Calculation Cover Sheet

Project	Calculation Number	Project Number
F-Area Type IV Tanks	T-CLC-F-00373	N/A
Title Tanks 18 and 19 Closure Structural Calculation (U)	**Functional Classification** SS	**Sheet:** 1 of 39
	Discipline Structural Mechanics	
Calc Level: ☑ Type 1 Type 2	**Type 1 Calc Status** Preliminary ☑ Confirmed	
Computer Program: ☐ N/A	**Version/Release No.:** N/A	

Purpose and Objective

Evaluate the Type IV Tanks 18 and 19 for tank structural integrity, reducing grout and intruder grout stress levels, and foundation pressures throughout Tanks 18 and 19 grouting activities.

Summary of Conclusion

See Section 5.0 for a summary of results and conclusions for the evaluations performed in this calculation. The table in Section 5.11 summarizes the grout and concrete compressive strength and stresses.

UNCLASSIFIED
DOES NOT CONTAIN UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION
ADC & Reviewing Official: J.R. JOSHI, Engineer
(Name and Title)
Date: 05/11/06

	Revisions:			
Rev No.	**Revision Description**			
0	See sheet 2			
Rev. No.	**Originator (Print) Sign/Date**	**Verification/Checking Method**	**Verifier/Checker (Print) Sign/Date**	**Manager (Print) Sign/Date**
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Unclassified

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RECORD OF REVISIONS

REV. NO.	DESCRIPTION	SHT. NO.
0	ORIGINAL ISSUE	ALL

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OPEN ITEMS

REV. NO.	DESCRIPTION	SHT. NO.
0	NONE	NA

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1.0 INTRODUCTION

THIS CALCULATION PROVIDES DOCUMENTATION FOR TANK STRUCTURAL INTEGRITY, REDUCING GROUT AND INTRUDER GROUT STRESS LEVELS, AND FOUNDATION PRESSURES THROUGHOUT TANK 18 AND TANK 19 CLOSURE ACTIVITIES, (SEE APPENDIX A)

2.0 SCOPE

2.1 THE CALCULATIONS WOULD ESTABLISH PROCEDURAL REQUIRMENTS TO MAINTAIN TANK STRUCTURAL INTEGRITY DURING THE GROUTING PROCESS.

2.2 ESTABLISH THE COMPRESSIVE STRESS ADEQUACY OF THE REDUCING GROUT AT CRITICAL STAGES OF THE GROUTING PROCESS AND AT COMPLETION OF BACKFILL,

2.3 ESTABLISH THE COMPRESSIVE STRESS ADEQUACY OF THE INTRUDER GROUT AT THE COMPLETION OF BACKFILL.

2.4 ESTABLISH THE COMPRESSIVE STRESS ADEQUACY OF THE FLEXIBLE BASE SLAB AT THE COMPLETION OF BACKFILL,

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2.5 CONSIDER THE FOLLOWING ENGINEERED BACKFILL SCENARIOS;

① BACKFILL TO THE LEVEL OF THE RISER COVER AT THE DOME APEX.

② BACKFILL TO THE LEVEL 10 FT. ABOVE ①

③ BACKFILL TO GRADE LEVEL WEST OF TANK 17 THROUGH 20.

④ BACKFILL TO THE LEVEL 10 FT. ABOVE THE TOP OF EVAPORATOR BLDG. 242-F.

2.6 THE CALCULATION WILL PROVIDE THE HIGHEST SOIL BEARING PRESSURE UNDER THE APPROPRIATE BACKFILL SCENARIO. THE CALCULATED SOIL PRESSURE DOES NOT INCLUDE THE WEIGHTS OF EARTHMOVING EQUIPMENT SINCE THESE LOADS ARE TEMPORARY AND HAVE NO BEARING ON LONG-TERM SETTLEMENT.

2.7 THE INCREASED SOIL BEARING PRESSURE IS EVALUATED BY SRS SITE GEOTECHNICAL FOR ULTIMATE SETTLEMENT AFTER TANK CLOSURE.

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3.0 METHODOLOGY/ASSUMPTIONS/INPUT

3.1 THE MAXIMUM GROUT POUR RATE IS 75 CU. YD. PER HR WHICH IS EQUAL TO THE BATCH PLANT PRODUCTION RATE. THIS RATE IS USED TO ESTABLISH GROUT VOLUME VS TIME IN THE CALCULATIONS SUCH AS THE TIME IT WOULD TAKE TO POUR REDUCING GROUT THAT WOULD LOAD THE FLEXIBLE BASE SLAB TO THE SPECIFIED ALLOWABLE SOIL BEARING PRESSURE AND THE TIME IT WOULD TAKE TO POUR REDUCING GROUT TO A DEPTH SUCH THAT THE GROUT FLUID PRESSURE WOULD BALANCE THE SURROUNDING AT-REST LATERAL SOIL PRESSURE. THESE CONDITIONS WOULD ALLOW GROUT POUR TO CONTINUE WITHOUT ADDITIONAL CONSIDERATION FOR THE INTEGRITY OF THE TANK FLEXIBLE BASE SLAB AND TANK WALL.

3.2 CHECK GROUT POUR CONTINUITY FOR THE REDUCING GROUT UP TO THE DOME SPRINGLINE BY SUFFICIENT GROUT STRENGTH USING THE VOLUME VS TIME RELATIONSHIP MENTIONED IN 3.1 AND LINEAR TIME VS STRENGTH DATA FOR SIMILAR GROUT MIX.

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3.3 CHECK GROUT POUR CONTINUITY FOR THE INTRUDER GROUT WITH SPECIAL CONSIDERATION OF DOME UPLIFT.

3.4 CALCULATE COMPRESSIVE STRESS IN THE REDUCING GROUT AT THE FLEXIBLE BASE SLAB AT COMPLETION OF GROUT POUR.

3.4 CALCULATE COMPRESSIVE STRESS IN THE INTRUDER GROUT FOR THE MAXIMUM BACKFILL LOAD.

3.5 CALCULATE COMPRESSIVE STRESS IN THE FLEXIBLE BASE SLAB FOR THE GROUTED TANK PLUS THE MAXIMUM BACKFILL LOAD.

3.6 USE THE FOLLOWING PARAMETERS IN THE CALCULATIONS:

1. GROUT UNIT WEIGHT = 128 LB/CU FT (PCF), [1]
2. SOIL BACKFILL UNIT WEIGHT = 125 PCF, [6, 7]
3. REDUCING GROUT STRENGTHS: [3, Table 4]

   7 DAYS = 360 PSI
   28 DAYS = 1085 PSI
   56 DAYS = 1300 PSI
   } USE LINEAR VARIATION VS TIME BETWEEN THESE CONTROL POINTS.

