ARKANSAS POWER & LIGHT COMPANY
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March 3, 1983

ØCANØ28310

Director of Nuclear Reactor Regulation
ATTN: Mr. J. F. Stolz, Chief
Operating Reactors Branch #4
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Director of Nuclear Reactor Regulation
ATTN: Mr. Robert A. Clark, Chief
Operating Reactors Branch #3
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: Arkansas Nuclear One - Units 1 & 2
Docket Nos. 50-313 and 50-368
License Nos. DPR-51 and NPF-6
Additional Information Concerning
Spent Fuel Storage Expansion

Gentlemen:

Your letter dated January 5, 1983 (ØCNAØ18304) requested additional information concerning the proposed spent fuel storage expansion at Arkansas Nuclear One (ANO). This submittal is in response to that request.

This submittal contains proprietary information of Westinghouse Electric Corportion. In conformance with the requirements of 10CFR Section 2.790, as amended, of the Commission's regulations, enclosed are an application from Westinghouse for withholding from public disclosure and an affidavit. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission.

Regarding the proprietary information, enclosed are:

1. Three (3) copies of Westinghouse Drawings 613ØE41C1, Rev. 1 (sheets 1 thru 3) and 613ØE44C1 Rev. 1 (sheets 1 thru 4)-Proprietary.

2. Three (3) copies of Westinghouse Drawings 613ØE41C2, Rev. 1 (sheets 1 thru 3) and 613ØE44C2, Rev. 1 (sheets 1 thru 4)-Non-Proprietary.

A001 1/3 Prop Drawings To: G. Vissing D.T. Lynch Reg Files

3. One (1) copy of Application for Withholding (CAW-83-16)-Non-Proprietary.

4. One (1) original Affidavit (CAW-83-16)-Non-Proprietary.

Correspondence with respect to the affidavit or application for withholding should reference CAW-83-16 and should be addressed to R.A. Wiesemann, Manager, Regulatory & Legislative Affairs, Westinghouse Electric Corporation, P. O. Box 355, Pittsburgh, PA 15230.

Very truly yours,

John R. Marshall
Manager, Licensing

JRM:DB:sl

Attachments

QUESTIONS RELATING TO THE STRUCTURAL AREA

Question 1:

Provide structural drawings of the racks including fabrication details.

Response:

Spent fuel rack assembly drawings 6130E41C1, Revision 1 (sheets 1 thru 3) and 6130E441C1, Revision 1 (sheets 1 thru 4) contain information considered proprietary to Westinghouse Electric Corporation, and as requested, should be withheld from public disclosure. Non-proprietary copies of these drawings are also enclosed.

Question 2:

Provide structural drawings of the pools including foundation and liner details.

Response:

The following drawings have been transmitted with this submittal:

C-203	C-209	C-214	C-232	C-249
C-204	C-210	C-216	C-233	C-2204
C-205	C-211	C-219	C-235	C-2205
C-206	C-212	C-231	C-236	C-2206

Question 3:

Provide results of an analysis for potential sliding and/or tiping of the racks. If rack-to-rack or rack-to-pool wall/floor impact is postulated, include the resultant loads in the rack analysis as well as the pool structure analysis, as applicable. Describe the analysis procedure.

Response:

The analysis procedure for these loads on the pool structure is as follows:

The fuel rack loads utilized in this analysis consist of a submerged deadweight loading, and a vertical and horizontal reaction loading due to the operating basis earthquake. These reaction loads are distributed to the pool floor node points based on the proximity of each pad to the surrounding nodes. The earthquake loads are distributed in the same proportion as the deadweight loads, with the total force equal to that specified by Westinghouse.

Rack Displacements, Sliding, and Rocking Stability

The support pad vertical and horizontal displacements are tabulated for both high and low friction coefficients. The support pad vertical displacements are used to calculate the overall rack module rocking for partial and full fuel loading conditions. This calculation shows that the minimum factor of safety against overturn is produced by a partial fuel loading of the rack module. The factor of safety is in excess of the 1.5 minimum requirements of the NRC Position Paper.

