings take 2 Days Once per Month for 10 Yrs											
	CERCLA tp Monitor after Leaks are Filled with Class A Grout											
	ELECTRICAL S/T						8,700	$278,661		$1,260,000		$1,538,661
	PROJECT SUBTOTAL						118,364	$4,539,160	$10,101	$2,604,603	$6,965,631	$14,119,495

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: ICPP Bin Set Closure (EIS Stud Place NRC Class A Grout
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-B1
PREPARED BY: S. L. Coward

DATE: 27-Jan-1998
TIME: 20:07:15

REPORT NAME: Contingency Analysis

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	2,660,185	15.17	10	40	1.52	6.07	5.310%	15.17%	935,540	3,595,725
1.1.2	TITLE III INSPECTION	532,037	3.03	10	40	0.30	1.21	1.062%	3.03%	187,108	719,145
1.2.1	PROJECT MANAGEMENT	2,530,262	14.43	10	40	1.44	5.77	5.051%	14.43%	889,848	3,420,110
1.2.2	CONSTRUCTION MANAGEMENT	1,064,074	6.07	10	40	0.61	2.43	2.124%	6.07%	374,216	1,438,290
1.3.1	GENERAL CONDITIONS	3,437,150	19.60	10	40	1.96	7.84	6.861%	19.60%	1,208,785	4,645,935
1.3.2	SITEWORK	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.3.3	CONCRETE	1,387,185	7.91	10	40	0.79	3.16	2.769%	7.91%	487,848	1,875,033
1.3.15	MECHANICAL	3,365,584	19.19	10	40	1.92	7.68	6.718%	19.19%	1,183,616	4,549,200
1.3.16	ELECTRICAL	2,450,822	13.98	10	40	1.40	5.59	4.892%	13.98%	861,911	3,312,733
1.5.2	PROCUREMENT FEES	106,407	0.61	10	40	0.06	0.24	0.212%	0.61%	37,421	143,828
	ESCALATION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	1	1
	SUBTOTAL	17,533,706	100.00					35.000%			
	CALCULATED CONTINGENCY	6,136,797									
	RESULTANT TEC	23,670,503									
	ROUNDED TEC	23,700,000									
	PROJECT CONTINGENCY	6,166,294						35.17%			
	MANAGEMENT RESERVE	1,074,715									
	CONTINGENCY	5,091,579									
	TOTAL ESTIMATED COST	23,700,000								6,166,294	23,700,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE

CLOSURE TO RCRA LANDFILL STANDARDS; CLASS A FILL; UNESCALATED

FILL BINS W/ NRC CLASS A GROUT

PROCUREMENT FEE:

CONSTRUCTION = $10,640,741
GFE =
Subtotal $10,640,741

FEE @ 1% = $10,640,741 * 0.01 = $106,407

G&A @ 23% (with a ceiling of $500,000 imposed per year , 7 Years)

CONSTRUCTION OR
CEILING * # OF YEARS = $3,500,000
GFE = $0
PROCUREMENT FEE = $106,407
Subtotal $3,606,407

FEE @ 23% = $3,606,407 * 0.23 = $829,474

PIF @ 5.5%

CONSTRUCTION = $10,640,741
GFE = $0
PROCUREMENT FEE = $106,407
G&A = $829,474
Subtotal $11,576,622

FEE @ 5.5% = $11,576,622 * 0.055 = $636,714

TOTAL PROCUREMENT FEE:	$106,407
TOTAL G&A FEE:	$829,474
TOTAL PIF:	$636,714

Lockheed Martin Idaho Technologies Co.
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COST ESTIMATE SUMMARY

PROJECT NAME: **ICPP Bin Set Closure D&D of Equipment**
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423D&D**
PREPARED BY: **S.L.Coward/smb**
REPORT NAME: **Cost Estimate Summary**

DATE: **27-Jan-1998**
TIME: **19:33:11**
CHECKED BY: SMB
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $0
1.1.1	DESIGN ENGINEERING TITLE I & II	0	0	0
1.1.2	TITLE III INSPECTION	0	0	0
1.2	MANAGEMENT COSTS			>> $800,213
1.2.1	PROJECT MANAGEMENT	800,213	0	800,213
1.2.2	CONSTRUCTION MANAGEMENT	0	0	0
1.3	CONSTRUCTION			>> $11,709,711
1.3.13	SPECIAL CONSTRUCTION	11,709,711	0	11,709,711
1.5.2	PROCUREMENT FEES	117,097	0	>> $117,097
	SUBTOTAL INCLUDING ESCALATION	12,627,021	0	>> $12,627,021
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $0
	CONTINGENCY			>> $4,372,979
	TOTAL ESTIMATED COST			>> $17,000,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *0.00%*

CONTINGENCY= *34.63%*

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: **ICPP Bin Set Closure**
D&D of Equipment
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423D&D**
PREPARED BY: **S.L.Coward/smb**

DATE **27-Jan-1998**
TIME: **19:30:57**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	**DESIGN ENGINEERING TITLE I & II**											
	Costs for Design activities included in Special Construction											
	DESIGN ENGINEERING TITLE I & II S/T						0					
1.1.2	**TITLE III INSPECTION**											
	Costs for Inspection activities included in Special Construction											
	TITLE III INSPECTION S/T						0					
1.2.1	**PROJECT MANAGEMENT**											
	Costs for Project Management activities included in Special Construction											
	G&A	1	LS		*LMITCO*	0.000					141,932	141,932
	PIF	1	LS		*LMITCO*	0.000					658,281	658,281
	PROJECT MANAGEMENT S/T						0				$800,213	$800,213
1.2.2	**CONSTRUCTION MANAGEMENT**											

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure**
D&D of Equipment
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423D&D**
PREPARED BY: **S.L.Coward/smb**

DATE **27-Jan-1998**
TIME: **19:30:57**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	CONSTRUCTION MANAGEMENT Costs for Construction Management activities included in Special Construction											
	CONSTRUCTION MANAGEMENT S/T						0					
1.3.13	SPECIAL CONSTRUCTION											
	Ventilation, Instrument and Control Building (VIC) - 7 ea @ 2400 sf	1	lot			0.000					969,133	969,133
	- Assume facility will have low levels of hazardous material											
	- Assume facility will have no rad contamination											
	- Assume facility will have no asbestos											
	Confinement Enclosures (top of Bin Sets) - 7 ea @ 1600 sf	1	lot			0.000					1,248,126	1,248,126
	Bridge Crane - 7 ea @ 300 sf	1	lot			0.000					369,376	369,376
	- Assume bridge 40' across x 45' high x 2' wide for rails											
	- Assume trolley @ 5' x 5' x 5'											
	HVAC Equipment/System - 1 ea @ 5800 sf	1	lot			0.000					449,044	449,044
	- Assume 7 air handlers @ 5'x5'x6'											
	- Assume 3 exhaust fans @ 4'x4'x3'											

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 3

PROJECT NAME: **ICPP Bin Set Closure**
D&D of Equipment
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423D&D**
PREPARED BY: **S.L.Coward/smb**

DATE **27-Jan-1998**
TIME: **19:30:57**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	SPECIAL CONSTRUCTION - Assume 63 HEPA filters @ 6'x6'x2'											
	Jumper Retrieval Piping (Shielded) - 1 ea @ 420 sf	1	lot			0.000					109,494	109,494
	- Assume 210' long x 2' wide concrete											
	Remote Core Drilling Platform/Saw, etc. - 1 ea @ 250 sf	1	lot			0.000					55,966	55,966
	- Assume platform @ 5' x 5' x 6' and saw is 100 sf											
	Remote Welding and Cutting Equipment - Allowance - 1 ea @ 500 sf	1	lot			0.000					111,932	111,932
	Vertical Deployment Appartus - 7 ea @ 150 sf	1	lot			0.000					235,057	235,057
	- Assume 5' x 5' x 6'											
	Shielding & Riser Plugs - 100 ea @ 4 sf	1	lot			0.000					116,794	116,794
	- Assume 2' x 2'											
	CO2 Blasting Equipment - Allowance - 2 ea @ 500 sf	1	lot			0.000					223,864	223,864
	Retrieval Lines - 1 ea @ 2310 sf	1	lot			0.000					373,116	373,116
	- Assume 2310' long x 1' wide											
	Control Consoles, Cameras, Lighting - Allowance - 1 ea @ 1000 sf	1	lot			0.000					107,934	107,934
	Grouting Manifolds - Clean - Allowance - 8 ea @ 300 sf	1	lot			0.000					259,043	259,043

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure**
D&D of Equipment
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423D&D**
PREPARED BY: **S.L.Coward/smb**

DATE **27-Jan-1998**
TIME: **19:30:57**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	**SPECIAL CONSTRUCTION**											
	Grouting Manifolds - Class C - Allowance - 8 ea @ 300 sf	1	lot			0.000					537,274	537,274
	LDUA's - Allowance - 7 ea @ 150 sf	1	lot			0.000					209,873	209,873
	Pipe Crawler Robots - Allowance - 7 ea @ 150 sf	1	lot			0.000					209,873	209,873
	Tractor Robots - Allowance - 53 ea @ 250 sf	1	lot			0.000					2,648,393	2,648,393
	Misc Robot Wire and Hose Lines - Allowance - 1 ea @ 1000 sf	1	lot			0.000					199,879	199,879
	Waste Disposal - quantities as stated in EDF											
	- Solid Waste	500	cf			0.000					540	540
	- Radioactive Waste	10,000	cf			0.000					3,000,000	3,000,000
	- Mixed Waste	2,200	cf			0.000					275,000	275,000
	SPECIAL CONSTRUCTION S/T						0				$*,***,***	$11,709,711
	PROJECT SUBTOTAL						0	$0	$0	$0	$12,509,924	$12,509,924

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure**
D&D of Equipment
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423D&D**
PREPARED BY: **S.L.Coward/smb**