4. INTRUDER GROUT STRENGTH: [1]

   28 DAYS = 2000 PSI

   USE LINEAR VARIATION FROM 0 TO 2000 PSI

Calculation Continuation Sheet

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5. ALLOWABLE SOIL BEARING PRESSURE UNDER THE FLEXIBLE BASE SLAB = 3700 LB/SQ FT. (PSF), [9]

6. ALLOWABLE SOIL BEARING PRESSURE UNDER THE TANK FOUNDATION ANNULUS = 10000 PSF, [9]

7. FLEXIBLE BASE SLAB NOMINAL CONCRETE STRENGTH OF 3000 PSI IS MULTIPLIED BY THE FACTOR 0.7 DUE TO HISTORICAL THERMAL DEGRADATION, [8]

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4.0 CALCULATIONS

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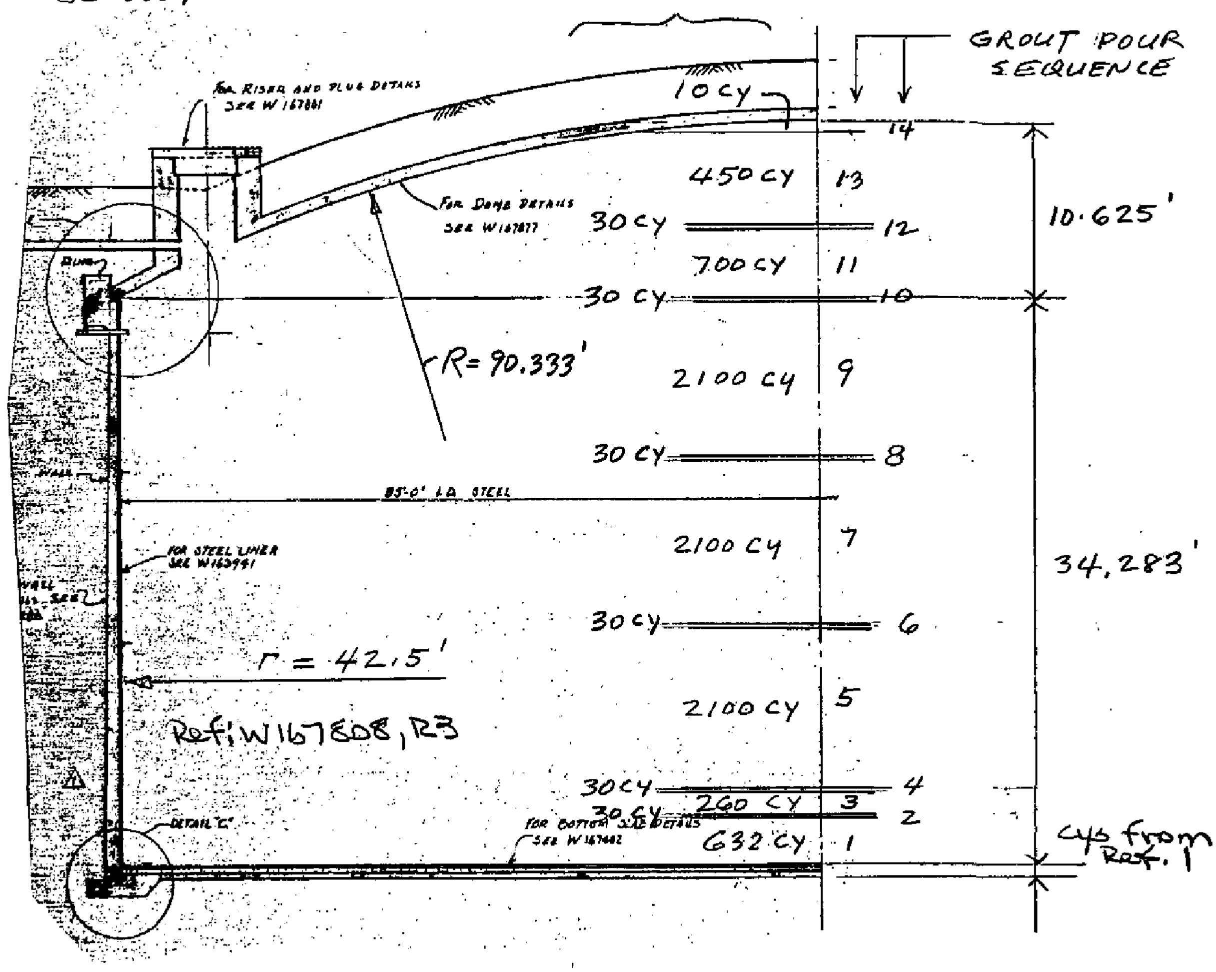
4.1 GROUTING SEQUENCE (PRELIMINARY AND OPTIONAL)

GROUTING SEQUENCE AND VOLUME AS SUMMARIZED IN REF. 1 FOR CLOSING TANK 18 AND TANK 19 IN F-AREA. CONTINUOUS GROUTING COULD BE EMPLOYED IN LIEU OF THE SEQUENCE BELOW.



REF. 1

POUR 1, 3, 5 — REDUCING GROUT, 128.17 PCF

POUR 2, 4, 6 — DRY GROUT MIXTURE, 118.11 PCF

POUR 7, 9 — REDUCING CLSM, 128.17 PCF

POUR 8, 10, 12, 14 — DRY REDUCING CLSM, 118.04 PCF

POUR 11, 13 — STRONG GROUT, 125.08 PCF (INTRUDER GRT)

POUR 15 — RISER GROUT, 110.70 PCF (100 C.Y.)

Calculation Continuation Sheet

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4.2 FLEXIBLE SLAB BASE PRESSURE

THE NOMINAL GROUT VOLUMES SHOWN ON THE SKETCH ABOVE TOTAL 7342 CUBIC YARDS (CY) TO THE DOME SPRINGLINE. THE TOTAL GROUT VOLUME UNDER THE DOME TO THE SPRINGLINE, EXCLUDING THE RISER GROUT IS 1190 CUBIC YARDS.

R1 REF. 1 REQUIRES THE GROUT SUBCONTRACTOR TO PROVIDE CENTRALIZED BATCHING FACILITY CAPABLE OF GENERATING 75 CUBIC YARDS PER HOUR. THIS RATE OF GROUT PRODUCTION IS USED TO ESTABLISH THE FASTEST TIME EACH POUR LIFT COULD BE PLACED. THE TRASITION FROM POURING WET MIX TO PLACING DRY MIX WOULD REQUIRE CHANGING EQUIPMENT. THUS, TWENTY FOUR HOURS TIME LAPSE IS CONSIDERED BETWEEN WET MIX POURS. LIFTS TO BASE PRESSURE = 3700 PSF:

LIFT NO.	VOL. (CY)	TIME (HR) (VOL/75)	Σ DEPTH (F)	BASE PRES. (PSF) (ΣDepth×128)
1	632	8.5	2.95	378
2	30	(24)	3.09	396
3	260	3.5	4.30	551
4	30	(24)	4.44	569
5	2100	28	14.25	1824
6	30	(24)	14.39	1842
7	2100	28	24.20	3098
8	30	(24)	24.34	3116
9	2100	28	34.15	4372
10	30	(24)	34.29	4390