The horizontal displacements of support pads sliding and top of the rack structural deflection are used in conjunction with thermal displacements to show that the rack module does not collide with another rack or with a pool floor obstruction or the pool wall.

Displacement Results

The rack displacement, pad vertical lift-off, pad horizontal sliding, and rack top lateral displacement are obtained from the nonlinear analysis. The maximum support pad lift-off was obtained for the high coefficient of friction run ($\mu = 0.8$) while the maximum support pad sliding was obtained for the low coefficient of friction run ($\mu = 0.2$). The results are tabulated below:

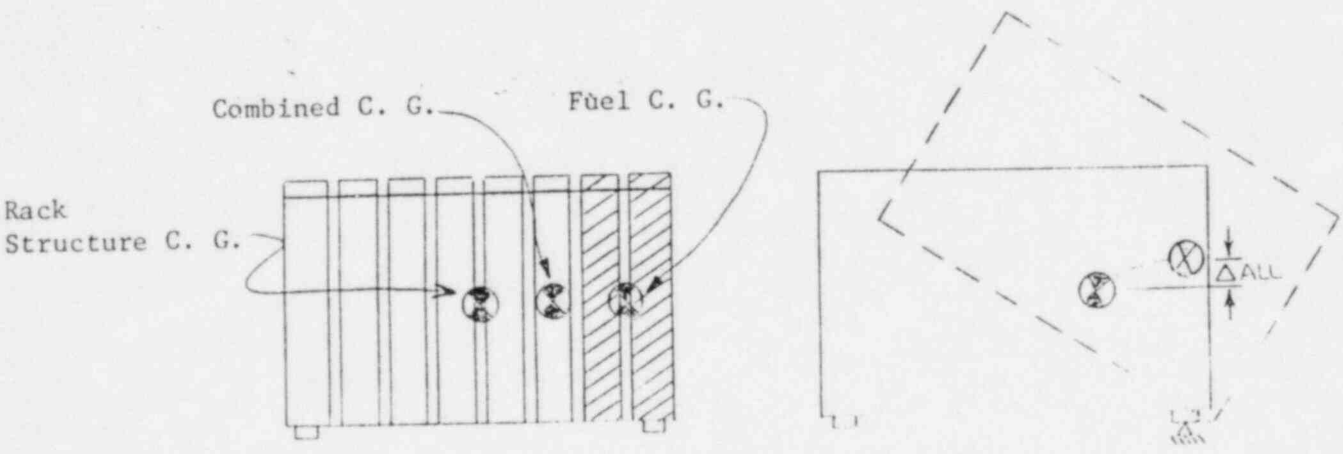
			Unit 2	Unit 1
High Coefficient of Friction Results ($\mu = .8$)				
Support Pad Lift-Off	Δy	in	0.055	0.005
Rack Top Lateral Displacement	Δx	in	0.200	0.150
Low Coefficient of Friction Results ($\mu = .2$)				
Support Pad Maximum Sliding	Δx	in	0.095	0.030
Rack Top Lateral Displacement	Δx	in	0.135	0.140

Rack Lift-Off Stability

The energy which produced lift-off of the nonlinear model is applied to the fuel rack module with various fuel loadings in order to obtain the loading configuration which produces the maximum lift-off or minimum factor of safety against overturn. The lift-off energy is equated to the potential energy of lifting the center of gravity of the combined fuel and fuel rack masses to obtain the maximum lift-off of the rack. The maximum allowable lift of the center of gravity is obtained by calculating the lift of the center of gravity from the static position to the point directly above the support pad center line, as shown in the figure below. The factor of safety against overturn is obtained by comparing the allowable lift to the actual lift.

For Arkansas Unit 2, the 8 x 10 rack module was analyzed since it has the minimum support pad spacing (8 cell direction) and the minimum resistance to overturn. The loading condition of two outside rows of fuel produces the minimum factor of safety against overturn of FS = 59.

For Arkansas Unit 1, the 10 x 11 rack module was analyzed in the 10 cell direction. The loading condition of three outside rows of fuel produces the minimum factor of safety against overturn of FS>100.