DATE: **27-Jan-1998**
TIME: **19:33:04**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.1.2	TITLE III INSPECTION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.2.1	PROJECT MANAGEMENT	800,213	6.34	10	40	0.63	2.53	2.218%	6.34%	277,129	1,077,342
1.2.2	CONSTRUCTION MANAGEMENT	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.3.13	SPECIAL CONSTRUCTION	11,709,711	92.74	10	40	9.27	37.09	32.457%	92.74%	4,055,297	15,765,008
1.5.2	PROCUREMENT FEES	117,097	0.93	10	40	0.09	0.37	0.325%	0.93%	40,553	157,650
	ESCALATION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
	SUBTOTAL	12,627,021	100.00					35.000%			
	CALCULATED CONTINGENCY	4,419,457									
	RESULTANT TEC	17,046,478									
	ROUNDED TEC	17,000,000									
	PROJECT CONTINGENCY	4,372,979						34.63%			
	MANAGEMENT RESERVE	0									
	CONTINGENCY	4,372,979									
	TOTAL ESTIMATED COST	17,000,000								4,372,979	17,000,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions	............Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions	............Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

INEL RAD Contaminated Surplus Facilities Cost Model ==> D&D Cost

CPP Bin Set Closure

Project File #015720
Prepared by Sherry Coward

Qty (ea.)	ID Number	Facility Description	Total Usable Floor Space Square Feet	Bldg Lvls	Facility Rating						D&D ROM Cost ($)
					ACM	HAZ	RAD	SYS	Bldg	CHRTZ	
7	See Note 1	Ventilation, Instr. & Control Bldg (VIC)	2,400	1	NA	L	NA	L	S	L	969,133
7		Confinement Enclosures (top of Bin Sets)	1,600	1	NA	A	A	L	S	L	1,248,128
7	See Note 2	Bridge Crane	300	1	NA	L	H	L	S	L	369,376
1	See Note 3	HVAC Equipment/System	5,600	1	NA	L	A	L	S	L	449,044
1	See Note 4	Jumper Retrieval Piping (Shielded)	420	1	NA	A	H	L	C	L	109,494
1	See Note 5	Remote Core Drilling Platform/Saw, etc.	250	1	NA	H	H	L	S	L	55,966
1	Allowance	Remote Welding and Cutting Equipment	500	1	NA	H	H	L	S	L	111,932
7	See Note 6	Vertical Deployment Apparatus	150	1	NA	H	H	L	S	L	235,057
100	See Note 7	Shielding and Riser Plugs	4	1	NA	H	H	L	C	L	116,794
2	Allowance	CO2 Blasting Equipment	600	1	NA	H	H	L	S	L	223,864
1	See Note 8	Retrieval Lines	2,310	1	NA	H	H	L	S	L	373,116
1	Allowance	Control Consoles, Cameras & Lighting	1,000	1	NA	L	L	L	S	L	107,934
8	Allowance	Grouting Manifolds - Clean	300	1	NA	L	L	L	S	L	259,043
8	Allowance	Grouting Manifolds - Class C	300	1	NA	H	H	L	S	L	637,274
7	Allowance	LDUA's	150	1	NA	A	H	L	S	L	209,873
7	Allowance	Pipe Crawler Robots	150	1	NA	A	H	L	S	L	209,873
53	Allowance	Tractor Robots	250	1	NA	A	H	L	S	L	2,648,393
1	Allowance	Misc. Robot wire and hose lines	1,000	1	NA	A	H	L	S	L	199,879
	See Note 9	Waste Disposal									
		Solid Waste (in CF)	500								540
		Radioactive Waste (in CF)	10,000								3,000,000
		Mixed Waste (in CF)	2,200								275,000
		Subtotal ICPP BIN SET CLOSURE									11,709,711

NOTES:

1 - Assumed that facility will have low levels of hazardous material, no rad contamination, and no asbestos
2 - Assume 40' across by 45' high x 2' w for rails plus trolley (5' x 5' x 5')
3 - Assume 7 Air handlers (5' x 5' x 6'), 3 Exhaust Fans (4' x 4' x 3'), and 63 HEPA filters (6' x 6' x 2')
4 - Assume 210 LF x 2' wide concrete
5 - Assume platform (5' x 5' x 6) plus saw (100 sf)
6 - Assume 5' x 5' x 6'
7 - Assume 2' x 2' plugs
8 - Assume 2310' x 1' wide
9 - Waste Disposal Quantities were provided by EDF
Assume the following Waste Disposal Unit Costs:

Industrial Landfill	$1.08/cf
Low Level Waste Repository	$125/cf
Rad Waste	$300/cf

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE

CLOSURE TO RCRA LANDFILL STANDARDS; CLASS A FILL; UNESCALATED

D&D OF EQUIPMENT

PROCUREMENT FEE:

CONSTRUCTION =	$11,709,711		
GFE =			
Subtotal	$11,709,711		
FEE @ 1% =	$11,709,711	* 0.01 =	$117,097

G&A @ 23% (with a ceiling of $500,000 imposed per year , 1 Year)

CONSTRUCTION OR CEILING * # OF YEARS =	$500,000		
GFE =	$0		
PROCUREMENT FEE =	$117,097		
Subtotal	$617,097		
FEE @ 23% =	$617,097	* 0.23 =	$141,932

PIF @ 5.5%

CONSTRUCTION =	$11,709,711		
GFE =	$0		
PROCUREMENT FEE =	$117,097		
G&A =	$141,932		
Subtotal	$11,968,740		
FEE @ 5.5% =	$11,968,740	* 0.055 =	$658,281

TOTAL PROCUREMENT FEE:	$117,097
TOTAL G&A FEE:	$141,932
TOTAL PIF:	$658,281

COST ESTIMATE SUMMARY
ESCALATED

ICPP BIN SET CLOSURE CLOSURE TO RCRA LANDFILL STANDARDS; CLASS A FILL Requestor: B. C. Spaulding	Planning Estimate Estimate #2423 Prepared by: S. L. Coward	1/28/98 Checked by: SMB Approved by:

Regulatory Compliance		31,600,000
Fill Vaults with Clean Grout		23,300,000
Clean Bins with Robots		
Floor		157,000,000
Fill Bins with NRC Class A Grout		53,100,000
D&D of Equipment		50,600,000
TOTAL		**$315,600,000**
	USE	**$316,000,000**

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COST ESTIMATE SUMMARY

PROJECT NAME: Permitting/Documentation Risk Based - NRC Class C
LOCATION 1: INEEL/ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: PLANNING
PROJECT NO: 2423-BD-E
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 28-Jan-1998
TIME: 11:02:58
CHECKED BY: SMB
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	CONCEPTUAL			>> $0
1.1.1	CONCEPTUAL DESIGN	0	0	0
1.2	MANAGEMENT			>> $3,800,720
1.2.1	PM FOR PROJECT DEVELOPMENT	1,942,993	1,107,506	3,050,499
1.2.2	PROJECT EXECUTION	477,848	272,373	750,221
1.3	PERMITTING			>> $19,444,616
1.3.1	PERMITTING	12,385,106	7,059,510	19,444,616
1.5.2	PROCUREMENT FEES	123,851	70,595	>> $194,446
	SUBTOTAL INCLUDING ESCALATION	14,929,798	8,509,984	>> $23,439,782
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $1,963,906
	CONTINGENCY			>> $6,196,312
	TOTAL ESTIMATED COST			>> $31,600,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *0.00%*

CONTINGENCY= *34.81%*

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **Permitting/Documentation Risk Based - NRC Class C**
LOCATION 1: **INEEL/ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **PLANNING**
PROJECT NO.: **2423-BD-E**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **11:03:00**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	CONCEPTUAL DESIGN											
	CONCEPTUAL DESIGN S/T						0					
1.2.1	PM FOR PROJECT DEVELOPMENT											
	G&A	1	LS		LMITCO	0.000					619,723	619,723
	PIF	1	LS		LMITCO	0.000					725,960	725,960
	PM FOR PROJECT DEVELOPMENT S/T						0				$1,345,683	$1,345,683
1.2.1.1	PROJECT ADMINISTRATION Project Admin. during Documentation (5% of Doc. Costs)	1	LOT		LMITCO	0.000					597,310	597,310
	PROJECT ADMINISTRATION S/T						0				$597,310	$597,310
1.2.2	PROJECT EXECUTION											
	PROJECT EXECUTION S/T						0					
1.2.1.2	PROJECT SUPPORT Support During permitting/Doc. (4% of doc. costs)	1	LOT		LMITCO	0.000					477,848	477,848
	PROJECT SUPPORT S/T						0				$477,848	$477,848

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DETAILED COST ESTIMATE SHEET

PAGE # 2

PROJECT NAME: **Permitting/Documentation**
Risk Based - NRC Class C
LOCATION 1: **INEEL/ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **PLANNING**
PROJECT NO.: **2423-BD-E**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **11:03:00**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.1	**PERMITTING**											
	RCRC Closure (Incl. Writing, Reviews, Public Comments & Issuance of Permits)	2	FTE		Z-1700 *LMITCO*	1440.00	2,880	186,221				186,221
	Air Monitoring Activities, Fees, etc.	2	LS		*LMITCO*	0.000					1,208,900	1,208,900
	P.E. Activities	1	LS		*LMITCO*	0.000					60,000	60,000
	CAA Permit to Construct (Incl. Preparing, Reviews, Public comments & Issuance)	1	LS		Z-1700 *LMITCO*	1800.00	1,800	116,388				116,388
	CERCLA Coordinator	2	FTE		Z-1700 *LMITCO*	1500.00	3,000	193,980				193,980
	Regulatory Affairs Oversight	10	YR		Z-1700 *LMITCO*	150.000	1,500	96,990				96,990
	Other Regulatory Compliance (CWA, Storm Water, Historical, etc.)	1	LS		Z-1700 *LMITCO*	1000.00	1,000	64,660				64,660
	Survey Plat	1	LS		*LMITCO*	0.000					10,000	10,000
	SARR	1	LS		Z-3170 *LMITCO*	4500.00	4,500	312,255				312,255
	NRC Landfill Disposal Requirements	10	LS		Z-1710 *LMITCO*	9000.00	90,000	4,960,800				4,960,800
	Environmental & Hazards Analysis	2	FTE		Z-1710 *LMITCO*	1800.00	3,600	198,432				198,432
	Seismic Test Bores (Allowance)	20	HOLES		Z-1710 *LMITCO*	2700.00	54,000	2,976,480				2,976,480
	Operational Readiness Review	1	LS		*LMITCO*	0.000					2,000,000	2,000,000
	PERMITTING S/T						162,280	$9,106,206			$3,278,900	$12,385,106
	PROJECT SUBTOTAL						162,280	$9,106,206	$0	$0	$5,699,741	$14,805,947