Calculation Continuation Sheet

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THE BASE PRESSURE IS CALCULATED USING AN AVERAGE GROUT UNIT WEIGHT EQUAL TO 128 PCF. PER DRAWING W167482 REV. 22, THE ALLOWABLE SOIL BEARING PRESSURE UNDER THE FLEXIBLE BASE SLAB IS 3700 PSF. TO PRECLUDE ADDITIONAL EVALUATION OF THE FLEXIBLE BASE SLAB SUBJECTED TO LOADS GREATER THAN THE LIMITING VALUE CORRESPONDING TO THE ALLOWABLE SOIL PRESSURE, THE GROUT IS CONSIDERED FLUID UP TO A DEPTH, D, SUCH THAT

$$\gamma D + W_{(SLAB)} = 3700$$

AND ALLOWED TO CURE UNTIL THE GROUT BLOCK OF DEPTH D COULD BE CONSIDERED A RIGID MASS. ALLOWING FOR $W_{(SLAB)} = 100$ PSF AND $\gamma = 128$ PSF:

$$D = \frac{3700 - 100}{128} = 28.13 \text{ FT.}$$

THE LIFT SEQUENCE SHOWN ON SHT. NO. 12 WOULD ALLOW THE GROUT TO DEVELOP STRENGTH BEFORE D ABOVE IS REACHED. ALTERNATIVELY, THE DRY GROUT IS OPTIONAL AND THE POUR RATE WOULD BE CONTINUOUS AT 75 CU. YDS. PER HOUR.

Calculation Continuation Sheet

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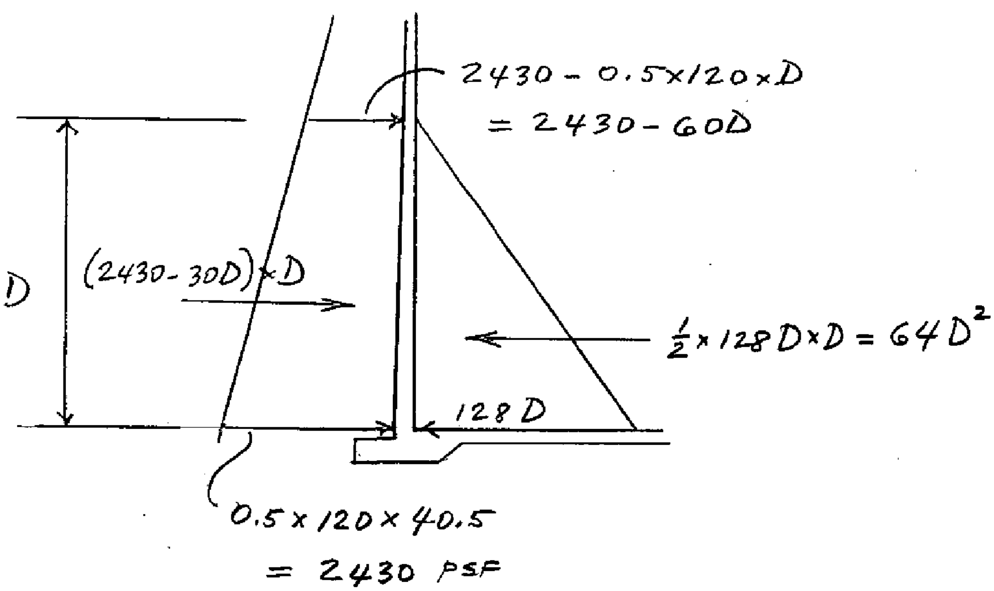
4.3 TANK WALL

FIND FLUID GROUT DEPTH D SUCH THAT THE RESULTANT INTERNAL PRESSURE IS EQUAL TO THE RESULTANT EXTERNAL AT-REST SOIL PRESSURE. CONSIDER SOIL UNIT WEIGHT $w_s = 120$ PCF AND AT-REST SOIL PRESSURE COEFFICIENT $K_o = 0.5$. SOIL DEPTH TO THE LEVEL OF THE TANK BOTTOM IS 40.5 FT (Cf. REF. 5, SH. NO. E30)



$$(2430 - 30D) \times D = 64 D^2$$

$$D = \frac{2430}{94} = 25.85 \text{ FT.}$$

Calculation Continuation Sheet

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4.4 GROUT POUR CONTINUITY

CONTINUOUS GROUT POUR AT 75 CUBIC YARDS PER HOUR

THE TOTAL DEPTH OF CONTINUOUS GROUT POUR, WHERE THE GROUT IS CONSIDERED FLUID, IS 25.85 FT. WITH NO ADDITIONAL EVALUATION OF TANK INTEGRITY. THE TIME REQUIRED TO REACH THIS DEPTH, CONSDERING THE RATE OF POUR IS 75 CUBIC YARDS PER HOUR, IS

$$T = \frac{\pi \times (42.5)^2 \times 25.85}{27 \times 75}$$

$$= 72 \text{ HRS.} \qquad (3 \text{ DAYS})$$

AT THIS POINT ALLOW THE POURED GROUT BLOCK OF DEPTH $D = 25.85$ FT. TO DEVELOP STRENGTH f_c' AND DETERMINE THE AVERAGE f_c' THAT WOULD ALLOW CONTINUATION OF GROUT POUR TO THE HIGH POINT OF THE DOME UNDESIDE. THE MAXIMUM FLUID GROUT DEPTH FOR THIS CONDITION WOULD BE