Rack Module Stability

Evaluation of Rack Lateral Displacements

The nonlinear time history analysis calculates the fuel rack sliding distance for the low coefficient of friction, and the top of the rack structural deflection for the high coefficient of friction. In this portion of the evaluation, the rack to rack, rack to floor obstructions, and rack to wall gaps will be examined to show that there is no impact due to the lateral motion.

To evaluate potential impact for the rack to rack, rack to wall, and rack to pool floor obstruction gaps, the gap will be modified to account for thermal growth of hot operating conditions, and compared with the rack's maximum seismic displacement to show that the gap is not closed and impact of a rack module does not occur.

Rack Thermal Displacement

Since the pool temperature during installation is below the hot operating condition, the gap must be reduced by the thermal expansion of the rack. The rack to rack thermal displacement is for maximum normal condition and also the accident condition of cooling system not operational.

			Arkansas Unit 2	Arkansas Unit 1
Rack Thermal Growth Maximum Normal Condition	$\delta_T 1$	in	0.070	0.090
Rack Thermal Growth Accident Condition	δ_T^2	in	0.150	0.200

Combined Seismic & Thermal Displacement

The condition which produces the maximum fuel rack seismic response is all fuel racks filled with fuel. For this configuration the racks responses (sliding and structural deflection) will be in phase, thus the rack to rack gap is not affected. The major factor which produces the phase relationship for this condition is the hydrodynamic coupling effect of the submerged structure.

However, due to variation of friction or for other than racks full of fuel, there may be a condition where one rack slides and the adjacent rack does not slide. For this condition the rack to rack gap will be reduced by the amount of one rack sliding, two racks structurally deflecting, and the thermal movement of the racks for the installed temperature to the maximum normal temperature. Since the structural displacements of the racks are out of phase or unrelated, the combined seismic displacements will be obtained by the SRSS method.

In addition to this condition, the thermal accident condition must be addressed. Since it is highly unlikely that the thermal accident condition, which requires days of inoperative cooling train to obtain, and the SSE seismic event occur simultaneously, only the sliding distance of the SSE event, without the structural displacements, will be combined with the thermal accident displacement.

Combined Displacement Results

			Unit 2	Unit 1
Combined Thermal & Seismic Displacement	δ	in	0.40	0.35
Limiting Gaps;				
Rack to Rack	G_1	in	1.5	1.5
Rack to Pool Wall	G_2	in	5.0	19.0
Rack to Pool Floor Obstruction	G_3	in	>2.0	>2.0

Question 4:

Provide results of an analysis for impact loads from the heaviest object to be transported over the fuel pool. Evaluate the affects on both rack structure and the pool structure including the liner. Describe the analysis procedure.

*Response:

An analysis has been conducted for dropping a 2000 lb fuel assembly from the maximum height to which it will be raised, based on the Technical Specificaiton requirements that weights no greater than 2000 lbs will be transported over spent fuel. The criticality analysis of drop accidents is performed with dissolved boron in the pool water, since not taking credit for the boron would mean assuming two unlikely independent events. With this credit no credible deformations caused by a fuel drop accident would cause a criticality accident. For the straight or inclined drop on top of the rack, the rack deformations are limited to the top region of the rack. For the straight drop through a cell the fuel assembly impacts the base plate of the rack, causes a portion of it to separate from the bottom of the rack, and impacts the floor of the spent fuel pool. Stresses on the liner, however, are not high enough to cause it to be punctured.

In the analysis the potential energy of the dropped fuel assembly is equated to the strain energy of the energy absorbing structure to obtain the impact force. The energy absorbing structure for this drop is the lower portion of the fuel assembly and the deformed portion of the rack. No credit is taken for water drag on the fuel assembly or for pumping action in the cell.

*This analysis was performed using drop heights above the fuel racks of 2'-1" for Unit 1 and 0'-10" for Unit 2 as determined by AP&L supplied drawings 21943-1 and I-16615-E which defined the maximum heights of the fuel assemblies.

