WOLF CREEK
NUCLEAR OPERATING CORPORATION

Bart D. Withers
President and
Chief Executive Officer

December 28, 1990

WM 90-0204

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Station P1-137
Washington, D. C. 20555

Reference: 1) Letter dated May 25, 1989 from F. J. Hebdon, NRC to B. D. Withers, WCNOC
2) ET 89-0076, dated September 22, 1989 from F. T. Rhodes, WCNOC to NRC
3) Letter dated March 27, 1990 from D. V. Pickett, NRC to B. D. Withers, WCNOC
4) WM 90-0118, dated July 5, 1990 from B. D. Withers, WCNOC to NRC
5) Letter dated September 27, 1990 from D. V. Pickett, NRC to B. D. Withers, WCNOC

Subject: Docket No 50-482: Response to Request for Additional Information Concerning Seismic Design Considerations for Certain Safety-Related Vertical Steel Tanks

Gentlemen:

Attachment 1 provides Wolf Creek Nuclear Operating Corporation's (WCNOC) response to the request for additional information which is documented in Reference 5. The request for additional information concerned the seismic design considerations for certain safety-related vertical steel tanks.

Reference 1 requested information concerning seismic design considerations for the Wolf Creek Generating Station (WCGS) Refueling Water Storage Tank (RWST) which was subsequently provided in Reference 2. Reference 2 provided the results of a reanalysis of the RWST which was performed in accordance with the guidance of Draft Revision 2 of the Standard Review Plan Section 3.7.3. The Nuclear Regulatory Commission (NRC) Staff performed an audit of the reanalysis on February 14, 1990, which resulted in a request for additional information (Reference 3). Reference 4 provided WCNOC's response to the request for additional information. Reference 5 requested additional information for the staff to continue its review.

A001

If you have any questions concerning this matter, please contact me or Mr. H. K. Chernoff of my staff.

Very truly yours,

Bart D. Withers
President and
Chief Executive Officer

BDW/jra

Attachment

cc: A. T. Howell (NRC),w/a
R. D. Martin (NRC), w/a
D. V. Pickett (NRC, w/a
M. E. Skow (NRC, w/a

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING SEISMIC DESIGN CONSIDERATIONS FOR CERTAIN SAFETY-RELATED VERTICAL STEEL TANKS

QUESTION 1:

During the audit on February 14, 1990, the licensee's consultant (Bechtel) had provided a handout of what was presented. Provide revised Tables 2 and 3 and any other changes to the handout resulting from the reanalysis.

RESPONSE:

The handout presented to the NRC during the audit on February 14, 1990 has been revised to indicate the subsequent results of the reanalysis. Attachment 2 provides the revised handout including Tables 2 and 3. Pages 18, 19, 26, 28 (Table 2), 29, and 31 (Table 3) of 31 have been revised as indicated by Revision bars on these pages. New pages 20 and 30 are due to text "carryover" from changes to previous pages.

Changes were made to Table 2, Flexible Analysis, Shell Course 6 OBE calculated and allowable stresses. The calculated stress was revised to reflect the use of the licensed OBE level of 0.12g rather than the previous use of 0.13g. The allowable stress was revised to reflect a more accurate interpolation of values from Figure VII-1102-4 of the ASME Code, 1974 Edition through Winter 1975 Addenda.

The Table 3 value for shear in a typical slab strip, calculated using flexible analysis, was revised per the response to Question 3 below.

QUESTION 2:

Provide the maximum stress values (due to sloshing) in the angle welds at the roof-cylinder junction with stresses combined from the three components of earthquake (SSE). Compare with the allowables.

RESPONSE:

The maximum force on the 1/4 inch circumferential fillet weld of the steel angle connecting the tank roof to the tank cylinder was calculated with consideration given to the sloshing effects during an earthquake. A comparison of the calculated maximum force with the allowable force is shown below.

CALCULATED MAXIMUM FORCE (KIPS/INCH)	ALLOWABLE FORCE (KIPS/INCH)
0.0253	3.00

QUESTION 3:

Provide a summary of the maximum stresses in base slab (rebar and concrete), including those under the sump. Compare with the allowables.

RESPONSE:

The table below provides values of the allowable moments and shears at various sections of the base slab and the corresponding maximum design values. The maximum design values are based on factored loads and the allowable values are based on nominal strength multiplied by strength reduction factors in accordance with the American Concrete Institute code (ACI 318-1983).