$$D' = 34.28 + 10.63 - 25.85$$

$$= 19.06 \text{ F.}$$

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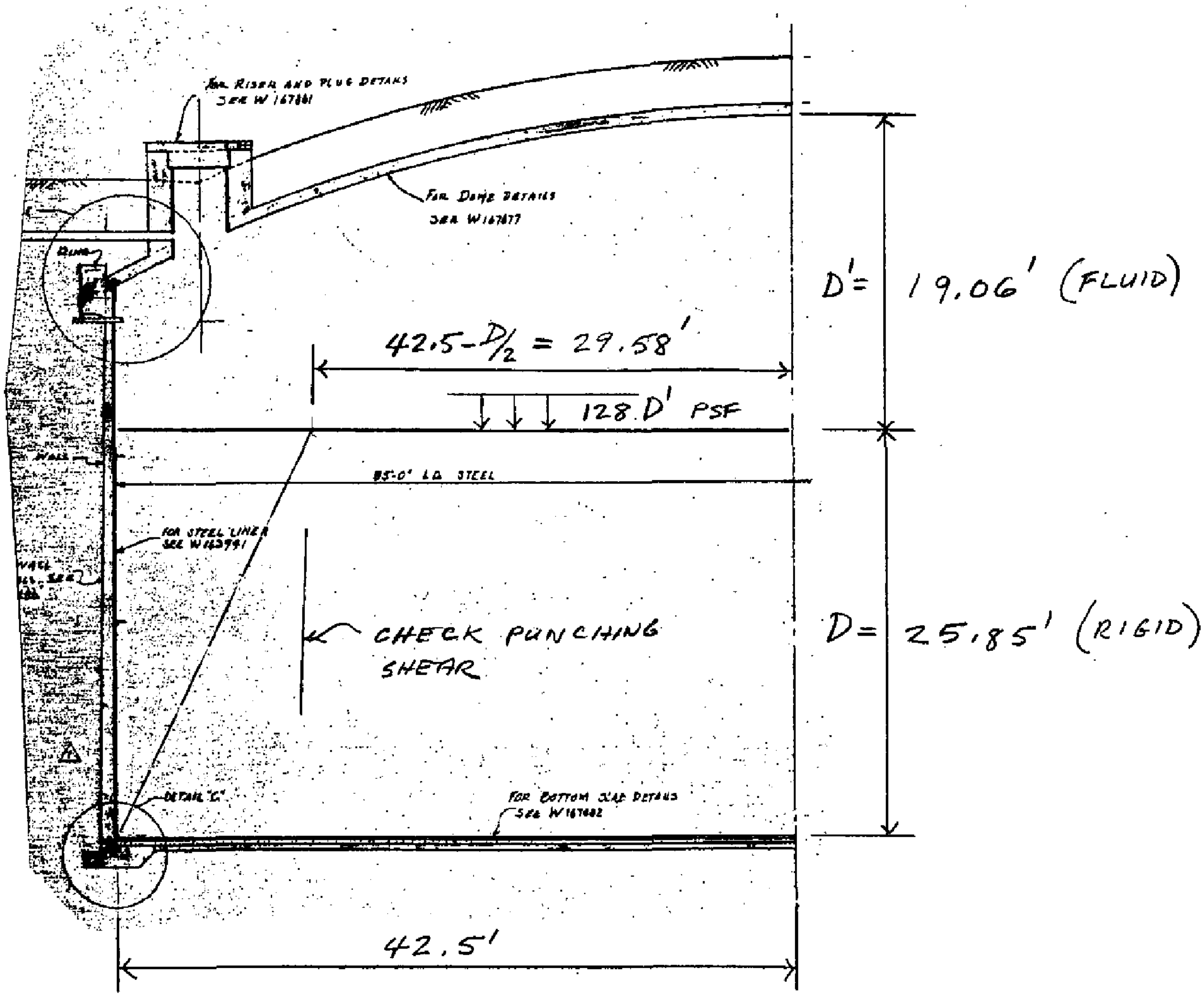

Calculation Continuation Sheet

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FOR THE CONDITION SHOWN ON SHT. NO. 16 THE POURED GROUT BLOCK OF DEPTH D IS FULLY SUPPORTED BY THE FLEXIBLE BASE SLAB AND SOIL PRESSURE LESS THAN 3700 PSF. AFTER THE POURED GROUT BLOCK HAS GAINED STRENGTH THE ADDITIONAL LOAD OF $128 \times D'$ PSF WOULD BE TRASMITTED TO THE FLEXIBLE BASE SLAB THROUGH THE RIGID BLOCK OF DEPTH D. CONSIDER THAT THE BLOCK HAS SUFFICIENT STRENGTH IF THE PUNCHING SHEAR STRESS DOES NOT EXCEED THE AVERAGE PUNCHING SHEAR CAPACITY.

WITH THE PUNCHING SHEAR LOAD AS SHOWN ON SHT. NO. 16 AND USING ALLOWABLE STRESS DESIGN (REF. 2, APP. A)

$$\text{ALLOWABLE SHEAR} \quad v_c = \left(1+\frac{2}{\beta_c}\right)\sqrt{f'_c} \le 2\sqrt{f'_c}$$

$$= 2\sqrt{f'_c} \qquad \beta_c = 1.0$$

$$\text{DEMAND SHEAR} \quad v_c = \frac{\pi \times (29.58)^2 \times 128 \times 19.06}{2 \times \pi \times 29.58 \times 25.85 \times 144} = 9.69 \text{ psi}$$

$$\therefore \text{AVE. } f'_c = \left(\frac{v_c}{2}\right)^2 = \left(\frac{9.69}{2}\right)^2 = 23.5 \text{ psi}$$

Calculation Continuation Sheet

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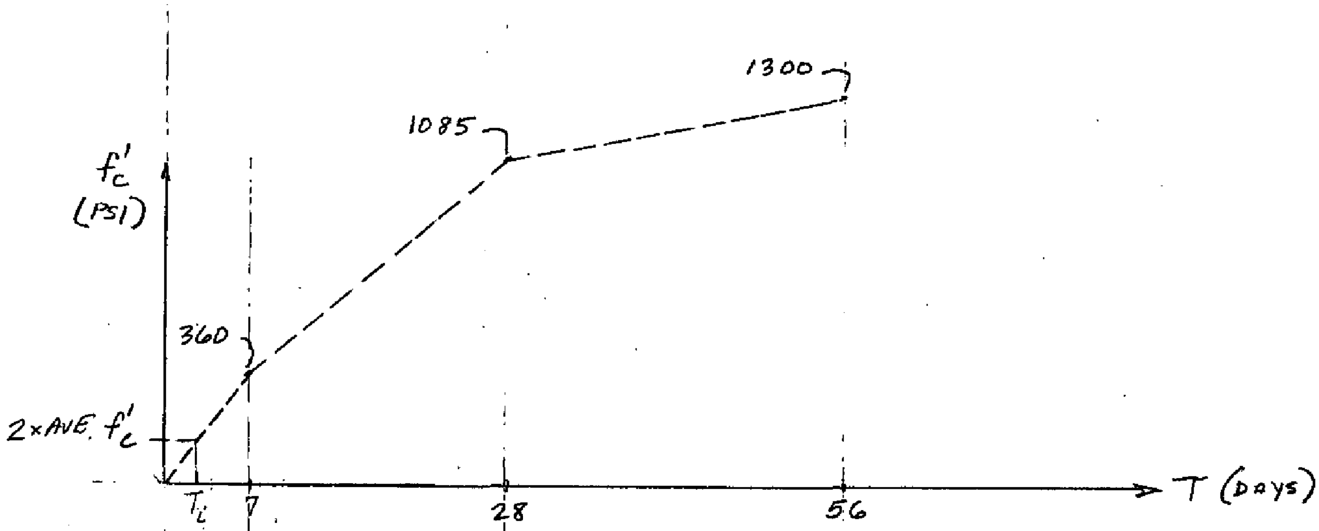

(WSRC-TR-98-00271 : RG3-TABLE 4, P.17)

THE CHART ABOVE DEPICTS THE STRENGTH VS. TIME CURVE FOR THE TYPICAL REDUCING GROUT MIX (REF. 3). CONSERVATIVELY CONSIDER LINEAR VARIATION BETWEEN CONTROL POINTS AND FIND THE TIME T_i FOR THE FIRST POUR TO ACHIEVE TWICE THE REQUIRED AVERAGE GROUT STRENGTH OF 23.5 PSI. THIS WOULD ACCOUNT FOR GROUT STRENGTH VARIATION FROM 47 PSI AT BOTTOM TO ZERO AT TOP.

$$T_i = 7 \times \frac{2 \times 23.5}{360} = 0.91 \text{ DAY} \quad (22 \text{ HRS})$$

SINCE T_i IS LESS THAN $T = 72$ HRS NEEDED TO POUR GROUT TO DEPTH $D = 25.85$ F., THE AVERAGE STRENGTH OF THE POURED GROUT WOULD EXCEED $f'_c = 23.5$ PSI AND THE POURED GROUT OF DEPTH $D = 25.85$ F. COULD BE CONSIDERED AS A RIGID BLOCK. <u>GROUT POURING NEED NOT STOP.</u>