Question 5:

Provide key calculations and results of the seismic analysis. Include sketches of the mathematical model and discuss the method of modeling potential rack-to-rack and rack-to-pool interaction due to sliding and/or tipping, if any.

Response:

The Arkansas spent fuel storage racks are the free standing type. During the seismic event it is possible for the rack to slide or rock and lift a support pad off the floor. Since the support pad boundary conditions as well as the gaps between the fuel assembly and cell assembly are structurally nonlinear, the seismic analysis is a nonlinear time history analysis.

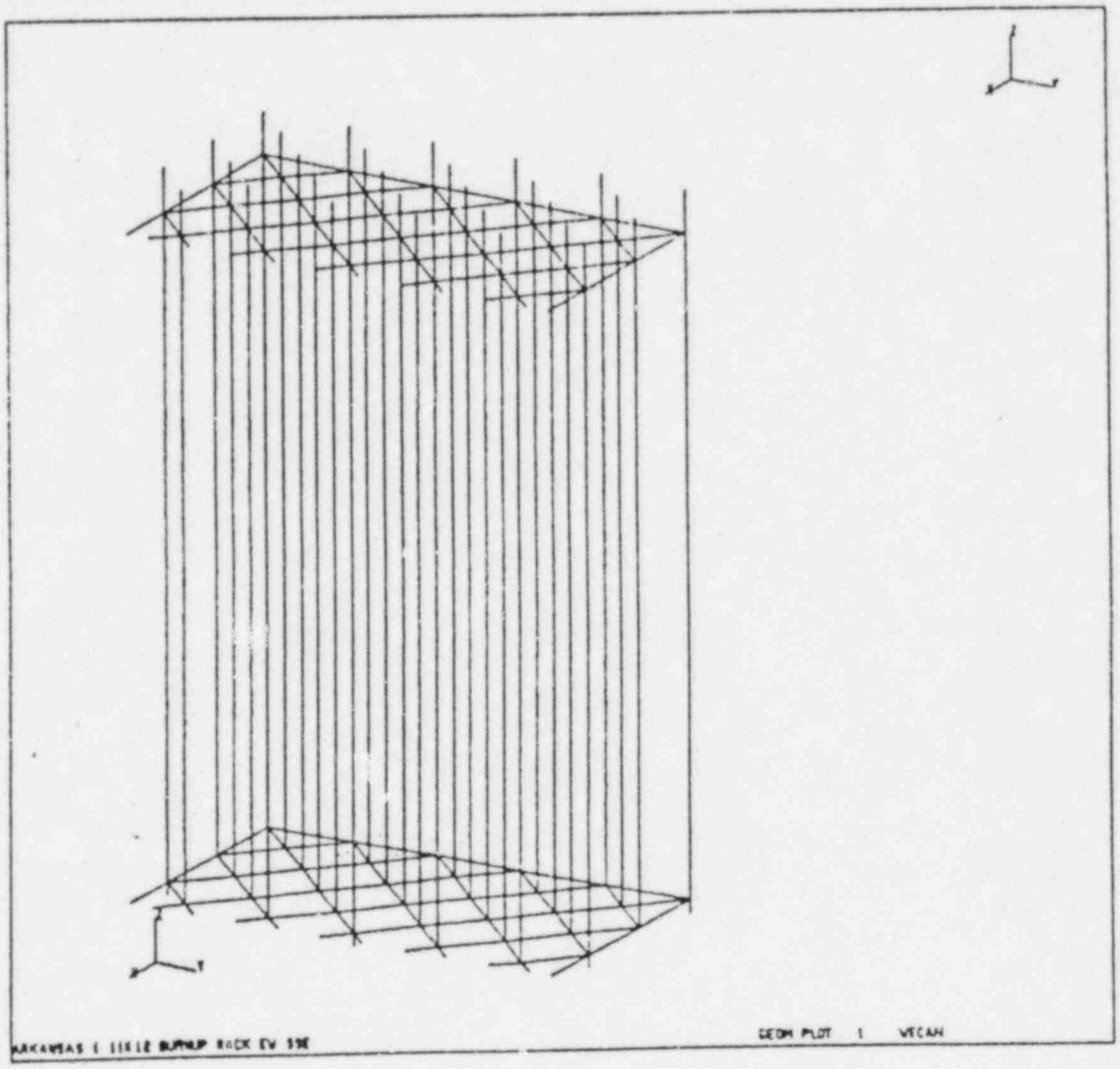
The seismic analysis is performed in two phases. The first is a response spectrum analysis on a linear detail rack model which produces the effective stiffness values for a single cell representation. The second phase is a time history analysis of the single cell model which has been modified to include the nonlinearities of the fuel to cell gaps and the support pad boundary conditions. The analysis is performed for a range of support pad friction coefficients (μ = .2 - .8) to determine the maximum sliding with the low friction and the maximum rocking and lift off with the high friction. This analysis produces the rack response, which is used to calculate overall rack stability, and rack loads, which are used in the structural analysis to calculate stresses. The results of this analysis are given in the response to Question 3.