LOCATION	ALLOWABLE MOMENT (KIP-FT/ft)	MAXIMUM DESIGN/MOMENT (KIP-FT/ft)	ALLOWABLE SHEAR (KIPS/ft)	MAXIMUM DESIGN SHEAR (KIPS/ft)
1. Typical base slab strip	216.57	174.2	79.35	63.5
2. Slab strip around the sump pit	568.3	494.0	79.35	74.5
3. Sump pit slab (2'6"Thick)	88.5	13.2	32.9	11.9

QUESTION 4:

In response to question 2(a) of the previous RAI, it is indicated that the bolts will not experience any shear load because of the static friction between the tank bottom and the concrete slab. This cannot be justified unless slotted or oversized bolt holes are used to allow for tank bending and flexibility. Provide maximum calculated stresses in bolts under the three components of earthquake (SSE), in pure tension as well as when tension and shear are combined. Compare them with the corresponding allowables.

RESPONSE:

As requested in Reference 3 and reported in Reference 4, the anchor bolt analysis was revised using classical methods to be consistent with the foundation analysis. The analysis for transmitting shear loads from the tank to the foundation was also revised to utilize static friction between the tank bottom and the concrete footing. With consideration given to this static friction, it was demonstrated that tank sliding did not occur, and therefore, the anchor bolts did not experience any shear loads.

The tank base is anchored to the foundation by 2 inch diameter anchor bolts and the base plate is provided with 3 1/4 inch diameter holes for the bolts. Since oversized bolt holes are used, the static friction utilized in the analysis for transferring shear loads is justified. Based upon the above, the anchor bolts have been adequately evaluated for pure tension resulting from uplift loads. The maximum tension load calculated in any anchor bolt under the three components of the earthquake (SSE) is 9.864 kips and the corresponding allowable bolt tension value is 50.625 kips.

CALLAWAY & WOLF CREEK

RWST SEISMIC ANALYSIS

1. TANK MODEL - MASS

1 MASS FOR CONVECTIVE (SLOSHING) EFFECTS

1 MASS FOR BASE SLAB

9 MASS POINTS FOR SHELL AND IMPULSIVE COMPONENTS OF FLUID

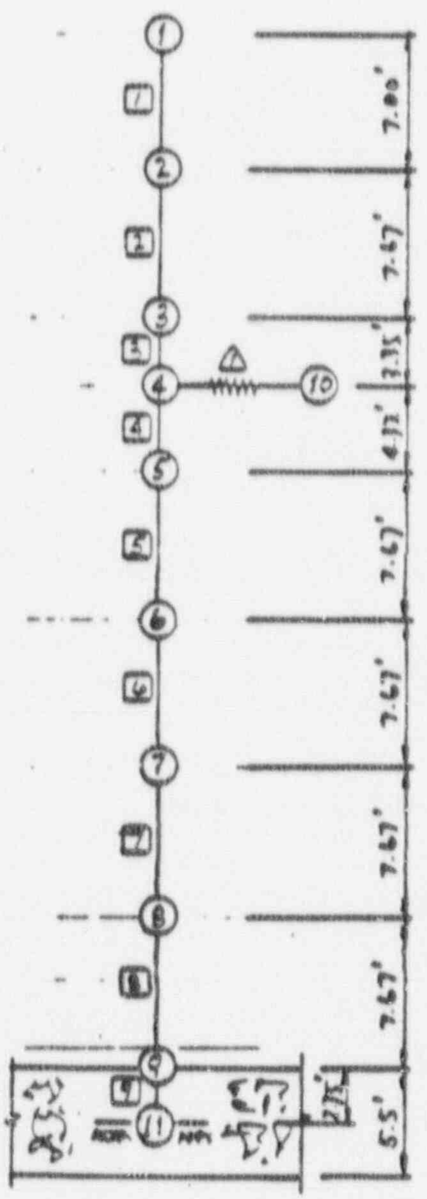
CALCULATION SHEET

JOB NO.	CALC. NO.	REV. NO.	SHEET NO.
14894	C-1989-130	0	7

ORIGINATOR	DATE	CHECKED	DATE
James D. Stefano	6-29-89	J.C. Oleinik	7-11-89

B. ANALYTICAL / COMPUTER MODELS:

1. FIXED-BASE LUMPED MASS MODEL:



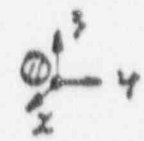
LEGEND:

① - MASS AND NODE NO.

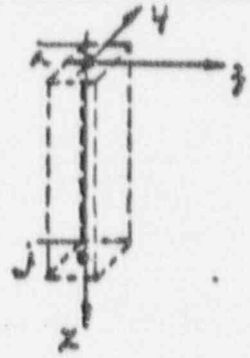
▢ - ELEMENT NO., BEAM

△ - ELEMENT NO., SPRING

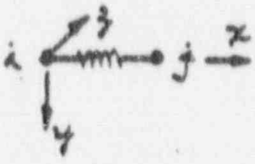
GLOBAL COORDINATES:



LOCAL COORDINATES:



BEAMS



SPRINGS

CALCULATION SHEET

JOB NO.	CALC. NO.	REV. NO.	SHEET NO.
14894	C-1989-130	0	24

ORIGINATOR	DATE	CHECKED	DATE
James Di Stefano	7-10-89	J.C. Oleinik	7.14.89

SUMMARY OF MASS POINT WEIGHTS:

POINT	WEIGHTS (K) HORIZONTAL	VERTICAL	
1	8	8	
2	12	12	
3	6	6	
4	4	725	*
5	9	9	
6	2859	2859	
7	18	18	
8	20	20	
9	36	36	
10	721	0	*
11	1210	1210	
Σ =	4903 K	4903 K	

* THE CONVECTIVE WATER WILL BE LUMPED AT NODE 4 FOR THE VERTICAL ANALYSIS. THIS IS ACCEPTABLE FOR THE VERTICAL DIRECTION SINCE SLOSHING DOES NOT OCCUR.