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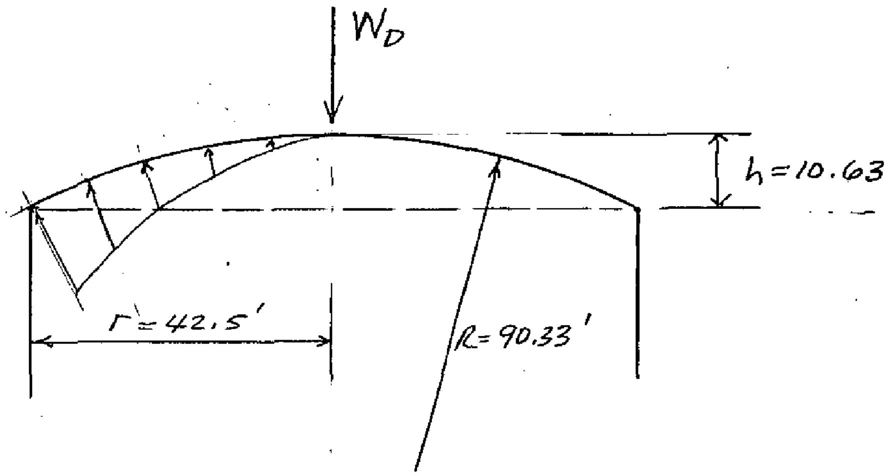
4.5 TANK DOME / INTRUDER GROUT



CONSIDER INTRUDER GROUT CONTNUOUS POUR REMAINS FLUID FROM THE SPRINGLINE TO THE HIGHEST POINT OF THE DOME UNDERSIDE.

$h = 10.63$ F.

$r = 42.5$ F.

$R = 90.33$ F.

$\gamma = 128$ PCF. (FLUID GROUT)

THE NET UPLIFT IS EQUAL TO THE DISPLACED VOLUME MULTIPLIED BY γ MINUS DOME DEAD LOAD W_D.

$$U = U_{PLIFT} = \left(\pi r^2 h - \frac{\pi}{3} h^2 (3R - h)\right) \times \gamma \qquad (\text{REF } 4, \text{ PG } 18, 19)$$

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$$U = \pi h \gamma \left(r^2 - hR + \frac{h^2}{3} \right)$$

$$= \pi \times 10.63 \times 0.128 \times \left(\overline{42.5}^2 - 10.63 \times 90.33 + \frac{\overline{10.63}^2}{3} \right)$$

$$= 3777.48 \ k$$

R5 791

$$W_D = 3452.68 \ k \qquad (\text{REF. 5 P. E19})$$

NET UPLIFT $= U - W_D$

$= 324.80 \ k \uparrow$ <u>N.G.</u>

FIND NET UPLIFT IF FIRST TWO FEET OF INTRUDER GROUT IS ALLOWED TO HARDEN.

$$h_1 = 10.63 - 2 = 8.63 \ F.$$

$$r_1 = \left(R^2 - (R - h_1)^2 \right)^{1/2} = 38.53 \ F.$$

$$\gamma_w = 62.4 \ \text{PCF} \quad (\text{WATER})$$

$$U = \pi h \gamma_w \left(r^2 - hR + \frac{h^2}{3} \right) + \pi h_1 (\gamma - \gamma_w) \left(r_1^2 - h_1 R + \frac{h_1^2}{3} \right)$$

Calculation Continuation Sheet

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$$U = 3777.48 \times \frac{62.4}{128}$$

$$+ \pi \times 8.63 \times (128-62.4) \times \left(\overline{38.53}^2 - 8.63 \times 90.33 + \frac{\overline{8.63}^2}{3}\right) \times \frac{1}{1000}$$

$$= 3139.57 \text{ k} \quad < \quad W_D = 3452.68 \text{ k} \quad \underline{\text{O.K}}$$

POUR INTRUDER GROUT TO A DEPTH OF 2 FT. ABOVE THE DOME SPRINGLINE AND ALLOW TO HARDEN FOR 24 HRS. THE REMAINDER OF THE INTRUDER GROUT COULD BE ONE CONTINUOUS POUR.

FOR DOME POUR $D = 2$ FT.

$$V_2 = \frac{1}{27} \times \frac{\pi}{3}\left(h^2(3R-h) - h_1^2(3R-h_1)\right) = 383 \text{ C.Y.}$$

<u>POUR 383 C.Y.</u>

<u>STOP 24 HRS</u>

<u>CONTINUE</u>

Calculation Continuation Sheet

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4.6 Maximum Grout Stress/No Backfill

AT THE COMPLETION OF TANK GROUT POUR TO THE HIGH POINT OF THE DOME UNDERSIDE THE MAXIMUM COMPRESSIVE STRESS IN THE REDUCING GROUT AT THE FLEXIBLE BASE SLAB IS

$$\sigma = (34.28 + 10.63) \times 128 \times \frac{1}{144}$$
$$= 39.92 \text{ psi}$$

CONSIDER ALLOWABLE STRESS OF $0.3 f'_c$: (REF. 2, APP. A)

$$\sigma = 0.3 f'_c = 39.92 \text{ psi}$$
$$f'_c = 133 \text{ psi}$$

FROM THE LINEAR GRAPH ON SHT. NO. 18 THE REQUIRED f'_c IS REACHED IN

$$T_\sigma = 7 \times \frac{133}{360} \times 24 = 62 \text{ HRS.}$$

Calculation Continuation Sheet

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T_σ IS LESS THAN THE TIME REQUIRED TO FULLY GROUT THE TANK IN ONE CONTINUOUS POUR EXCEPT FOR THE REQUIRED 24 HRS BREAK AT THE DOME POUR.

$$T = \frac{7342 + 1190}{75} + 24 = 138 \text{ HRS.}$$

THUS, f'_c IS GREATER THAN 133 PSI.

Calculation Continuation Sheet

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4.7 BACKFILL OVER GROUTED TANK

THE FULLY GROUTED TANK IS CONSIDERED AS ONE SOLID BLOCK AND THE IN-PLACE GROUTED TANK DEAD LOAD PLUS BACKFILL MATERIAL PLACED OVER IT COULD BE CONSIDERED AS UNIFORMLY DISTRIBUTED LOAD OVER THE TANK FOUNDATION FOOTPRINT WHICH HAS A RADIUS OF 45.33 FT. $A = \pi \times \overline{45.33}^2 = 6455.37\ F^2$

R5 791 4.7.1 TANK BASE LOAD / NO BACKFILL

EMPTY TANK (REF. 5, P. E39)

FOOTING ———— = 241.28 k

SOIL ANNULUS ———— = 3122.19

DOME DL ———— = 3452.68

WALL/RING GIRDER DL ——— = 1557.39

FLEXIBLE SLAB – $\pi \times \overline{40.5}^2 \times 0.1$ = 515.30

8888.84 k

GROUT:

CYLINDER – 7342 × 27 × 0.128 = 25373.95

DOME – 1190 × 27 × 0.128 = 4112.64

RISER – 100 × 27 × 0.128 = 345.60

29832.19 k

W_o = 38721.03 k

Calculation Continuation Sheet

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$$q_0 = \frac{W_0}{A}$$

$$= \frac{38721.03}{6455.37} = 6.00 \text{ KSF}$$

REDUCING GROUT $\sigma = \frac{6000-100}{144} = 40.97$ PSI

FLEXIBLE BASE SLAB $\sigma = \frac{6000}{144} = 41.67$ PSI

INTRUDER GROUT $\sigma = \frac{10.63 \times 128}{144} = 9.45$ PSI

Calculation Continuation Sheet

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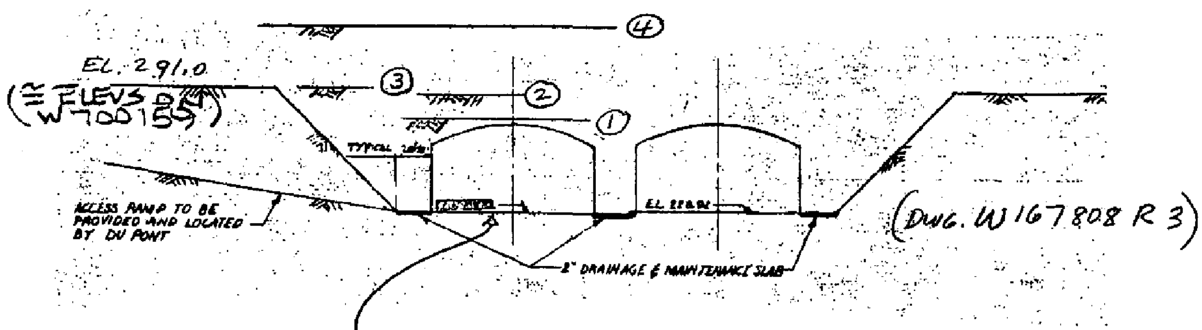
4.7.2 BACKFILL SCENARIOS



EL. 228.64	(REF.)
34.28	SHT. NO. 11
262.92	(SPRINGLINE)
10.63	SHT. NO. 11 (DWG. W167477R21, SEC. A-A)
273.55	(DOME APEX UNDERSIDE)
3.25	(2'-8" + 7" - DWG. W167477R21, SEC A-A)
276.80	(SOIL COVER AT DOME APEX)
1.00	(Estimated - From Soil Cover to Top of Plug)
EL. 277.80	(BACKFILL ① - 1 F. ABOVE SOIL COVER)
10.00	
EL. 287.80	(BACKFILL ② - 11 F. ABOVE SOIL COVER)
EL. 291.00	(BACKFILL ③ - 14.2 F. ABOVE SOIL COVER)
EL. 294.50	(TOP EVAPORATOR COVER)
10.00	
EL. 304.50	(BACKFILL ④ - 27.70 F. ABOVE SOIL COVER)

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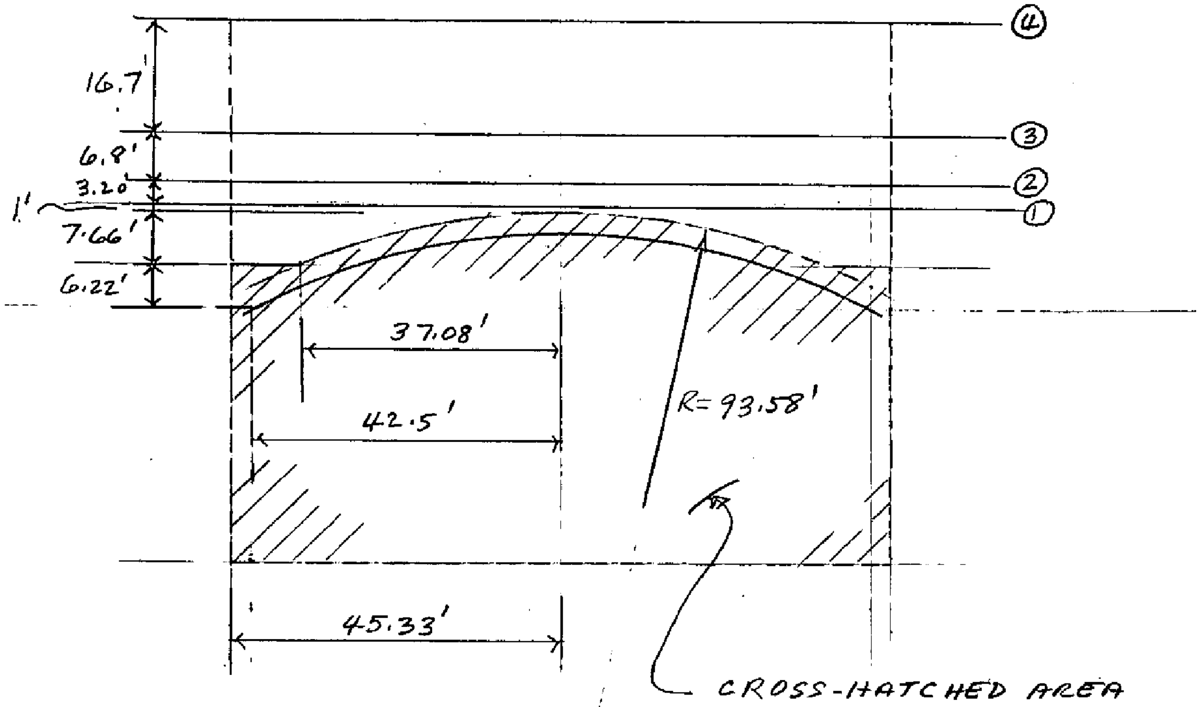

$W_0 = 38721.03$ K

USE BACKFILL UNIT WEIGHT = 125 PCF. SEE REF. 6 AND 7 FOR GUIDANCE,

BACKFILL ①

$$W_{①} = \left(\pi \times \overline{45.33}^2 \times 8.66 - \frac{\pi}{3} \times \overline{7.66}^2 \times (3 \times 93.58 - 7.66)\right) \times 0.125$$

$$= 4890.52 \text{ K}$$

$$\Sigma W_{①} = 38721.03 + 4890.52 = 43611.55 \text{ k}$$

$$q_{①} = \frac{43611.55}{6455.37} = 6.76 \text{ KSF.}$$

Calculation Continuation Sheet

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4.7.4 BACKFILL ②

$$W_{②} = \pi \times \overline{45.33}^2 \times 10.0 \times 0.125 + 4890.52$$

$$= 12959.74\ k$$

$$\Sigma W_{②} = 38721.03 + 12959.74 = 51680.76\ k$$

$$q_{②} = \frac{51680.76}{6455.37} = 8.01\ ksf$$

4.7.5 BACKFILL ③

$$W_{③} = \pi \times \overline{45.33}^2 \times 3.20 \times 0.125 + 12959.74$$

$$= 15541.89\ k$$

$$\Sigma W_{③} = 38721.03 + 15541.89 = 54262.92\ k$$

$$q_{③} = \frac{54262.92}{6455.37} = 8.41\ ksf$$

Calculation Continuation Sheet

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4.7.6 BACKFILL ④

$$W_{④} = \pi \times \overline{45.33}^2 \times 13.50 \times 0.125 + 15541.89$$

$$= 26435.33 \text{ k}$$

$$\Sigma W_{④} = 38721.03 + 26435.33 = 65156.36 \text{ k}$$

$$q_{④} = \frac{65156.36}{6455.37} = 10.09 \text{ ksf}$$

4.7.7 STRESSES – REDUCING GROUT, FLEXIBLE BASE SLAB, INTRUDER GROUT

1. REDUCING GROUT

$q_{④}$ IS THE HIGHEST SUBGRADE REACTION CONSIDERED. THE CORRESPONDING NOMINAL STRESS IN THE REDUCING GROUT AT THE TOP OF THE FLEXIBLE BASE SLAB WOULD BE