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CONTINGENCY ANALYSIS

PROJECT NAME: **Permitting/Documentation**
Risk Based - NRC Class C
LOCATION 1: **INEEL/ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **PLANNING**
PROJECT NO: **2423-BD-E**
PREPARED BY: **S. L. Coward**

DATE: **28-Jan-1998**
TIME: **11:02:47**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	CONCEPTUAL DESIGN	0	0.00	10	40	0.00	0.00	0.000%	0.00%	0	0
1.2.1	PM FOR PROJECT DEVELOPMENT	1,942,993	8.29	10	40	0.83	3.32	2.901%	8.29%	676,425	2,619,418
1.2.2	PROJECT EXECUTION	477,848	2.04	10	40	0.20	0.82	0.714%	2.04%	166,356	644,204
1.3.1	PERMITTING	12,385,106	52.84	10	40	5.28	21.14	18.493%	52.84%	4,311,694	16,696,800
1.5.2	PROCUREMENT FEES	123,851	0.53	10	40	0.05	0.21	0.185%	0.53%	43,117	166,968
	ESCALATION	8,509,984	36.31	10	40	3.63	14.52	12.707%	36.31%	2,962,626	11,472,610
	SUBTOTAL	23,439,782	100.00					35.000%			
	CALCULATED CONTINGENCY	8,203,924									
	RESULTANT TEC	31,643,706									
	ROUNDED TEC	31,600,000									
	PROJECT CONTINGENCY	8,160,218						34.81%			
	MANAGEMENT RESERVE	1,963,906									
	CONTINGENCY	6,196,312									
	TOTAL ESTIMATED COST	31,600,000								8,160,218	31,600,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions	............Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions	............Up to 40%
TITLE I	10% –20%
TITLE II	5% –15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE
CLOSURE TO RCRA LANDFILL STANDARDS; CLASS A FILL; ESCALATED

REGULATORY COMPLIANCE

PROCUREMENT FEE:

CONSTRUCTION =	$19,444,616		
GFE =			
Subtotal	$19,444,616		
FEE @ 1% =	$19,444,616	* 0.01 =	$194,446

G&A @ 23% (with a ceiling of $500,000 imposed per year, 5 yrs)

CONSTRUCTION OR CEILING • 5 YEARS =	$2,500,000		
GFE =	$0		
PROCUREMENT FEE =	$194,446		
Subtotal	$2,694,446		
FEE @ 23% =	$2,694,446	• 0.23 =	$619,723

PIF @ 5.5%

CONSTRUCTION =	$12,385,106		
GFE =	$0		
PROCUREMENT FEE =	$194,446		
G&A =	$619,723		
Subtotal	$13,199,275		
FEE @ 5.5% =	$13,199,275	* 0.055 =	$725,960

TOTAL PROCUREMENT FEE:	$194,446
TOTAL G&A FEE:	$619,723
TOTAL PIF:	$725,960

Lockheed Martin Idaho Technologies Co.
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COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure (EIS Stud
Place Clean Grout in Vault
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-A2-E1
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 28-Jan-1998
TIME: 10:21:14
CHECKED BY: SmB
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $2,493,296
1.1.1	DESIGN ENGINEERING	1,324,812	649,158	1,973,970
1.1.2	TITLE III INSPECTION	264,962	254,364	519,326
1.2	MANAGEMENT COSTS			>> $4,288,659
1.2.1	PROJECT MANAGEMENT	1,701,574	1,548,432	3,250,006
1.2.2	CONSTRUCTION MANAGEMENT	529,925	508,728	1,038,653
1.3	CONSTRUCTION			>> $10,386,530
1.3.1	GENERAL CONDITIONS	1,067,791	1,025,079	2,092,870
1.3.2	SITEWORK	0	0	0
1.3.3	CONCRETE	4,231,459	4,062,201	8,293,660
1.5.2	PROCUREMENT FEES	52,992	50,873	>> $103,865
	SUBTOTAL INCLUDING ESCALATION	9,173,515	8,098,835	>> $17,272,350
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $1,049,039
	CONTINGENCY			>> $4,978,611
	TOTAL ESTIMATED COST			>> $23,300,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *24.00%*

CONTINGENCY= *34.90%*

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DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: ICPP Bin Set Closure (EIS Study)
Place Clean Grout in Vault
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423-A2-E1
PREPARED BY: S. L. Coward

DATE 28-Jan-1998
TIME: 10:21:16
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	DESIGN ENGINEERING ENGINEERING AND DESIGN											
MEMO:	Title I &II Engineering & Design @ 20% of Construction	1	LS		LMITCO	0.000					1,059,850	1,059,850
MEMO:	Conceptual Engineering & Design @ 5% of Construction	1	LS		LMITCO	0.000					264,962	264,962
	DESIGN ENGINEERING S/T						0				$1,324,812	$1,324,812
1.1.2	TITLE III INSPECTION INSPECTION - TITLE III	1	LS		LMITCO	0.000					264,962	264,962
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$264,962	$264,962
1.2.1	PROJECT MANAGEMENT PROJECT MANAGEMENT	1	LS		LMITCO	0.000					529,925	529,925
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		LMITCO	0.000					828,889	828,889
	PIF	1	LS		LMITCO	0.000					342,760	342,760
	PROJECT MANAGEMENT S/T						0				$1,701,574	$1,701,574

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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place Clean Grout In Vault
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-A2-E1**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **10:21:16**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	**CONSTRUCTION MANAGEMENT** CONSTRUCTION MANAGEMENT	1	LS		LMITCO	0.000					529,925	529,925
MEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$529,925	$529,925
1.3.1	**GENERAL CONDITIONS** SUPERVISION (Duration of Schedule - Assume 3 Years)	1	FTE		CONF GEN	6240.00	6,240	207,480				207,480
	TRAINING	10	FTE		CONC GEN	165.000	1,650	52,850				52,850
	RADCON TECHNICIAN (Duration of Schedule - Assume 3 Years)	2	FTE		Z-1342 LMITCO	6240.00	12,480	616,512				616,512
	GENERAL CONDITIONS S/T						20,370	$876,842				$876,842
1.3.2	**SITEWORK**											
	SITEWORK S/T						0					
1.3.3	**CONCRETE**											
	PROCURE EQUIPMENT FOR PLACEMENT OF GROUT											
	Grout Pump	1	EA		GEN	0.000			55,000			55,000

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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place Clean Grout in Vault
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-A2-E1**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **10:21:16**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.3	CONCRETE Air Compressor and Miscellaneous Cleaning Equipment	1	EA		GEN	0.000			25,000			25,000
	GROUT DELIVERY PIPING AND ACCESSORIES PURCHASE (Incl. 10% Waste)	415	LF	20.00	GEN	0.000				8,300		8,300
	GROUT DELIVERY PIPING (Incl. 10% Waste)	2,905	LF		CONC GEN	0.470	1,365	43,732				43,732
MEMO:	Install, Remove & Clean Pipe after Each Vault (7 Vaults)											
	GROUT DELIVERY PIPING CLEANING BETWEEN MANIFOLDS & DROP TUBES	676	LIFTS	30.00	CONC GEN	0.500	338	10,826		20,280		31,106
MEMO:	Assume cleaning between each lift											
	GROUT MANIFOLD AND CLEANING SYSTEM	1	LOT	7,500.00	CONC GEN	254.000	254	8,136		7,500		15,636
MEMO:	Can be Reused after each Vault Set (7 times)											
	CONCRETE S/T						1,957	$62,694	$80,000	$36,080		$178,774
1.3.3.1	VAULT GROUTING PURCHASE GROUT DROP TUBES AND ACCESSORIES	390	LF	20.00	GEN	0.000				7,800		7,800
MEMO:	Assume 88' long for 4 Tubes per Vault Plus 10% Waste (Can be Reused)											
	INSTALL AND REMOVE DROP TUBES	2,123	LF		CONC GEN	0.500	1,062	34,000				34,000

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PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place Clean Grout in Vault
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

DETAILED COST ESTIMATE SHEET

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-A2-E1**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **10:21:16**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.3.1 MEMO:	VAULT GROUTING Assume 4 tubes x 7 vaults plus 10% waste											
	GROUT PLACEMENT & CLEANUP (Includes 10% Waste)	22,946	CY	80.00	CONC GEN	0.350	8,031	257,236		1,835,680		2,092,916
	VAULT GROUTING S/T						9,093	$291,236		$1,843,480		$2,134,716
1.3.3.2	BIN SET VAULT ACCESS HOLES CORE DRILL 18" HOLE THROUGH VAULT ROOF (4 PLACES/VAULT)	28	EA	1,000.00	CONC GEN	100.000	2,800	89,684		28,000		117,684
	SHIELDING AROUND VAULT HOLES	28	EA	5,000.00	CONC GEN	24.000	672	21,524		140,000		161,524
	CAP 18" DIAMETER HOLES	28	EA	1,800.00	CONC GEN	40.000	1,120	35,874		50,400		86,274
	BIN SET VAULT ACCESS HOLES S/T						4,592	$147,082		$218,400		$365,482
	PROJECT SUBTOTAL						36,012	$1,377,853	$80,000	$2,097,960	$3,821,273	$7,377,086