NOTE:

THE PREVIOUS ANALYSES, BY THE VENDOR (REFERENCES 12-14), CONSERVATIVELY INCLUDED AN ADDITIONAL ROOF LOAD (SNOW LL AT 73 PSF, 91.734 K) AT MASS POINT ①. CONSISTENT WITH THE SNUPPS CRITERIA AND BUILDING ANALYSES (REFERENCES 27-29), THIS LOAD NEED NOT BE INCLUDED IN THE SEISMIC ANALYSIS.

BECHTEL

CALCULATION SHEET

JOB NO.	CALC. NO.	REV. NO.	SHEET NO.
14894	C-1989-130	0	31

ORIGINATOR	DATE	CHECKED	DATE
[signature]	7-3-89	J.C. Olivik	7-14-89

SUMMARY OF LUMPED MASS PARAMETERS:

MASS No.	WEIGHT $(W_i)^K$	HEIGHT ABOVE BASE (h_i) ft	$(W_i)(h_i)^2$ k·ft²	I_i k·ft²	IW_i k·ft²
①	8	55.77	24882	863	25745
②	12	48.77	28542	1617	30159
③	6	41.10	10135	1084	11219
④	4	37.75	5700	754	6454
⑤	9	33.43	10058	1686	11744
⑥	2859	25.76	1897169	2768	1899937
⑦	18	18.09	5891	3514	9405
⑧	20	10.42	2172	4015	6187
⑨	36	2.75	272	2008	2280
⑩	721	37.75	1027470	0	1027470
⑪	1210	0	0	151797	151797
Σ =	4903		3012291	170106	3182397

TOTAL $IW_i = I_o^W = 3,182,397$ k·ft² (BOTH HORIZONTAL DIRECTIONS)

$$\therefore I_o^M = \frac{3182397}{32.2} = 98832 \text{ k·ft-sec}^2$$

RWST SEISMIC ANALYSIS

1. TANK MODEL - STIFFNESS

STRUCTURE - 3D BEAMS
(TANK SHELL ONLY)