$$\sigma = \frac{10090 - 100}{144} = 69.4 \text{ psi}$$

USING ALLOWBLE STRESS DESIGN, (REF. 2, APP. A),

$$\sigma = 0.3 f'_c$$

$$\therefore f'_c = \frac{69.4}{0.3} = 232 \text{ psi}$$

THIS IS THE REQUIRED STRENGTH OF THE REDUCING GROUT AT THE COMPLETION OF BACKFILL ④.

Calculation Continuation Sheet

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USE THE LINEAR PLOT OF GROUT f'_c VS TIME (REF. 3) SHOWN ON SHT. NO. 18. THE SET TIME NEEDED TO REACH THE REQUIRED STRENGTH IS $T = (232/360) \times 7 \times 24 = 108$ HRS OR 30 HRS BEFORE COMPLETION OF GROUT POUR OPERATIONS, (SHT. NO. 23)

2. FLEXIBLE BASE SLAB

AS NOTED ON DRAWING W167482 REV. 22 THE FLEXIBLE BASE SLAB CONCRETE DESIGN STRENGTH IS $f'_c = 3000$ PSI AT 28 DAYS. CONSIDERING THERMAL DEGRADATION FACTOR $N^* = 0.7$ (REF. 8, SHT. NO. 11)

$$f_c'^* = 0.7 \times 3000$$
$$= 2100 \text{ psi}$$

$$0.3 f_c'^* = 630 \text{ psi} > \frac{10090}{144} = 70.07 \text{ psi}$$

OK

3. INTRUDER GROUT

CONSIDER $W_{④} = 26435.33$ k TRANSFERRED DIRECTLY ON THE DOME INTRUDER GROUT.

$$\sigma = \frac{26435.33}{\pi \times 42.5^2} \times \frac{1000}{144} + 9.45 = 41.80 \text{ psi}$$

(9.45 ← P25)

Calculation Continuation Sheet

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WITH $\sigma = 0.3 f'_c$, THE REQUIRED STRENGTH OF THE INTRUDER GROUT WHEN LOADED BY $W_{④}$ IS

$$f'_c = \frac{41.80}{0.3} = 140 \text{ PSI}$$

REF. 1, PG. 8 GIVES FOR REFERENCE $f'_c = 2000$ PSI AT 28 DAYS. CONSIDERING LINEAR STRENGTH GAIN FROM 0 TO 2000 PSI IN 28 DAYS, $f'_c = 140$ PSI WOULD BE ACHIEVED IN 2.0 DAYS. THUS, AT THE COMPLETION OF BACKFILL ④, THE STRENGTH OF THE INTRUDER GROUT WOULD EXCEED 140 PSI.

4. THE CALCULATED STRESSES DUE TO LOWER LOADS CORRESPONDING TO BACKFILL SCENARIOS ①, ②, AND ③ ARE TABULATED BELOW

COMPONENT	STRESS – PSI		
	BACKFILL ①	BACKFILL ②	BACKFILL ③
REDUCING GROUT	46.25	54.93	57.71
FLEXIBLE BASE SLAB	46.94	55.63	58.40
INTRUDER GROUT	15.44	25.31	28.47

Calculation Continuation Sheet

Calculation No. T-CLC-F-00373	Sheet No. 32	Rev. 0

5.0 SUMMARY OF CALCULATION RESULTS AND CONCLUSIONS

5.1 GROUT UNIT WEIGHT AVERAGE OF 128 PCF DERIVED FROM DATA SHOWN IN SECTION 4.1 (REF. 1) IS USED TO CALCULATE TANK AND FOUNDATION LOADS AND GROUT STRESSES.

5.2 THE MAXIMUM DEPTH OF FLUID REDUCING GROUT WITHOUT EXCEEDING THE ALLOWABLE SOIL BEARING PRESSURE OF 3700 PSF UNDER THE FLEXIBLE BASE
3 SLAB IS D = 28.13 F. (SHT. NO. 13).

5.3 THE MAXIMUM DEPTH OF FLUID REDUCING GROUT WITHOUT EXCEEDING THE AT-REST SOIL PRESSURE
4 AGAINST THE TANK WALL IS D = 25.85 F (SHT. NO. 14). AT A CONTINUOUS POURING RATE OF 75 CU. YD. PER HR, DEPTH D = 25.85 F. WOULD BE REACHED IN 72 HRS
5 (SHT. NO. 15).

5.4 THE TIME REQUIRED TO POUR TO DEPTH D = 25.85 F. EXCEEDS THE TIME REQUIRED FOR THIS BLOCK TO GAIN STRENGTH TO BE CONSIDERED RIGID WITH
7 RESPECT TO THE FLEXIBLE BASE SLAB (SHT. NO. 18)

THEREFORE, CONTINUOUS POURING OF THE REDUCING GROUT COULD CONTINUE UNINTERRUPTED BEYOND $D = 25.85$ F, TO THE DOME SPRINGLINE.

5.5 THE INTRUDER GROUT POUR SEQUENCE FROM THE DOME SPRINGLINE TO THE DOME APEX MUST BE INTERRUPTED AT $D = 2$ F, OR ROUGHLY 383 CU. YD. POURED, AND ALLOWED TO CURE FOR 24 HRS BEFORE RESUMING GROUT POUR TO COMPLETION. THIS WOULD PRECLUDE THE POSSIBILITY OF EXCESSIVE DOME UPLIFT, (SECTION 4.5).