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CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud Place Clean Grout in Vault**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-A2-E1**
PREPARED BY: **S. L. Coward**

DATE: **28-Jan-1998**
TIME: **10:20:01**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING	1,324,812	7.67	10	40	0.77	3.07	2.685%	7.67%	462,329	1,787,141
1.1.2	TITLE III INSPECTION	264,962	1.53	10	40	0.15	0.61	0.537%	1.53%	92,466	357,428
1.2.1	PROJECT MANAGEMENT	1,701,574	9.85	10	40	0.99	3.94	3.448%	9.85%	593,810	2,295,384
1.2.2	CONSTRUCTION MANAGEMENT	529,925	3.07	10	40	0.31	1.23	1.074%	3.07%	184,932	714,857
1.3.1	GENERAL CONDITIONS	1,067,791	6.18	10	40	0.62	2.47	2.164%	6.18%	372,634	1,440,425
1.3.2	SITEWORK	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.3.3	CONCRETE	4,231,459	24.50	10	40	2.45	9.80	8.574%	24.50%	1,476,681	5,708,140
1.5.2	PROCUREMENT FEES	52,992	0.31	10	40	0.03	0.12	0.107%	0.31%	18,493	71,485
	ESCALATION	8,098,835	46.89	10	40	4.69	18.76	16.411%	46.89%	2,826,305	10,925,140
	SUBTOTAL	17,272,350	100.00					35.000%			
	CALCULATED CONTINGENCY	6,045,323									
	RESULTANT TEC	23,317,673									
	ROUNDED TEC	23,300,000									
	PROJECT CONTINGENCY	6,027,650						34.90%			
	MANAGEMENT RESERVE	1,049,039									
	CONTINGENCY	4,978,611									
	TOTAL ESTIMATED COST	23,300,000								6,027,650	23,300,000

CONFIDENCE LEVEL AND ASSUMED RISKS:

The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE

Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE

CLOSURE TO RCRA LANDFILL STANDARDS; CLASS A FILL; ESCALATED

FILL VAULTS W/ CLASS A GROUT

PROCUREMENT FEE:

CONSTRUCTION =	$10,386,530		
GFE =			
Subtotal	$10,386,530		
FEE @ 1% =	$10,386,530	* 0.01 =	$103,865

G&A @ 23% (with a ceiling of $500,000 imposed per year, 7 yrs)

CONSTRUCTION OR CEILING * 7 YEARS =	$3,500,000		
GFE =	$0		
PROCUREMENT FEE =	$103,865		
Subtotal	$3,603,865		
FEE @ 23% =	$3,603,865	* 0.23 =	$828,889

PIF @ 5.5%

CONSTRUCTION =	$5,299,250		
GFE =	$0		
PROCUREMENT FEE =	$103,865		
G&A =	$828,889		
Subtotal	$6,232,004		
FEE @ 5.5% =	$6,232,004	* 0.055 =	$342,760

TOTAL PROCUREMENT FEE:	$103,865
TOTAL G&A FEE:	$828,889
TOTAL PIF:	$342,760

Lockheed Martin Idaho Technologies Co.
Rev. 6-96

COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure (EIS Stud Tractor (RCRA Estimates)
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-C-E1
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 28-Jan-1998
TIME: 09:54:26
CHECKED BY: SmB
APPR'D BY:

WBS Element	*Cost Estimate Element*	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $12,889,502
1.1.1	DESIGN ENGINEERING TITLE I & II	6,128,131	2,757,659	8,885,790
1.1.2	TITLE III INSPECTION	2,042,710	1,961,002	4,003,712
1.2	MANAGEMENT COSTS			>> $22,485,654
1.2.1	PROJECT MANAGEMENT	7,783,994	6,694,235	14,478,229
1.2.2	CONSTRUCTION MANAGEMENT	4,085,421	3,922,004	8,007,425
1.3	CONSTRUCTION			>> $80,074,253
1.3.1	GENERAL CONDITIONS	6,840,414	6,566,797	13,407,211
1.3.13	SPECIAL CONSTRUCTION	34,013,797	32,653,245	66,667,042
1.5.2	PROCUREMENT FEES	408,542	392,200	>> $800,742
	SUBTOTAL INCLUDING ESCALATION	61,303,009	54,947,142	>>$116,250,151
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $8,087,499
	CONTINGENCY			>> $32,662,350
	TOTAL ESTIMATED COST			>> $157,000,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *16.00%*

CONTINGENCY= *35.05%*

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: ICPP Bin Set Closure (EIS Study)
Tractor (RCRA Estimates)
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423-C-E1
PREPARED BY: S. L. Coward

DATE 28-Jan-1998
TIME: 10:09:30
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	DESIGN ENGINEERING TITLE I & II ENGINEERING AND DESIGN											
MEMO:	Title I &II Engineering & Design @ 10% of Construction	1	LS		LMITCO	0.000					4,085,421	4,085,421
	Conceptual Engineering & Design @ 5% of Construction	1	LS		LMITCO	0.000					2,042,710	2,042,710
	DESIGN ENGINEERING TITLE I & II S/T						0				$6,128,131	$6,128,131
1.1.2	TITLE III INSPECTION INSPECTION - TITLE III	1	LS		LMITCO	0.000					2,042,710	2,042,710
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$2,042,710	$2,042,710
1.2.1	PROJECT MANAGEMENT PROJECT MANAGEMENT	1	LOT		LMITCO	0.000					4,085,421	4,085,421
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		LMITCO	0.000					1,334,171	1,334,171
	PIF	1	LS		LMITCO	0.000					2,364,402	2,364,402
	PROJECT MANAGEMENT S/T						0				$7,783,994	$7,783,994

Lockheed Martin Idaho Technologies Co.
Rov 6-96

DETAILED COST ESTIMATE SHEET

PROJECT NAME:	**ICPP Bin Set Closure (EIS Study) Tractor (RCRA Estimates)**	TYPE OF ESTIMATE:	**Planning**	DATE	**28-Jan-1998**
LOCATION 1:	**ICPP**	PROJECT NO.:	**2423-C-E1**	TIME:	**10:09:30**
REQUESTOR:	**Bryan Spaulding**	PREPARED BY:	**S. L. Coward**	REPORT NAME:	**Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	**CONSTRUCTION MANAGEMENT**											
	CONSTRUCTION MANAGEMENT	1	LOT		*LMITCO*	0.000					4,085,421	4,085,421
MEMO:	CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$4,085,421	$4,085,421
1.3.1	**GENERAL CONDITIONS**											
	SUPERVISION (Duration of Schedule for Installation of Robots - 10 years)	1	FTE		PIPF *GEN*	20800.0	20,800	839,696			2,841,100	3,680,796
	TRAINING	15	FTE		SKWK *GEN*	165.000	2,475	81,947				81,947
	RADCON TECHNICIAN SUPPORT (Duration of Schedule - Assume 10 Years)	2	FTE		Z-1342 *LMITCO*	20800.0	41,600	2,055,040				2,055,040
	GENERAL CONDITIONS S/T						64,875	$2,976,683			$2,841,100	$5,817,783
1.3.13	**SPECIAL CONSTRUCTION**											
	FABRICATION OF FOLDABLE TRACTOR ROBOT											
	Design & Develop 1rst Tractor Robot, Including:	1	EA		*GEN*	0.000					3,000,000	3,000,000
	Design, Approvals, Mock-up, Proof of Process, etc.											
	Fabrication of Additional Units	52	EA		*GEN*	0.000					*,***,***	13,000,000

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Tractor (RCRA Estimates)
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-C-E1**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **10:09:30**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	**SPECIAL CONSTRUCTION** Design of Development of Modifications to Add'l Units	52	EA		GEN	0.000					1,300,000	1,300,000
	INSTALLATION OF CLEANING UNIT:											
	Install Robotic Units	50	EACH		SKWK GEN	160.000	8,000	264,880				264,880
	Install and Shield Unit Hose/Tubes (Mods, Electr., etc.) - Allowance	50	EA	5,000.00	SKWK GEN	160.000	8,000	264,880		250,000		514,880
	Systems Integration	1	LS		GEN	0.000					75,000	75,000
	CAP 18" DIAMETER HOLES	100	EA	1,800.00	SKWK GEN	40.000	4,000	132,440		180,000		312,440
	CAP 6" DIAMETER HOLES	100		500.00	SKWK GEN	24.000	2,400	79,464		50,000		129,464
	OPERATION OF CALCINE RETRIEVAL -	19	FTE		SKWK GEN	11530.0	219,070	7,253,408				7,253,408
	SPECIAL CONSTRUCTION S/T						241,470	$7,995,072		$480,000	$*,***,***	$25,850,072
	PROJECT SUBTOTAL						306,345	$10,971,755	$0	$480,000	$40,256,356	$51,708,111

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure (EIS Stud Tractor (RCRA Estimates)**
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423-C-E1**
PREPARED BY: **S. L. Coward**

DATE: **28-Jan-1998**
TIME: **09:54:36**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	6,128,131	5.27	10	40	0.53	2.11	1.845%	5.27%	2,148,130	8,276,261
1.1.2	TITLE III INSPECTION	2,042,710	1.76	10	40	0.18	0.70	0.615%	1.76%	716,043	2,758,753
1.2.1	PROJECT MANAGEMENT	7,783,994	6.70	10	40	0.67	2.68	2.344%	6.70%	2,728,569	10,512,563
1.2.2	CONSTRUCTION MANAGEMENT	4,085,421	3.51	10	40	0.35	1.41	1.230%	3.51%	1,432,087	5,517,508
1.3.1	GENERAL CONDITIONS	6,840,414	5.88	10	40	0.59	2.35	2.059%	5.88%	2,397,811	9,238,225
1.3.13	SPECIAL CONSTRUCTION	34,013,797	29.26	10	40	2.93	11.70	10.241%	29.26%	11,923,056	45,936,853
1.5.2	PROCUREMENT FEES	408,542	0.35	10	40	0.04	0.14	0.123%	0.35%	143,209	551,751
	ESCALATION	54,947,142	47.27	10	40	4.73	18.91	16.543%	47.27%	19,260,944	74,208,086
	SUBTOTAL	116,250,151	100.00					35.000%			
	CALCULATED CONTINGENCY	40,687,553									
	RESULTANT TEC	156,937,704									
	ROUNDED TEC	157,000,000									
	PROJECT CONTINGENCY	40,749,849						35.05%			
	MANAGEMENT RESERVE	8,087,499									
	CONTINGENCY	32,662,350									
	TOTAL ESTIMATED COST	157,000,000								40,749,849	157,000,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET
ICPP BIN SET CLOSURE
CLOSURE TO RCRA LANDFILL STANDARDS; CLASS A FILL; ESCALATED