BASE SLAB - 3D BEAM

CONVECTIVE (SLOSHING)
EFFECTS - SPRING

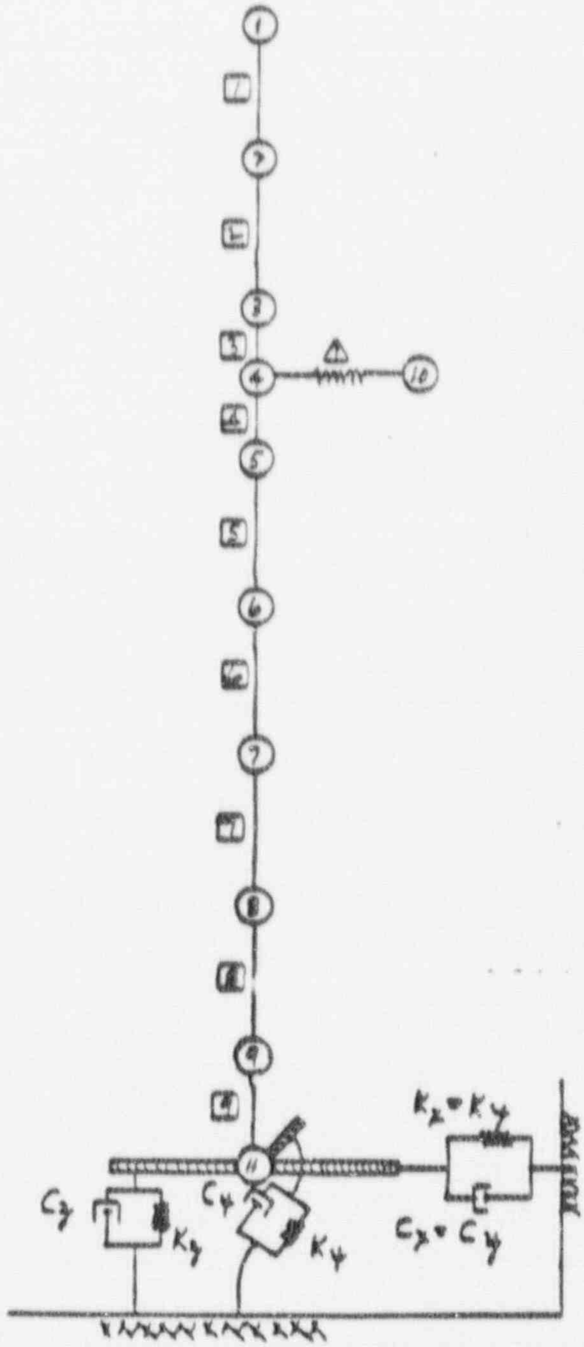
SOIL - SPRINGS

CALCULATION SHEET

JOB NO.	CALC. NO.	REV. NO.	SHEET NO.
14894	C-1989-130	0	8

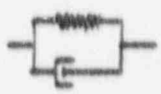
ORIGINATOR	DATE	CHECKED	DATE
James DeSimone	6-29-89	J.C. Olinik	7-11-89

2. LUMPED MASS MODEL OF STRUCTURE-FOUNDATION SYSTEM:



FOR INFORMATION NOT SHOWN, SEE SHEET NO. 7

LEGEND:

 SOIL SPRINGS AND DAMPERS

(MODEL USING BOUNDARY ELEMENTS)

SUMMARY OF MEMBER PROPERTIES :

MEMBER NUMBER	AREA (ft^2)	(1) SHEAR AREAS (ft^2)		AREA MOMENTS OF INERTIA (ft^4)	
		NS	EW	NS	EW
1	4.202	2.101	2.101	488	488
2	1.9627	0.982	0.982	392	392
3	1.9627	0.982	0.982	392	392
4	1.9627	0.982	0.982	392	392
5	3.27	1.635	1.635	653	653
6	3.924	1.962	1.962	784	784
7	5.231	2.6155	2.6155	1044	1044
8	5.231	2.6155	2.6155	1044	1044
9	1500	1350	1350	184397	184397

(1) SHEAR AREAS ARE TAKEN AS ½ AREA FOR TANK SHELL PER REFERENCE 31. FOR SLAB, SHEARS ARE TAKEN AS 0.9 AREA PER REFERENCE 31 ASSUMING A CIRCULAR SOLID SECTION.

DUE TO SYMMETRY, TORSION WILL NOT OCCUR. THE COMPUTER RUNS, HOWEVER, REQUIRE AN INPUT FOR J (TORSIONAL MOMENT OF INERTIA) TO EXECUTE. AS SUCH, EITHER THE CALCULATED VALUES OF C OR A FICTIOUS VALUE (OF 1.0 ft^4) WILL BE INPUT.

CALCULATION SHEET

JOB NO.	CALC. NO.	REV. NO.	SHEET NO.
14894	C-1989-130	0	32

ORIGINATOR	DATE	CHECKED	DATE
[signature]	7-1-89	J.C. Oleinik	7-14-89

H. MATERIAL PROPERTIES:

DENSITY,	OF CONCRETE	$\gamma_c = W$	= 145 pcf
	OF STEEL	γ_s	= 490 pcf
YOUNG'S MODULUS,	OF CONCRETE[1]	E_c	= 524757 Ksf
	OF STEEL	E_s	= 4176000 Ksf

WHERE $E_c = (W)^{1.5}(33)\sqrt{f'_c} = (145)^{1.5}(33)\sqrt{4000}$ psi[2]

SHEAR MODULUS,	OF CONCRETE[3]	G_c	= 209903 Ksf
	OF STEEL	G_s	= 1612800 Ksf

WHERE $G_c = 0.4\,E_c$

POISSON'S RATIO,	FOR CONCRETE	ν_c	= 0.25
	FOR STEEL	ν_s	= 0.30

WHERE ν_c IS BASED ON THE RELATIONSHIP BETWEEN E_c AND G_c

DAMPING,[4]	STRUCTURE	ξ	= 2% (OBE)
			= 4% (SSE)
	CONVECTIVE FLUID (REFERENCE 3)		= ½%

(1) SEE SECTION 8.5.1 OF REFERENCE 24.
(2) SEE REFERENCE 22.
(3) SEE PAGE 137 OF REFERENCE 26.
(4) PERCENT OF CRITICAL DAMPING FOR A WELDED STEEL STRUCTURE FROM REFERENCE 25.

RWST SEISMIC ANALYSIS

1. TANK MODEL - DAMPING

BASED ON SNUPPS FSAR
(REG. GUIDE 1.61)

STEEL TANK
OBE - 2%
SSE - 4%

CONVECTIVE FLUID
1/2 %

SOIL
(BASED ON SNUPPS
EHS/FEA STUDY APPROACH)

RWST SEISMIC ANALYSIS
2. FOUNDATION MEDIUM

- NRC SUGGESTION TO USE SIMPLIFIED APPROACH

- CONSISTENT WITH EHS/FEA STUDY

- RICHERT EQUATIONS

- LAYERING BASED ON WEIGHTED AVERAGE (DEPTH = BASE DIM.)