5.6 AT THE COMPLETION OF TANK GROUTING OR 138 HRS OF CONTINUOUS GROUT POUR, THE COMPRESSIVE STRESS IN THE REDUCING GROUT AT FLEXIBLE BASE SLAB INTERFACE IS $\sigma = 39.92$ PSI WHICH REQUIRES NOMINAL GROUT STRENGTH $f'_c = 133$ PSI. THIS REQUIRED f'_c IS REACHED IN 62 HRS., OR LESS THAN THE TIME THAT HAS ALREADY ELAPSED. (SECTION 4.6)

Calculation Continuation Sheet

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5.7 BEFORE THE GROUTED TANK IS BURIED IN BACKFILL THE PRESUMPTIVE UNIFORM SOIL PRESSURE AT
14 THE BASE IS 6.00 KSF (SHT. NO. 25)

5.8 THE FOLLOWING BACKFILL SCENARIOS AND THE CORRESPONDING PRESUMPTIVE UNIFORM SOIL PRESSURE AT THE TANK BASE WERE CONSIDERED IN THE CALCULATIONS: (SECTION 4.7)(SEE ALSO SECTION 2.6)

(1) TO DOME APEX RISER ——— $q_{①} = 6.76$ KSF

(2) TO LEVEL OF EXISTING BERM ——— $q_{②} = 8.01$ KSF

(3) 10 F. ABOVE DOME APEX RISER ——— $q_{③} = 8.41$ KSF

(4) 10 F. ABOVE TOP OF EVAP. BLDG. ——— $q_{④} = 10.09$ KSF

5.9 THE FOLLOWING COMPRESSIVE STRESSES WERE CALCULATED FOR THE REDUCING GROUT, INTRUDER GROUT AND FLEXIBLE BASE SLAB CONSIDERING BACKFILL SCENARIO (4) ABOVE.

5.9.1 REDUCING GROUT, $\sigma = 69.4$ PSI. THE REQUIRED REDUCING GROUT $f'_c = 232$ PSI IS REACHED BEFORE THE TANK IS FULLY GROUTED. (SH. NO. 29)

Calculation Continuation Sheet

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5.9.2 INTRUDER GROUT, $\sigma = 41.80$ PSI. THE REQUIRED INTRUDER GROUT $f'_c = 140$ PSI IS REACHED 48 HRS. AFTER GROUTING IS COMPLETED. (SH.NO. 30)

5.9.3 FLEXIBLE BASE SLAB, $\sigma = 70.07$ PSI IS LESS THAN $0.3 \times f'^{*}_c = 0.3 \times 2100 = 630$ PSI. f'^{*}_c IS THE THERMALLY DEGRADED FLEXIBLE BASE SLAB CONCRETE STRENGTH, (SH.NO. 30)

5.10 THE LOADED TANK FOOTPRINT HAS A RADIUS OF 45.33 F. ROUGHLY 16 PERCENT OF THE LOADED FOOTPRINT IS THE FOOTING ANNULUS WITH AN ALLOWABLE SOIL BEARING PRESSURE OF 10000 PSF. THE AVERAGE SOIL BEARING PRESSURE IS THEN

$$q_{AVE} = 0.16 \times 10 + 0.84 \times 3.7$$

$$= 4.71 \text{ KSF} \quad \text{VS} \quad q_{④} = 10.09 \text{ KSF}$$

THE INCREASE IN SOIL BEARING PRESSURE HAS NO STRUCTURAL SIGNIFICANCE WITH RESPECT TO THE INTEGRITY OF THE FULLY GROUTED TANK. SRS GEOTECHNICAL WILL EVALUATE THE TANK CLOSURE FOR ULTIMATE SETTLEMENT.

5.11 Grout and Concrete Compressive Strength and Stresses on the Closed Tank

The table below summarizes the grout and concrete compressive strength and stresses on the closed tank..

Component (Grout or Concrete)	Stresses with No Cap (psi)	Stresses due to Cap 10 Feet Above the Tank Top (psi)	Stresses due to Cap at Existing West Grade (psi)	Stresses due to Cap 10 Feet Above the 242-F Evaporator (psi)	Design Compressive Strength @ 28 Days (psi)
	From Sheet No. 25	From Sheet No. 31	From Sheet No. 31	From Sheet Nos. 29 & 30	
Intruder Grout	10	26	29	42	2000 (1)
Reducing Grout	41	55	58	69	1085 (2)
Concrete Basemat	42	56	59	70	3000 (3)

Notes:

(1) C-SPP-F-00047, page 44.
(2) WSRC-TR-98-00271, Table 4, page 17.
(3) W167482, Rev. 22.

Calculation Continuation Sheet

Calculation No. T-CLC-F-00373	Sheet No. 37	Rev. 0

6.0 REFERENCES

1. SPECIFICATION NO. C-SPP-F-00047 REV. 2
2. ACI 318-95, BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE, AMERICAN CONCRETE INSTITUTE, 1995.
3. WSRC-TR-98-00271, 3/30/98
4. THE ENGINEERS' MANUAL, SECOND EDITION, RALPH G. HUDSON, JOHN WILEY & SONS, INC., 1939.
5. CALCULATION T-CLC-H-00791, REV. A
6. WSRC-TR-2002-00354
7. CALCULATION T-CLC-E-00018
8. CALCULATION T-CLC-G-00156, REV. 3
9. DRAWING W167482 REV. 22

WASHINGTON SAVANNAH RIVER COMPANY
INTEROFFICE MEMORANDUM

CBU-PIT-2006-00086
Rev. 0

May 15, 2006

TO: W. E. Faires, Jr.
Structural Mechanics, 730-1B

FROM: B. A. Martin BAM
PIT Tank Closure Planning, 766-H

Tank 18 and 19 Closure Structural Calculation

Background

Tank closure plans include the use of two kinds of grout for closure of Tank 19 and Tank 18. Reducing grout will be used to fill the tank from the bottom to approximately the beginning of the dome (springline) to provide a long term chemical environment to reduce leaching of radionuclides into the environment and to provide compressive strength. Intruder grout will be used to fill the tank from the springline up to the tank top to provide compressive strength and to deter intrusion (Reference 1).

Task

Calculate the forces imposed on the three components of the closed tanks: 1) intruder grout, 2) reducing grout, and 3) concrete basemat from the overlying materials. Compare these forces to the compressive strength design values of these three components. The compressive strength design values for the intruder grout and reducing grout is given below. The compressive strength design value for the basemat must be determined. The calculation of forces shall include the following scenarios for an engineered cap: 1) no cap, 2) a cap 10-feet above the center riser, 3) a cap up to the existing grade around the 17-20 area, and 4) a cap 10-feet above the top of the 242-F evaporator.

Inputs

1) The design mix formula for intruder grout is Strong grout, Mix No. B2000-X-0-0-BS, Reference 2, page 44.
2) The design mix formula for reducing grout is Reducing grout, Mix No. OPDEXE-X-P-0-BS, Reference 2, page 46.
3) The compressive strength design value for intruder grout is 2000 psi (Reference 2).
4) The compressive strength design value for reducing grout is 1085 psi (Reference 3).
5) The configuration of the intruder grout and reducing grout is described in Reference 1.
6) The engineered cap wet bulk density value is 125 pounds per cubic foot based on Reference 4, sheet 36.

cc: T. C. Robinson, Jr., 766-H

References: 1) CBU-PIT-2005-00167, *Grout Delivery Plan for Tank 18 and Tank 19 Closure,* Rev. 0, August 2005.
2) C-SPP-F-00047, *F Tank Farm, Tank 18F and Tank 19F, Furnishing and Delivery of Tank Closure Mixes (U),* Rev. 2, April 1, 2003.
3) WSRC-TR-98-271, *Laboratory and Field Testing of High Performance-Zero Bleed CLSM Mixes for Future Tank Closure Applications (U),* March 30, 1998.
4) T-CLC-E-00018, *Low Activity Waste (LAW) Vault Structural Degradation Prediction,* Rev. 0, October 26, 2005.