CLEAN BINS W/ ROBOTS - FLOOR

PROCUREMENT FEE:

CONSTRUCTION = $80,074,253
GFE =
Subtotal $80,074,253

FEE @ 1% = $80,074,253 • 0.01 = $800,743

G&A @ 23% (with a ceiling of $500,000 imposed per year, 10 yrs)

CONSTRUCTION OR
CEILING * 10 YEARS = $5,000,000
GFE = $0
PROCUREMENT FEE = $800,743
Subtotal $5,800,743

FEE @ 23% = $5,800,743 • 0.23 = $1,334,171

PIF @ 5.5%

CONSTRUCTION = $40,854,211
GFE = $0
PROCUREMENT FEE = $800,743
G&A = $1,334,171
Subtotal $42,989,124

FEE @ 5.5% = $42,989,124 * 0.055 = $2,364,402

TOTAL PROCUREMENT FEE: $800,743

TOTAL G&A FEE: $1,334,171

TOTAL PIF: $2,364,402

Lockheed Martin Idaho Technologies Co.
Rev. 6-96

COST ESTIMATE SUMMARY

PROJECT NAME: ICPP Bin Set Closure (EIS Stud Place NRC Class A Grout
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-B1-E2
PREPARED BY: S. L. Coward
REPORT NAME: Cost Estimate Summary

DATE: 28-Jan-1998
TIME: 10:33:33
CHECKED BY: SMB
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
1.1	ENGINEERING, DESIGN AND INSPECTION			>> $6,315,279
1.1.1	DESIGN ENGINEERING TITLE I & II	2,660,185	2,420,768	5,080,953
1.1.2	TITLE III INSPECTION	532,037	702,289	1,234,326
1.2	MANAGEMENT COSTS			>> $8,101,483
1.2.1	PROJECT MANAGEMENT	2,572,069	3,060,762	5,632,831
1.2.2	CONSTRUCTION MANAGEMENT	1,064,074	1,404,578	2,468,652
1.3	CONSTRUCTION			>> $24,686,520
1.3.1	GENERAL CONDITIONS	3,437,150	4,537,038	7,974,188
1.3.2	SITEWORK	0	0	0
1.3.3	CONCRETE	1,387,185	1,831,085	3,218,270
1.3.15	MECHANICAL	3,365,584	4,442,571	7,808,155
1.3.16	ELECTRICAL	2,450,822	3,235,085	5,685,907
1.5.2	PROCUREMENT FEES	106,407	140,458	>> $246,865
	SUBTOTAL INCLUDING ESCALATION	17,575,513	21,774,634	>> $39,350,147
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $2,493,338
	CONTINGENCY			>> $11,256,515
	TOTAL ESTIMATED COST			>> $53,100,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *26.00%*

CONTINGENCY= *34.94%*

Lockheed Martin Idaho Technologies Co.
Rev 6-96

DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: ICPP Bin Set Closure (EIS Study)
Place NRC Class A Grout
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423-B1-E2
PREPARED BY: S. L. Coward

DATE 28-Jan-1998
TIME: 10:33:35
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	DESIGN ENGINEERING TITLE I & II											
MEMO:	Title I &II Engineering & Design @ 20% of Construction	1	LS		*LMITCO*	0.000					2,128,148	2,128,148
MEMO:	Conceptual Design @ 5% of Construction	1	LS		*LMITCO*	0.000					532,037	532,037
	DESIGN ENGINEERING TITLE I & II S/T						0				$2,660,185	$2,660,185
1.1.2	TITLE III INSPECTION INSPECTION - TITLE III	1	LS		*LMITCO*	0.000					532,037	532,037
MEMO:	Title III @ 5% of Construction											
	TITLE III INSPECTION S/T						0				$532,037	$532,037
1.2.1	PROJECT MANAGEMENT PROJECT MANAGEMENT	1	LS		*LMITCO*	0.000					1,064,074	1,064,074
MEMO:	PM @ 10% of Construction											
	G&A	1	LS		*LMITCO*	0.000					861,779	861,779
	PIF	1	LS		*LMITCO*	0.000					646,216	646,216
	PROJECT MANAGEMENT S/T						0				$2,572,069	$2,572,069
1.2.2	CONSTRUCTION MANAGEMENT CONSTRUCTION MANAGEMENT	1	LS		*LMITCO*	0.000					1,064,074	1,064,074

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place NRC Class A Grout
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-B1-E2**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **10:33:35**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2 MEMO:	**CONSTRUCTION MANAGEMENT** CM @ 10% of Construction Costs											
	CONSTRUCTION MANAGEMENT S/T						0				$1,064,074	$1,064,074
1.3.1	**GENERAL CONDITIONS** SUPERVISION (Duration of Project - Assume 10 Years)	1	FTE		CONF *GEN*	20800.0	20,800	691,600				691,600
	TRAINING	20	FTE		CONC *GEN*	165.000	3,300	105,699				105,699
	RADCON TECHNICIAN SUPPORT (Duration of Project - Assume 10 Years)	2	FTE		Z-1342 *LMITCO*	20800.0	41,600	2,055,040				2,055,040
	GENERAL CONDITIONS S/T						65,700	$2,852,339				$2,852,339
1.3.2	**SITEWORK**											
	ASSUME NO EXCAVATION WILL BE REQUIRED FOR MONITORS											
	SITEWORK S/T						0					
1.3.3	**CONCRETE**											
	PROCURE EQUIPMENT FOR PLACEMENT OF GROUT											

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 3

PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place NRC Class A Grout
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-B1-E2**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **10:33:35**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.3	CONCRETE Grout Booster Pump	1	EA	55,000.00	GEN	0.000				55,000		55,000
	Air Compressor and Miscellaneous Cleaning Equipment	1	LS	25,000.00	GEN	0.000				25,000		25,000
	"A" FRAME HOIST FOR LIFTING OF FILL PIPE	100	EA	2,000.00	CONC GEN	40.000	4,000	128,120		200,000		328,120
	POUR CLASS A GROUT AND CLEAN PIPE (Includes 10% Waste)	10,406	CY	0.28	CONC GEN	0.800	8,325	266,643		2,914		269,557
	CLEANING OF PIPING AFTER EACH LIFT	666	LIFTS	30.00	CONC GEN	0.500	333	10,666		19,980		30,646
	6" CAPS FOR PENETRATIONS (Assume 2 per bin)	100	EA	500.00	CONC GEN	24.000	2,400	76,872		50,000		126,872
	CONCRETE S/T						15,058	$482,301		$352,894		$835,195
1.3.15	MECHANICAL											
	DOUBLE CONTAINED GROUT DELIVERY PIPE (Includes 10% Waste)	3,367	LF	47.00	CONC GEN	1.200	4,040	129,414	10,101	158,249	13,468	311,232
	VALVE MANIFOLD ASSEMBLY (7 Vaults plus 1 Extra)	8	EA	100,000.00	CONC GEN	80.000	640	20,499		800,000		820,499
MEMO:	Self-Contained Sealed Unit to Mitigate Leakage during Grout Placement											
	REMOVAL OF RETR.TUBES (2 per Bin) Add'l labor for removal)	7,300	LF	0.20	CONC GEN	0.250	1,825	58,455		1,460		59,915
	REMOVAL AND DISPOSAL OF GROUT DELIVERY PIPE AND RETR. TUBES	10,667	LF	1.50	CONC GEN	1.740	18,561	594,495		16,001	160,005	770,501

Lockheed Martin Idaho Technologies Co.
Rev 6-96
PROJECT NAME: **ICPP Bin Set Closure (EIS Study)**
Place NRC Class A Grout
LOCATION 1: **ICPP**
REQUESTOR: **Bryan Spaulding**

DETAILED COST ESTIMATE SHEET

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423-B1-E2**
PREPARED BY: **S. L. Coward**

DATE **28-Jan-1998**
TIME: **10:33:35**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.15	**MECHANICAL**											
MEMO:	Incl. Glovebag, Cuts to Rad Box, Handl., Rad Box Purch. & Disposal											
	VALVE/MANIFOLD REMOVAL	8	EA	2,000.00	CONC *GEN*	480.000	3,840	122,995		16,000	5,600	144,595
MEMO:	Incl. Rad Tent, Disconnect from Piping &Pump, Rad Boxes & Disposal											
	MECHANICAL S/T						28,906	$925,859	$10,101	$991,710	$179,073	$2,106,742
1.3.16	**ELECTRICAL**											
	RAD MONITORS IN EXISTING LANCES	42	EA	30,000.00	CONC *GEN*	150.000	6,300	201,789		1,260,000		1,461,789
	MONITOR TANKS DURING CLASS A GROUT POUR	1	LS		CONC *GEN*	2400.00	2,400	76,872				76,872
MEMO;	Assume Readings take 2 Days Once per Month for 10 Yrs											
	CERCLA tp Monitor after Leaks are Filled with Class A Grout											
	ELECTRICAL S/T						8,700	$278,661		$1,260,000		$1,538,661
	PROJECT SUBTOTAL						<u>118,364</u>	$4,539,160	$10,101	$2,604,603	$7,007,438	$14,161,302