- USED DYNAM (CE-2607) (BSAP CE-800 FAMILY OF COMPUTER PROGRAMS

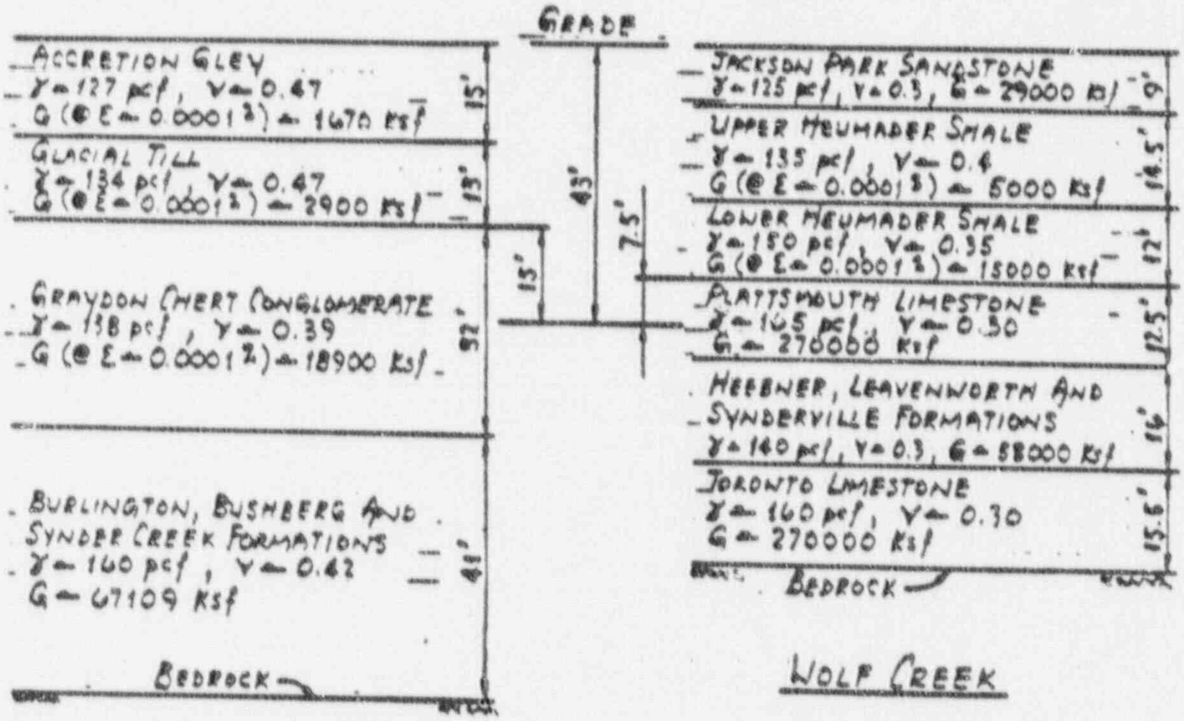
CALCULATION SHEET

JOB NO.	CALC. NO.	REV. NO.	SHEET NO.
14894	C-1959-130	0	16

ORIGINATOR	DATE	CHECKED	DATE
Jaspe De Stefano	7-10-89	J.C. Olivito	7.13.89

ONE BASE DIMENSION = (2)(21'-4") = 42'-8" ; USE 43'

SITE SPECIFIC SOIL PROFILES ARE:



WOLF CREEK

CALLAWAY

FOR CALLAWAY:

$$\gamma_a = \frac{\Sigma \gamma_i H_i}{\Sigma H_i} = \frac{(127)(15) + (134)(13) + (138)(15)}{43} = 133 \text{ pcf}$$

$$\nu_a = \frac{\Sigma \nu_i H_i}{\Sigma H_i} = \frac{(0.47)(15) + (0.47)(13) + (0.39)(15)}{43} = 0.442$$

$$G_a = \frac{\Sigma G_i H_i}{\Sigma H_i} = \frac{(1670)(15) + (2900)(13) + (18900)(15)}{43} = 8052 \text{ ksf}$$

INCORPORATE THE +/- 50% ON THE VALUE OF G_a.