The verification of the sliding capability for the WECAN Element 77, Dynamic Friction Element, has been performed by comparing the WECAN results with the results of classical solutions for simplified applications. In addition, the WECAN results of a free standing fuel rack analysis were compared with hand calculation results for a verification of a previous fuel rack license submittal.

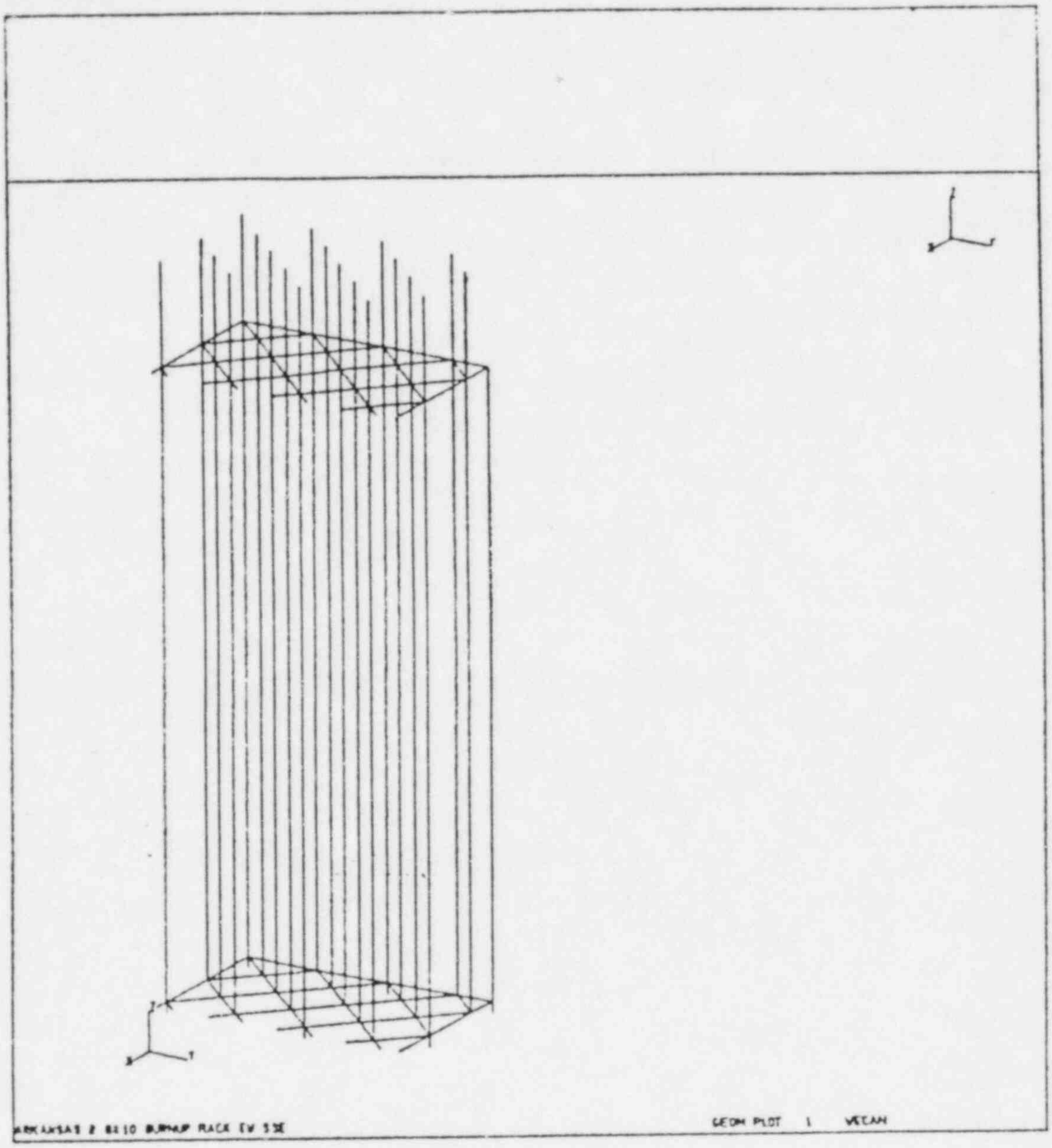
Linear Model

The linear model, shown in the following sketch, is a three-dimensional finite element representation of a rack assembly. The structural properties of the individual beams for the cells, grids, support pads, etc., are calculated from the effective sections. The mass is composed of the structural masses of rack, fuel assembly, and control rod assembly, the water inside the cells, and the hydrodynamic mass between the rack and pool wall. The structural mass and water inside the cells are distributed on the cells, and the hydrodynamic mass between the rack and pool is input with a mass matrix element. The model is constructed for half the rack and divided at the line of symmetry with appropriate boundary conditions. A geometry plot is included to show the construction of the model.

The structural properties of a single cell representation, which are used for the nonlinear model, are obtained from the results of the detail model. The results of the single cell model computer run, frequency and mode shape, are compared with that of the detail model to insure correct structural representation.



Arkansas Unit 1, Linear Model Geometry Plot, (11 x 12) Rack



Arkansas Unit 2, Linear Model Geometry Plot, (8 x 10) Rack

Nonlinear Model

The geometry plot, shown in the following sketch, is the single cell finite elements representation of the nonlinear mathematical model. The structural properties of the rack components are represented by six different finite elements. These elements and their identification number (ITYPE) are listed below:

ITYPE	Finite Element
1	STIF 4, Three-Dimensional Beam
2	STIF 77, Three-Dimensional Dynamic Friction Element
3	STIF 27, General Matrix, Stiffness, Input
4	STIF 27, General Matrix, Mass, Input
5	STIF 37, Three-Dimensional Dynamic Gap Element
6	STIF 34, Two-Dimensional Rotary Spring

The three-dimensional beam element (STIF 4) is a straight uniform cross section element with tension-compression, torsion, and bending capabilities. This element is used to model the fuel beam, cell beam, and rack base beam.