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: ICPP Bin Set Closure (EIS Stud
Place NRC Class A Grout
LOCATION 1: ICPP
REQUESTOR: Bryan Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO: 2423-B1-E2
PREPARED BY: S. L. Coward

DATE: 28-Jan-1998
TIME: 10:33:30

REPORT NAME: Contingency Analysis

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	2,660,185	6.76	10	40	0.68	2.70	2.366%	6.76%	929,530	3,589,715
1.1.2	TITLE III INSPECTION	532,037	1.35	10	40	0.14	0.54	0.473%	1.35%	185,906	717,943
1.2.1	PROJECT MANAGEMENT	2,572,069	6.54	10	40	0.65	2.61	2.288%	6.54%	898,740	3,470,809
1.2.2	CONSTRUCTION MANAGEMENT	1,064,074	2.70	10	40	0.27	1.08	0.946%	2.70%	371,812	1,435,886
1.3.1	GENERAL CONDITIONS	3,437,150	8.73	10	40	0.87	3.49	3.057%	8.73%	1,201,020	4,638,170
1.3.2	SITEWORK	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.3.3	CONCRETE	1,387,185	3.53	10	40	0.35	1.41	1.234%	3.53%	484,715	1,871,900
1.3.15	MECHANICAL	3,365,584	8.55	10	40	0.86	3.42	2.994%	8.55%	1,176,013	4,541,597
1.3.16	ELECTRICAL	2,450,822	6.23	10	40	0.62	2.49	2.180%	6.23%	856,374	3,307,196
1.5.2	PROCUREMENT FEES	106,407	0.27	10	40	0.03	0.11	0.095%	0.27%	37,181	143,588
	ESCALATION	21,774,634	55.34	10	40	5.53	22.13	19.367%	55.34%	7,608,562	29,383,196
	SUBTOTAL	**39,350,147**	**100.00**					**35.000%**			
	CALCULATED CONTINGENCY	13,772,551									
	RESULTANT TEC	53,122,698									
	ROUNDED TEC	53,100,000									
	PROJECT CONTINGENCY	13,749,853						34.94%			
	MANAGEMENT RESERVE	2,493,338									
	CONTINGENCY	11,256,515									
	TOTAL ESTIMATED COST	53,100,000								13,749,853	53,100,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Martin Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide, Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE

CLOSURE TO RCRA LANDFILL STANDARDS; CLASS A FILL; ESCALATED

FILL BINS W/ NRC CLASS A GROUT

PROCUREMENT FEE:

CONSTRUCTION =	$24,686,520		
GFE =			
Subtotal	$24,686,520		
FEE @ 1% =	$24,686,520	* 0.01 =	$246,865

G&A @ 23% (with a ceiling of $500,000 imposed per year , 7 Years)

CONSTRUCTION OR CEILING • 7 YEARS =	$3,500,000		
GFE =	$0		
PROCUREMENT FEE =	$246,865		
Subtotal	$3,746,865		
FEE @ 23% =	$3,746,865	* 0.23 =	$861,779

PIF @ 5.5%

CONSTRUCTION =	$10,640,741		
GFE =	$0		
PROCUREMENT FEE =	$246,865		
G&A =	$861,779		
Subtotal	$11,749,385		
FEE @ 5.5% =	$11,749,385	* 0.055 =	$646,216

TOTAL PROCUREMENT FEE:	$246,865
TOTAL G&A FEE:	$861,779
TOTAL PIF:	$646,216

Lockheed Martin Idaho Technologies Co.
Rev. 6-96

COST ESTIMATE SUMMARY

PROJECT NAME: **ICPP Bin Set Closure D&D of Equipment**
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423D&D**
PREPARED BY: **S.L.Coward/smb**
REPORT NAME: **Cost Estimate Summary**

DATE: **28-Jan-1998**
TIME: **09:58:46**
CHECKED BY: SMB
APPR'D BY:

WBS Element	Cost Estimate Element	Total Unescalated	Escalation	Total Incl Escalation
<u>1.1</u>	<u>ENGINEERING, DESIGN AND INSPECTION</u>			>> <u>$0</u>
1.1.1	DESIGN ENGINEERING TITLE I & II	0	0	0
1.1.2	TITLE III INSPECTION	0	0	0
<u>1.2</u>	<u>MANAGEMENT COSTS</u>			>> <u>$2,561,125</u>
1.2.1	PROJECT MANAGEMENT	868,178	1,692,947	2,561,125
1.2.2	CONSTRUCTION MANAGEMENT	0	0	0
<u>1.3</u>	<u>CONSTRUCTION</u>			>> <u>$34,543,647</u>
1.3.13	SPECIAL CONSTRUCTION	11,709,711	22,833,936	34,543,647
1.5.2	PROCUREMENT FEES	117,097	228,339	>> <u>$345,436</u>
	SUBTOTAL INCLUDING ESCALATION	12,694,986	24,755,222	>> $37,450,208
	PROJECT CONTINGENCY			
	MANAGEMENT RESERVE			>> $0
	CONTINGENCY			>> $13,149,792
	TOTAL ESTIMATED COST			>> $50,600,000

PROJECT COST PARAMETERS

EDI AS A % OF CONST. + GFE= *0.00%*

CONTINGENCY= *35.11%*

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 1

PROJECT NAME: ICPP Bin Set Closure
D&D of Equipment
LOCATION 1: INEEL / ICPP
REQUESTOR: B. C. Spaulding

TYPE OF ESTIMATE: Planning
PROJECT NO.: 2423D&D
PREPARED BY: S.L.Coward/smb

DATE 28-Jan-1998
TIME: 10:13:24
REPORT NAME: Detail Cost Estimate Sheet

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.1.1	DESIGN ENGINEERING TITLE I & II											
	Costs for Design activities included in Special Construction											
	DESIGN ENGINEERING TITLE I & II S/T						0					
1.1.2	TITLE III INSPECTION											
	Costs for Inspection activities included in Special Construction											
	TITLE III INSPECTION S/T						0					
1.2.1	PROJECT MANAGEMENT											
	Costs for Project Management activities included in Special Construction											
	G&A	1	LS		*LMITCO*	0.000					194,450	194,450
	PIF	1	LS		*LMITCO*	0.000					673,728	673,728
	PROJECT MANAGEMENT S/T						0				$868,178	$868,178
1.2.2	CONSTRUCTION MANAGEMENT											

Lockheed Martin Idaho Technologies Co.
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PROJECT NAME: **ICPP Bin Set Closure**
D&D of Equipment
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

DETAILED COST ESTIMATE SHEET

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423D&D**
PREPARED BY: **S.L.Coward/smb**

PAGE # **2**

DATE **28-Jan-1998**
TIME: **10:13:24**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.2.2	**CONSTRUCTION MANAGEMENT** Costs for Construction Management activities included in Special Construction											
	CONSTRUCTION MANAGEMENT S/T						0					
1.3.13	**SPECIAL CONSTRUCTION**											
	Ventilation, Instrument and Control Building (VIC) - 7 ea @ 2400 sf	1	lot			0.000					969,133	969,133
	- Assume facility will have low levels of hazardous material											
	- Assume facility will have no rad contamination											
	- Assume facility will have no asbestos											
	Confinement Enclosures (top of Bin Sets) - 7 ea @ 1600 sf	1	lot			0.000					1,248,126	1,248,126
	Bridge Crane - 7 ea @ 300 sf	1	lot			0.000					369,376	369,376
	- Assume bridge 40' across x 45' high x 2' wide for rails											
	- Assume trolley @ 5' x 5' x 5'											
	HVAC Equipment/System - 1 ea @ 5800 sf	1	lot			0.000					449,044	449,044
	- Assume 7 air handlers @ 5'x5'x6'											
	- Assume 3 exhaust fans @ 4'x4'x3'											

Lockheed Martin Idaho Technologies Co.
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DETAILED COST ESTIMATE SHEET

PAGE # 3

PROJECT NAME: **ICPP Bin Set Closure**
D&D of Equipment
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423D&D**
PREPARED BY: **S.L.Coward/smb**

DATE **28-Jan-1998**
TIME: **10:13:24**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	SPECIAL CONSTRUCTION - Assume 63 HEPA filters @ 6'x6'x2'											
	Jumper Retrieval Piping (Shielded) - 1 ea @ 420 sf	1	lot			0.000					109,494	109,494
	- Assume 210' long x 2' wide concrete											
	Remote Core Drilling Platform/Saw, etc. - 1 ea @ 250 sf	1	lot			0.000					55,966	55,966
	- Assume platform @ 5' x 5' x 6' and saw is 100 sf											
	Remote Welding and Cutting Equipment - Allowance - 1 ea @ 500 sf	1	lot			0.000					111,932	111,932
	Vertical Deployment Appartus - 7 ea @ 150 sf	1	lot			0.000					235,057	235,057
	- Assume 5' x 5' x 6'											
	Shielding & Riser Plugs - 100 ea @ 4 sf	1	lot			0.000					116,794	116,794
	- Assume 2' x 2'											
	CO2 Blasting Equipment - Allowance - 2 ea @ 500 sf	1	lot			0.000					223,864	223,864
	Retrieval Lines - 1 ea @ 2310 sf	1	lot			0.000					373,116	373,116
	- Assume 2310' long x 1' wide											
	Control Consoles, Cameras, Lighting - Allowance - 1 ea @ 1000 sf	1	lot			0.000					107,934	107,934
	Grouting Manifolds - Clean - Allowance - 8 ea @ 300 sf	1	lot			0.000					259,043	259,043

Lockheed Martin Idaho Technologies Co.
Rov 6-96

DETAILED COST ESTIMATE SHEET

PAGE # 4

PROJECT NAME: **ICPP Bin Set Closure**
D&D of Equipment
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO.: **2423D&D**
PREPARED BY: **S.L.Coward/smb**

DATE **28-Jan-1998**
TIME: **10:13:24**
REPORT NAME: **Detail Cost Estimate Sheet**