RWST SEISMIC ANALYSIS

3. SUMMARY OF RESPONSE

MODES:

FREQ. RANGE (Hz)	MODE	EFFECTIVE MASS
.22	(CONVECTIVE)	15%
4.6/6.2	(1ST HORIZ)	70%
8.4/13.1	(1ST VERT)	93%

RWST SEISMIC ANALYSIS

4. TREATMENT OF MODES

HORIZONTAL DIRECTIONS

- HYDRODYNAMIC COMPUTED PER NUREG CR-1161 (SRSS OF IMPULSE, SLOSHING AND VERTICAL MODES

- HYDROSTATIC & HYDRODYNAMIC SUMMED ABS

RWST SEISMIC ANALYSIS

4. TREATMENT OF MODES

HORIZONTAL DIRECTIONS:
(CONTINUED)

- ONE HORIZ. ANALYSIS (DUE TO SYMMETRY)
- 2ND HORIZ. DIRECTION IS 40% OF FIRST
- ADDED NOZZLE LOADS FROM SEPARATE ANALYSIS FOR EACH DIRECTION

RWST SEISMIC ANALYSIS

4. TREATMENT OF MODES (CONTINUED)

   - COMBINED TWO HORIZ. DIRECTIONS AS VECTOR SUM

   - VERTICAL DIRECTION CONSERVATIVELY ADDED ABS TO HORIZ

   - USED MULTIMODE APROACH TO COMBINE ALL MODES IN A SPECIFIC DIRECTION

RWST SEISMIC ANALYSIS

5. SLOSHING HEIGHT

- BASED ON NUREG CR-1161

- CONSIDERED ROOF STRESSES

  - SNOW LOAD CONTROLLED

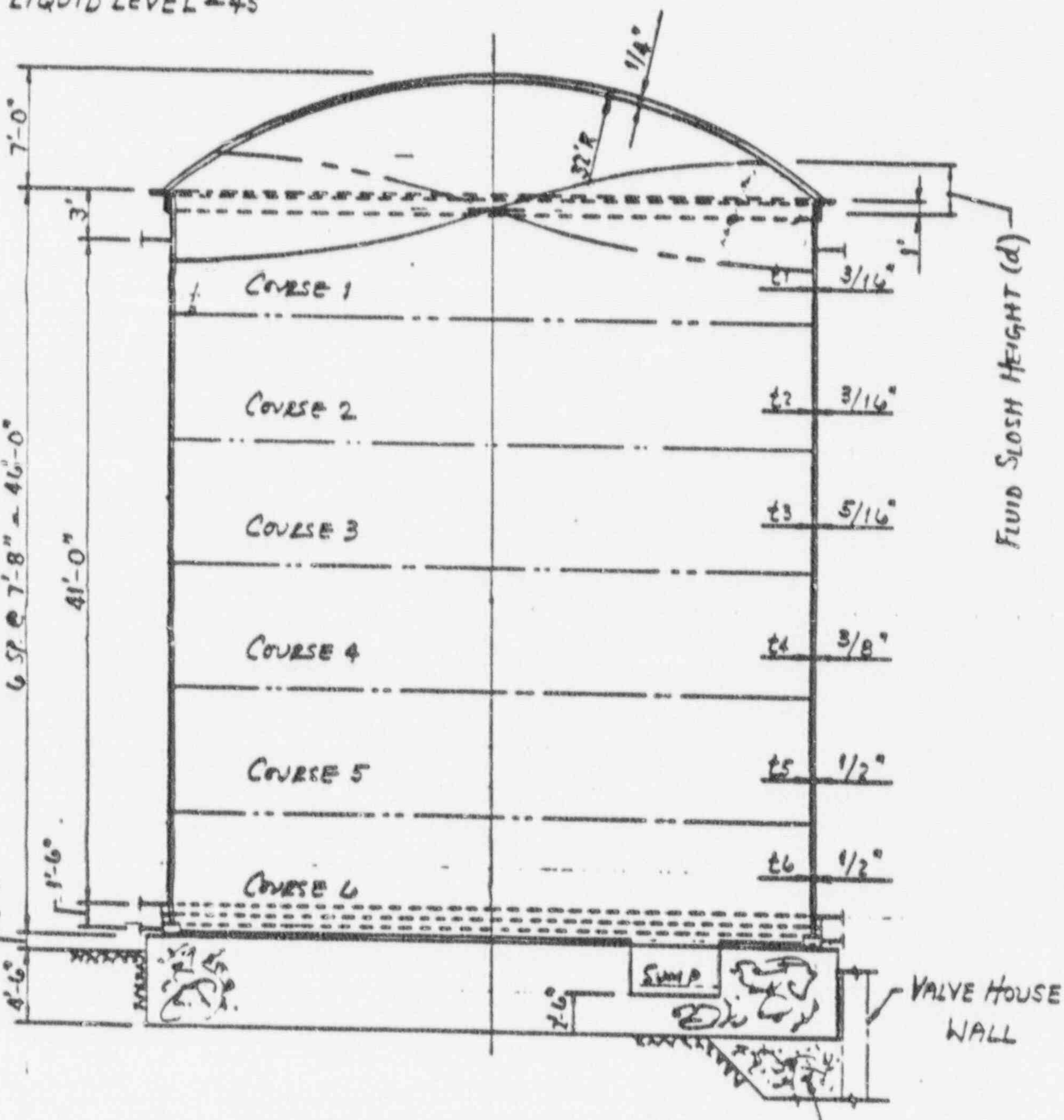
CALCULATION SHEET

JOB NO.	CALC. NO.	REV. NO.	SHEET NO.
14894	C-1989-130	0	6

ORIGINATOR	DATE	CHECKED	DATE
James Di Stefano	6-29-89	J.C. Olbinik	7-11-89

A. SKETCHES (CONTINUED):

LIQUID LEVEL ≈ 45'



ELEVATION VIEW
(SEE REFERENCES 12, 14 AND 22)

RWST SEISMIC ANALYSIS

6. UPLIFT POTENTIAL

- ANALYSIS BY CLASSICAL METHOD INDICATES UPLIFT (I.E. TENSION IN BOLTS)

- TANK DISPLACEMENTS CONSIDERED IN PIPE ANALYSIS

RWST SEISMIC ANALYSIS

7. OVERTURNING MOMENTS

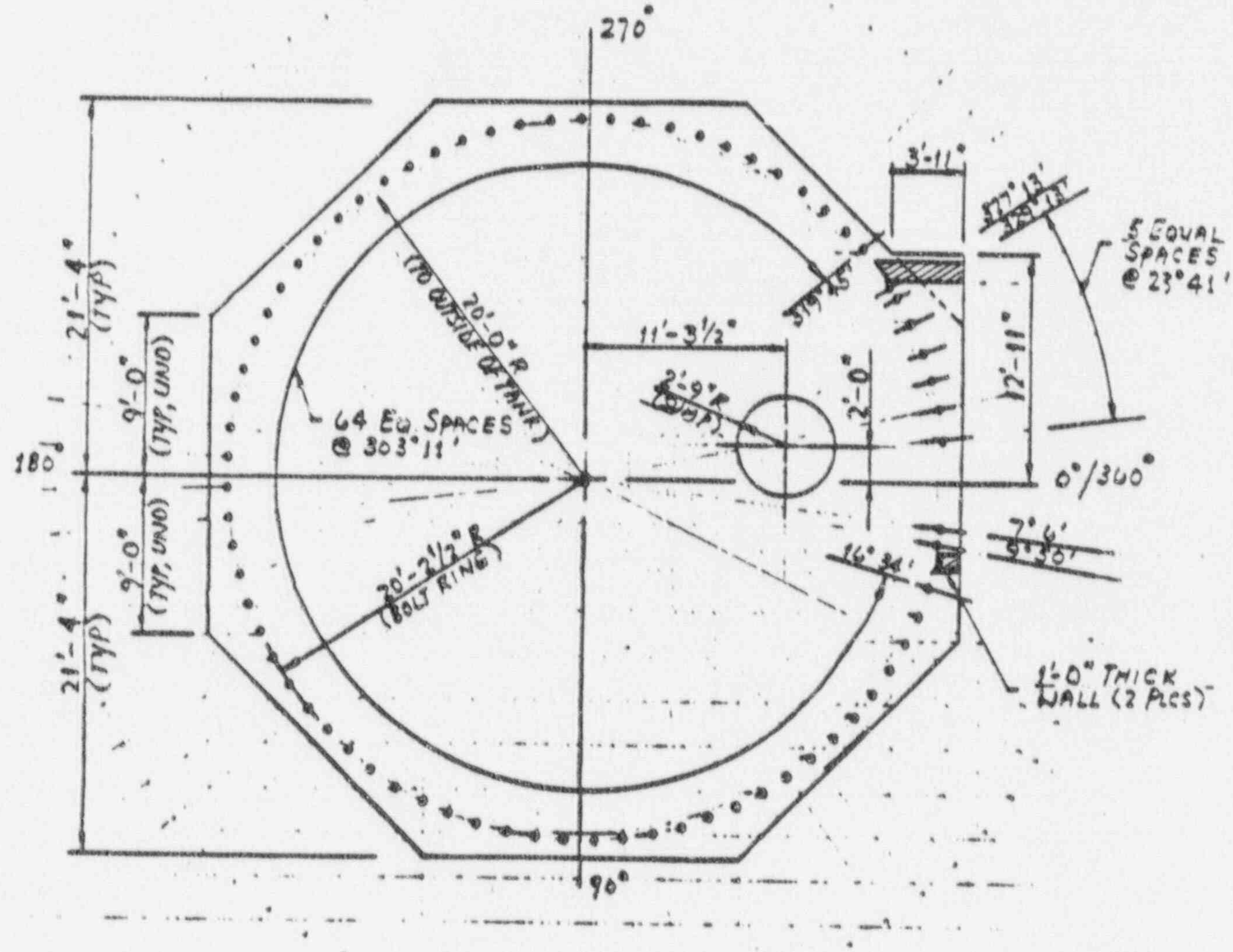
- CONTROLLING CASES
  - FULL TANK W/SEISMIC
  - EMPTY TANK W/WIND
- BOLTS DESIGN PER CLASSICAL METHOD, BOLTS TAKE TENSION LOAD ONLY
- SHEAR LOAD TRANSFERRED TO CONCRETE FOOTING BY STATIC FRICTION BETWEEN TANK BOTTOM AND CONCRETE (OVERSIZED HOLES PROVIDED