CODE	DESCRIPTION	QTY	UOM	MATL UNIT COST	CREW SUB	UNIT LAB HOURS	TOTAL LAB HRS	LABOR	CONST. EQUIP.	MAT'L	S/C (OTHER 1)	TOTAL COST
1.3.13	**SPECIAL CONSTRUCTION**											
	Grouting Manifolds - Class C - Allowance - 8 ea @ 300 sf	1	lot			0.000					537,274	537,274
	LDUA's - Allowance - 7 ea @ 150 sf	1	lot			0.000					209,873	209,873
	Pipe Crawler Robots - Allowance - 7 ea @ 150 sf	1	lot			0.000					209,873	209,873
	Tractor Robots - Allowance - 53 ea @ 250 sf	1	lot			0.000					2,648,393	2,648,393
	Misc Robot Wire and Hose Lines - Allowance - 1 ea @ 1000 sf	1	lot			0.000					199,879	199,879
	Waste Disposal - quantities as stated in EDF											
	- Solid Waste	500	cf			0.000					540	540
	- Radioactive Waste	10,000	cf			0.000					3,000,000	3,000,000
	- Mixed Waste	2,200	cf			0.000					275,000	275,000
	SPECIAL CONSTRUCTION S/T						0				$*,***,***	$11,709,711
	PROJECT SUBTOTAL						0	$0	$0	$0	$12,577,889	$12,577,889

Lockheed Martin Idaho Technologies Co.
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CONTINGENCY ANALYSIS

PROJECT NAME: **ICPP Bin Set Closure**
D&D of Equipment
LOCATION 1: **INEEL / ICPP**
REQUESTOR: **B. C. Spaulding**

TYPE OF ESTIMATE: **Planning**
PROJECT NO: **2423D&D**
PREPARED BY: **S.L.Coward/smb**

DATE: **28-Jan-1998**
TIME: **09:58:43**

REPORT NAME: **Contingency Analysis**

PROBABLE % VARIATION									PROJECT CONTINGENCY		SUMMARY
WBS Element	Cost Estimate Element	Total Cost w/o Contingency	% Total Cost	Prob. % Var. From Est.		Wt. % of Prob.		Contingency	%	Cost	Total Cost by Element
				-	+	-	+				
1.1.1	DESIGN ENGINEERING TITLE I & II	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.1.2	TITLE III INSPECTION	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.2.1	PROJECT MANAGEMENT	868,178	2.32	10	40	0.23	0.93	0.811%	2.32%	304,841	1,173,019
1.2.2	CONSTRUCTION MANAGEMENT	0	0.00	0	0	0.00	0.00	0.000%	0.00%	0	0
1.3.13	SPECIAL CONSTRUCTION	11,709,711	31.27	10	40	3.13	12.51	10.944%	31.27%	4,111,600	15,821,311
1.5.2	PROCUREMENT FEES	117,097	0.31	10	40	0.03	0.13	0.109%	0.31%	41,116	158,213
	ESCALATION	24,755,222	66.10	10	40	6.61	26.44	23.136%	66.10%	8,692,235	33,447,457
	SUBTOTAL	37,450,208	100.00					35.000%			
	CALCULATED CONTINGENCY	13,107,573									
	RESULTANT TEC	50,557,781									
	ROUNDED TEC	50,600,000									
	PROJECT CONTINGENCY	13,149,792						35.11%			
	MANAGEMENT RESERVE	0									
	CONTINGENCY	13,149,792									
	TOTAL ESTIMATED COST	50,600,000								13,149,792	50,600,000

CONFIDENCE LEVEL AND ASSUMED RISKS:
The Lockheed Idaho Technologies Co. Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18% and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90 % probability of underrun and a 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE
Guidelines established by DOE/FM 50, Cost Estimating Guide. Vol. 6, Cost Guide, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% – 30%
Experimental/Special Conditions............	Up to 50%
Conceptual	15% – 25%
Experimental/Special Conditions............	Up to 40%
TITLE I	10% – 20%
TITLE II	5% – 15%
TITLE II/AFC	Market Conditions

G&A/PIF ADDER CALCULATION SHEET

ICPP BIN SET CLOSURE

CLOSURE TO RCRA LANDFILL STANDARDS; CLASS A FILL; ESCALATED

D&D OF EQUIPMENT

PROCUREMENT FEE:

CONSTRUCTION =		$34,543,647		
GFE =				
	Subtotal	$34,543,647		
FEE @ 1% =		$34,543,647	* 0.01 =	$345,436

G&A @ 23% (with a ceiling of $500,000 imposed per year, 1 yr)

CONSTRUCTION OR CEILING • 1 YEARS =		$500,000		
GFE =		$0		
PROCUREMENT FEE =		$345,436		
	Subtotal	$845,436		
FEE @ 23% =		$845,436	* 0.23 =	$194,450

PIF @ 5.5%

CONSTRUCTION =		$11,709,711		
GFE =		$0		
PROCUREMENT FEE =		$345,436		
G&A =		$194,450		
	Subtotal	$12,249,598		
FEE @ 5.5% =		$12,249,598	• 0.055 =	$673,728

TOTAL PROCUREMENT FEE:	$345,436
TOTAL G&A FEE:	$194,450
TOTAL PIF:	$673,728

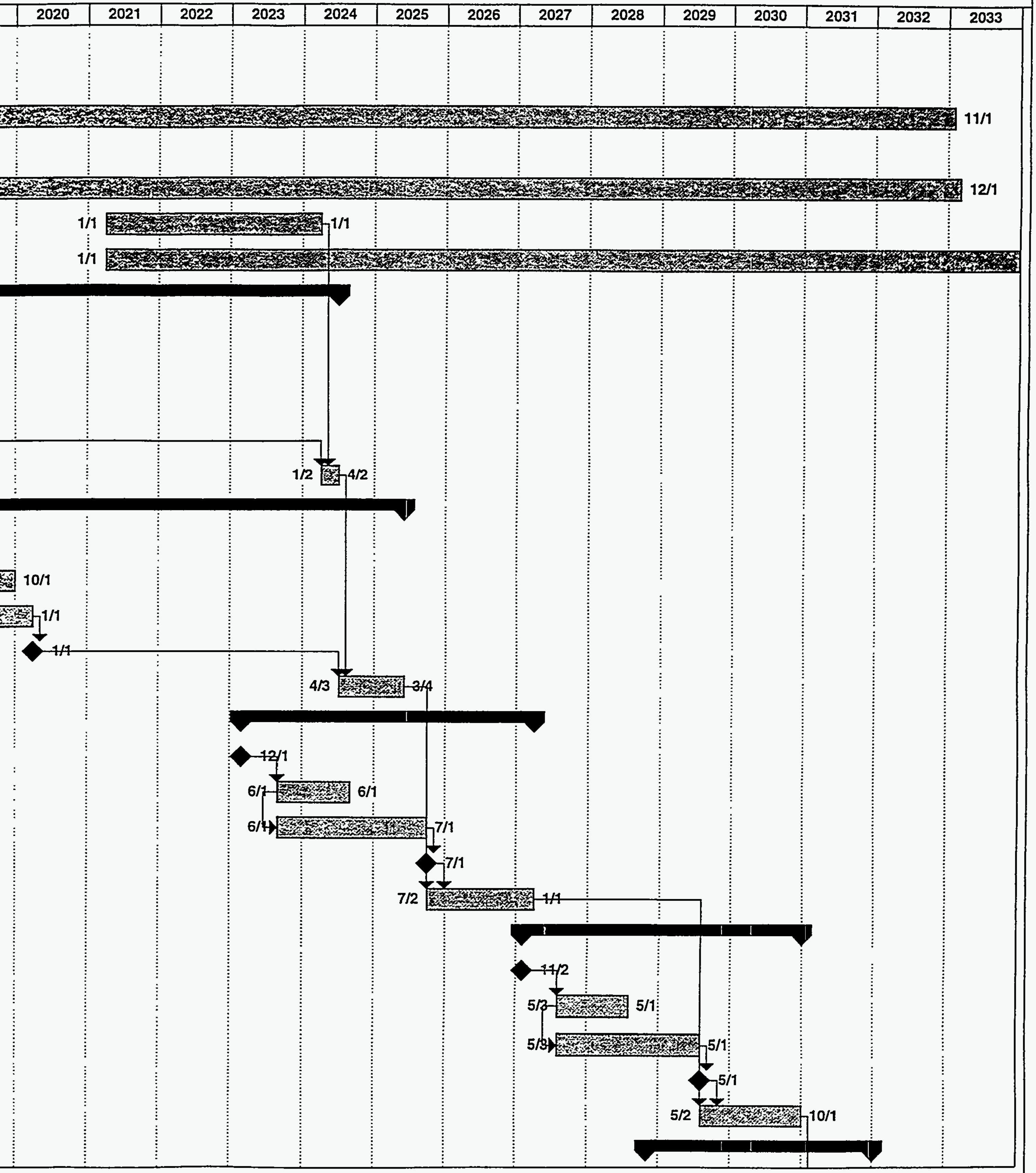
RCRA CLOSURE TO LAN
NRC CLASS

ID	Task Name
1	PERMITTING
2	DESIGN - GROUT VAULTS
3	MANAGEMENT - GROUT VAULTS
4	DESIGN - CLEAN BIN FLOORS
5	MANAGEMENT - CLEAN BIN FLOOR
6	DESIGN - GROUT BINS
7	MANAGEMENT - GROUT BINS
8	**BIN SET #1**
9	RETRIEVAL COMPLETE
10	GROUT VAULTS
11	CLEAN BIN FLOORS
12	RCRA CLOSURE
13	GROUT BINS
14	**BIN SET #5**
15	RETRIEVAL COMPLETE
16	GROUT VAULTS
17	CLEAN BIN FLOORS
18	RCRA CLOSURE
19	GROUT BINS
20	**BIN SET #7**
21	RETRIEVAL COMPLETE
22	GROUT VAULTS
23	CLEAN BIN FLOORS
24	RCRA CLOSURE
25	GROUT BINS
26	**BIN SET #6**
27	RETRIEVAL COMPLETE
28	GROUT VAULTS
29	CLEAN BIN FLOORS
30	RCRA CLOSURE
31	GROUT BINS
32	**BIN SET #3**

Project: 2423-5.MPP
Date: Tue 1/6/98

Task	▨	Milestone	◆	Rolled Up Task	▨
Progress	▬	Summary	▬	Rolled Up Milestone	◇

FILL STANDARDS -
GROUT



▨ Rolled Up Progress ■

ENGINEERING DESIGN FILE

Form L-0431.2#
(05-96-Rev.#02)

Project File Number 015720
EDF Serial Number EDF-BSC-017
Functional File Number RD-01

Project/Task BIN SET CLOSURE STUDY
Sub task Nitric Acid Corrosion Assessment

Title: NITRIC ACID CORROSION ASSESSMENT OF ICPP BIN SET VESSELS / BCN-1-98

Summary From Letter by B.C. Norby

A corrosion evaluation was performed to determine if the Calcine Bin Set vessels were compatible with nitric acid (HNO_3). It has been proposed to dissolve any calcine that might be left in the vessels after pneumatic transfer with nitric acid. The materials in question were: type 405, 304, and 304L stainless steel (the materials of construction for the Bin Sets).