RWST SEISMIC ANALYSIS

IN TANK BASE TO JUSTIFY THE ABOVE)

IV. DESIGN CALCULATIONS:

A. TANK/FOUNDATION ARRANGEMENT SKETCHES: (REFS. 12-18 AND 22)



PLAN VIEW.
(FROM REFERENCE 22)

RWST SEISMIC ANALYSIS

8. STRESSES IN SHELL

- BASED ON ORIGINAL SPEC. FOR TANKS

- ASME SECTION III SUBSECTION NC

RWST SEISMIC ANALYSIS

9. SUMMARY - HOOP STRESS RIGID ANALYSIS:

   -ONLY HYDROSTATIC PRESSURES CONSIDERED

   -PRESSURES COMPUTED AT BASE OF EACH COURSE

RWST SEISMIC ANALYSIS

FLEXIBLE ANALYSIS:

- HYDRODYNAMIC AND HYDROSTATIC PRESSURES WERE CONSIDERED

- PRESSURES COMPUTED ONE FOOT ABOVE BASE OF EACH COURSE

THICKNESS REQUIREMENTS COMPARED IN TABLE 1

TABLE 1

Comparison Of Required Shell Course Thicknesses (inches)

Shell Courses	Computed Required Thickness Rigid Analysis	Flexible Analysis	Actual Thickness
1	0.0520	0.1875 *	0.1875
2	0.1041	0.1875 *	0.1875
3	0.1563	0.2179	0.3125
4	0.2083	0.2789	0.3750
5	0.2605	0.3418	0.5000
6	0.3126	0.4061	0.5000

* Minimum Requirements Govern

RWST SEISMIC ANALYSIS

9. SUMMARY - ROOF DESIGN

- SLOSH HEIGHT OF 3.36 FT (CALCULATED PER NUREG CR-1161)

- PREVIOUS DESIGN LOADS (ROOF SNOW LOADS) CONTROL

- CONNECTION WELD BETWEEN TANK ROOF AND CYLINDER JUNCTION CHECKED

RWST SEISMIC ANALYSIS

9. SUMMARY - COMPRESSION

-SEISMIC GOVERNED OVER WIND

-SSE CONTROLLED RIGID ANALYSIS

-FLEXIBLE ANALYSIS CONSIDERED OBE AND SSE

COMPRESSION STRESSES COMPARED IN TABLE 2

TABLE 2

Comparison Of Longitudinal Compression Stresses (PSI)

Shell Courses	Rigid Analysis Stress	Rigid Analysis Allowable	Flexible Analysis Stress	Flexible Analysis Allowable
1	*	---	134 (----)	2698 (1484)
2	*	---	165 (----)	2698 (1484)
3	1912	3307	140 (----)	4200 (2310)
4	2925	3933	2670 (----)	5400 (2970)
5	**	---	4273 (2749)	7000 (3850)
6	4235	4964	6584 (3927)	7000 (3960)

* Signifies Negligible
** Course 5 was enveloped by Course 6

In flexible analysis, OBE values are given in parenthesis. Values shown as (----) were not computed since SSE stress was less than the OBE allowable.

RWST SEISMIC ANALYSIS

9. SUMMARY - FOUNDATION

- SOIL PRESSURES

- SHEAR AND MOMENT IN BASE SLAB EVALUATED

- SHEAR AND MOMENT IN BASE SLAB ADJACENT TO SUMP PIT EVALUATED

- SHEAR AND MOMENT IN SUMP PIT SLAB (2'-6" THICK) EVALUATED

RWST SEISMIC ANALYSIS

-COMPARISONS PROVIDED IN TABLE 3

TABLE 3

Foundation Comparisons

Item of Comparison	Rigid Analysis	Flexible Analysis	Allowable
Static Soil Pressure (ksf)	3.36	3.27	20.00
Dynamic Soil Pressure (ksf)	7.81	15.14	30.00
Shear in Typ. Slab Strip (Vu in Kips/FT)	49.90	63.5	79.35
Moment in Typ. Slab Strip (Mu in Kip-Ft/Ft)	107.90	174.20	216.57
Shear in Slab Strip around the Sump Pit (Vu in Kips/ft)	-	74.5	79.35
Moment in Slab Strip around the Sump Pit (Mu in Kip-FT/ft)	-	494.0	568.3
Shear in 2'-6" thick Sump Pit Slab (Vu in Kips/ft)	-	11.9	32.9
Moment in 2'-6" thick Sump Pit Slab (Mu in kip-FT/ft)	-	13.2	88.[illegible]