The evaluation indicated that nitric acid is not expected to be a problem for type 405 stainless steel (Bin Set 1) or 304L stainless steel (Bin Sets 4, 5, 6, and 7), but it would be a concern for type 304 stainless steel (Bin Sets 2 and 3).

The concern for type 304 stainless steel is the heat-affected-zone. When welding 304 stainless steel, the area adjacent to the weld undergoes a metallurgical transformation that reduces its corrosion resistance. If the nitric acid is left in the vessels, the heat-affected-zone of the metal will experience intergranular attack (a form of localized corrosion).

If the nitric acid dissolution process could be accomplished within a month or so and the nitric acid in the vessel could be rinsed and dried, there would be no problem with type 304 stainless steel.

Distribution: B.C. Spaulding, M.M. Dahlmeir, B.R. Helm, D.J. Harrell and project file (original +1)

Authors	Department	Reviewed	Approved
K.D. McAllister	4130	Date 2/2/98	Date 2/2/98
Date 2/3/98			

LOCKHEED MARTIN

Lockheed Martin Idaho Technologies Company

INTERDEPARTMENTAL COMMUNICATION

Date:	February 2, 1998		
To:	M. M. Dahlmeir	Mail Stop 3765	Phone 6-2793
From:	B. C. Norby BCN	Mail Stop 5217	Phone 6-3084
Subject:	NITRIC ACID CORROSION ASSESSMENT OF ICPP BIN SET VESSELS/ BCN-1-98		

Summary

A corrosion evaluation was performed to determine if the Calcine Bin Set vessels were compatible with nitric acid (HNO_3). It has been proposed to dissolve any calcine that might be left in the vessels after pneumatic transfer with nitric acid. The materials in question were: type 405, 304, and 304L stainless steel (the materials of construction for the Bin Sets).

The evaluation indicated that nitric acid is not expected to be a problem for type 405 stainless steel (Bin Set 1) or 304L stainless steel (Bin Sets 4, 5, 6, and 7), but it would be a concern for type 304 stainless steel (Bin Sets 2 and 3).

The concern for type 304 stainless steel is the heat-affected-zone. When welding 304 stainless steel, the area adjacent to the weld undergoes a metallurgical transformation that reduces its corrosion resistance. If the nitric acid is left in the vessels, the heat-affected-zone of the metal will experience intergranular attack (a form of localized corrosion).

If the nitric acid dissolution process could be accomplished within a month or so and the nitric acid in the vessel could be rinsed and dried, there would be no problem with type 304 stainless steel.

Bin Set One (Type 405 Stainless Steel)

Type 405 stainless steel is a ferritic stainless steel with only 11.5% to 14.5% chromium. There is no nickel in the alloy. This alloy is not as corrosion resistant to nitric acid as the austenitic stainless steels (300 series like 304L).

Corrosion tests were performed to determine the corrosion rate of type 405 stainless steel in nitric acid solutions. The test coupons were welded. The weld metal was 310 stainless steel, the same weld wire used for Bin Set One. The results are tabulated below.

Table 1 - Type 405 Stainless Steel Corrosion

Solution	Temperature (C)	Exposure Time (hrs.)	Coupon Number	Corrosion Rate (0.001"/year)
5 $\underline{M}$ HNO_3	32	2422	W-2555	0.19
5 $\underline{M}$ HNO_3	32	2422	W-2556	0.21
3 $\underline{M}$ HNO_3 with 0.67 $Al(NO_3)_3$	32	2422	W-2557	0.15
3 $\underline{M}$ HNO_3 with 0.67 $Al(NO_3)_3$	32	2422	W-2558	0.16

These results show that type 405 stainless steel welded with 310 weld wire has adequate corrosion resistance for this application. After 2422 hours of exposure there was no evidence of intergranular corrosion of the heat-affected-zones. Even though the corrosion rates were acceptably low, it would still be advisable to rinse and dry the vessels after dissolving the calcine.

Bin Sets Two and Three (Type 304 Stainless Steel)

The vessels of bin sets two and three were made with 304 stainless steel. This alloy is an austenitic stainless steel with roughly 18% chromium and 8% nickel. The vessels have excellent corrosion resistance to nitric acid in the unwelded condition, but, they are not acceptable for nitric acid service in the welded condition.

During welding of type 304 stainless steel, the heat affected zone experiences a metallurgical transformation. Chromium and carbon combine to form chromium carbide precipitates. In the areas adjacent to these precipitates the chromium level is reduced. This causes the alloy to lose corrosion resistance in these chromium lean areas. This leads to intergranular corrosion (see Figures 1 and 2). The heat affected zones of all the welds have these precipitates. This condition could only be corrected with a post-weld heat treatment (1900°F followed by a water quench).

The time to failure would be a function of nitric acid concentration. As the nitric acid concentration increases the time to failure would decrease. Corrosion experience at the Idaho Chemical Processing Plant (ICPP) has indicated that a 2 molar nitric acid based solution at ambient temperatures can penetrate the heat affected zone of a 0.053 inch thick piece of 304 stainless steel in three months. This is equivalent to a heat affected zone corrosion rate of about 210 mpy (0.210"/year) . This compares to less than 2 mpy for unwelded 304 stainless steel.

If it were possible to thoroughly flush and dry the vessels after dissolving the calcine, then a nitric acid dissolution would be acceptable.

Bin Sets 4-7 (Type 304L Stainless Steel)

Bin Sets 4, 5, 6, and 7 were made using 304L stainless steel. This alloy is similar to 304 stainless steel, except the percentage of carbon is lower (0.03% versus 0.08%). The low carbon prevents the formation of chromium carbide precipitates. Therefore, the corrosion resistance of the heat-affected-zone is comparable to the base metal. Nitric acid is compatible with this alloy even in the welded condition. There would be no problem using nitric acid to decontaminate the bin set vessels.

Conclusions

1. Nitric acid could be used to dissolve the residual calcine for bin sets 1, 4, 5, 6, and 7 (type 304L and 405 stainless steel) without compromising the integrity of the vessel.

2. Nitric acid should not be used for bin sets 2 and 3 (type 304 stainless steel) unless the vessels can be rinsed and dried within a short period of time (about a month).

Distribution:

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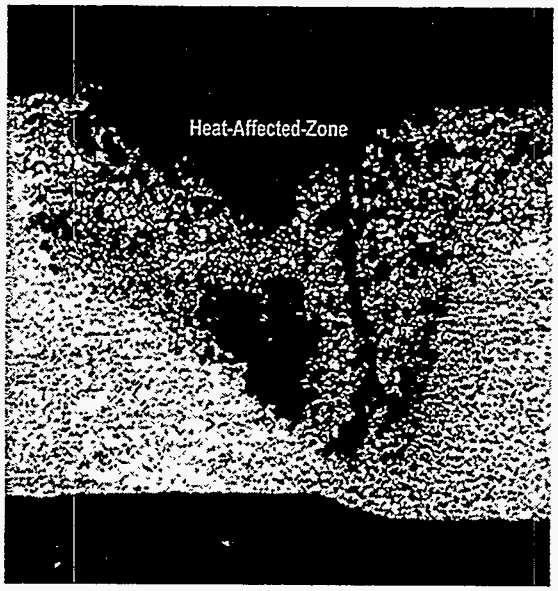

Figure 1 Nitric Acid Heat-affected-zone corrosion of 304 Stainless Steel (50X)

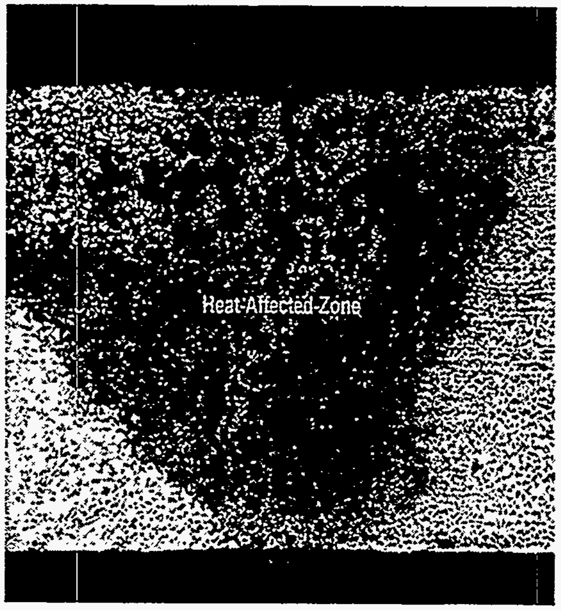

Figure 2: Cross section of the heat-affected-zone of 304 stainless steel after three months exposure to nitric acid at ambient temperature (50X)