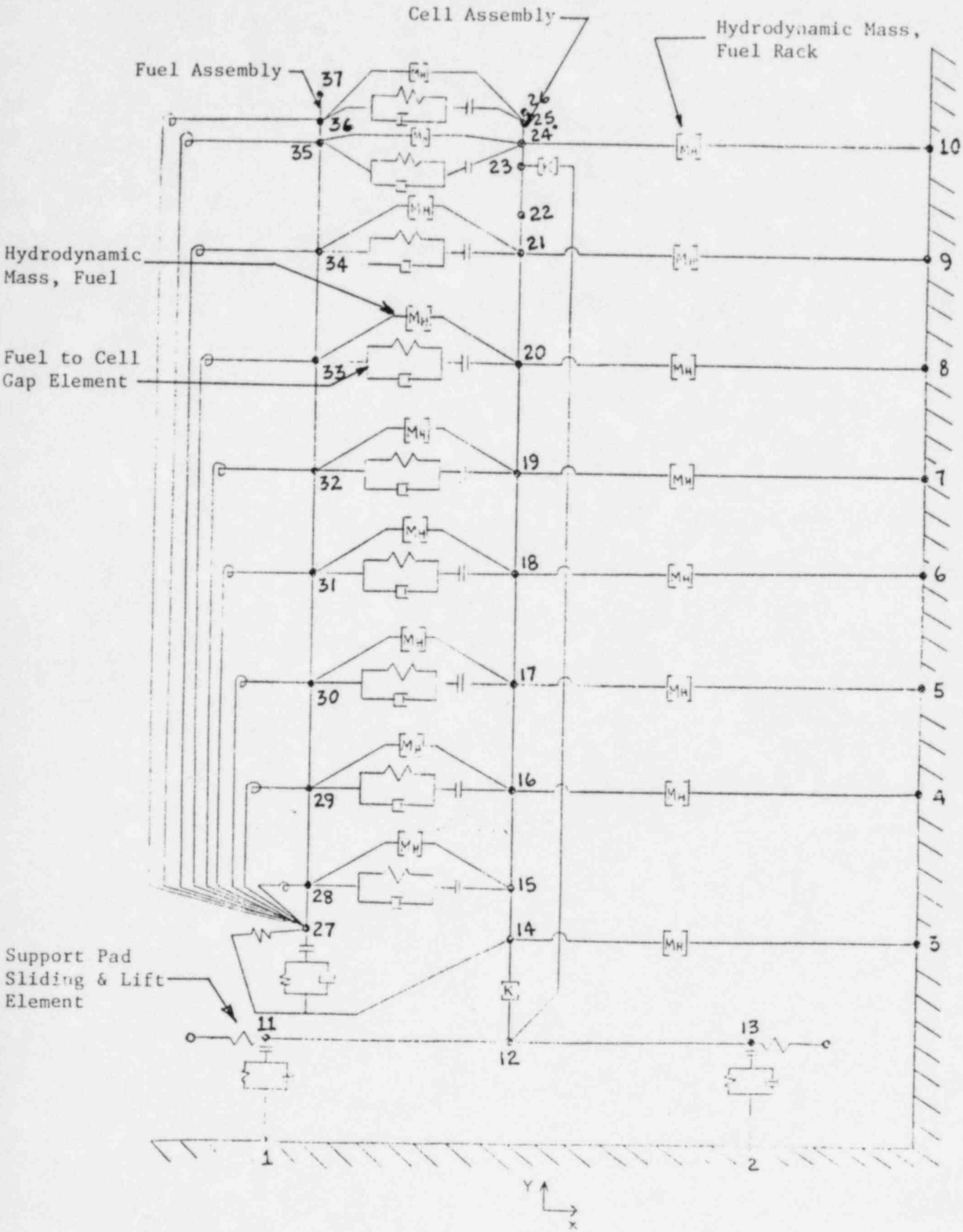
The three-dimensional dynamic friction element (STIF 77) is composed of a gap in series with a parallel combination of impact spring and impact damper with a frictional spring orthogonal to the gap. This element is designed to represent two surfaces which may slide relative to each other, and may separate or contact each other. The friction behavior is represented by a friction spring, and the impact behavior is represented by combination of an impact spring and a dashpot in parallel, coupled to a gap in series. The friction spring is along the direction of sliding which is normal to the direction of impact. The classical Coulomb friction is assumed between the sliding surfaces. The friction behavior is simulated by a stiffness method. The friction spring will transmit the shear forces across the surfaces as long as these forces are below the friction limit. Once sliding takes place, a pseudo force is applied to the sliding surface such that the resultant of the force in the friction spring and the pseudo force will represent the friction force. This element is used to model the sliding and or lift off of the support pads and the fuel base.

The general matrix, stiffness, element (STIF27) is an element whose geometry is undefined, but whose kinematic response is specified by stiffness coefficients. This element is used to represent the connection between the base of the cell and rack base cross beam with rigid vertical and lateral properties and the rotational stiffness of the cell base, and the connection between the top grid and rack base cross beam with the rotational stiffness of the top grid.

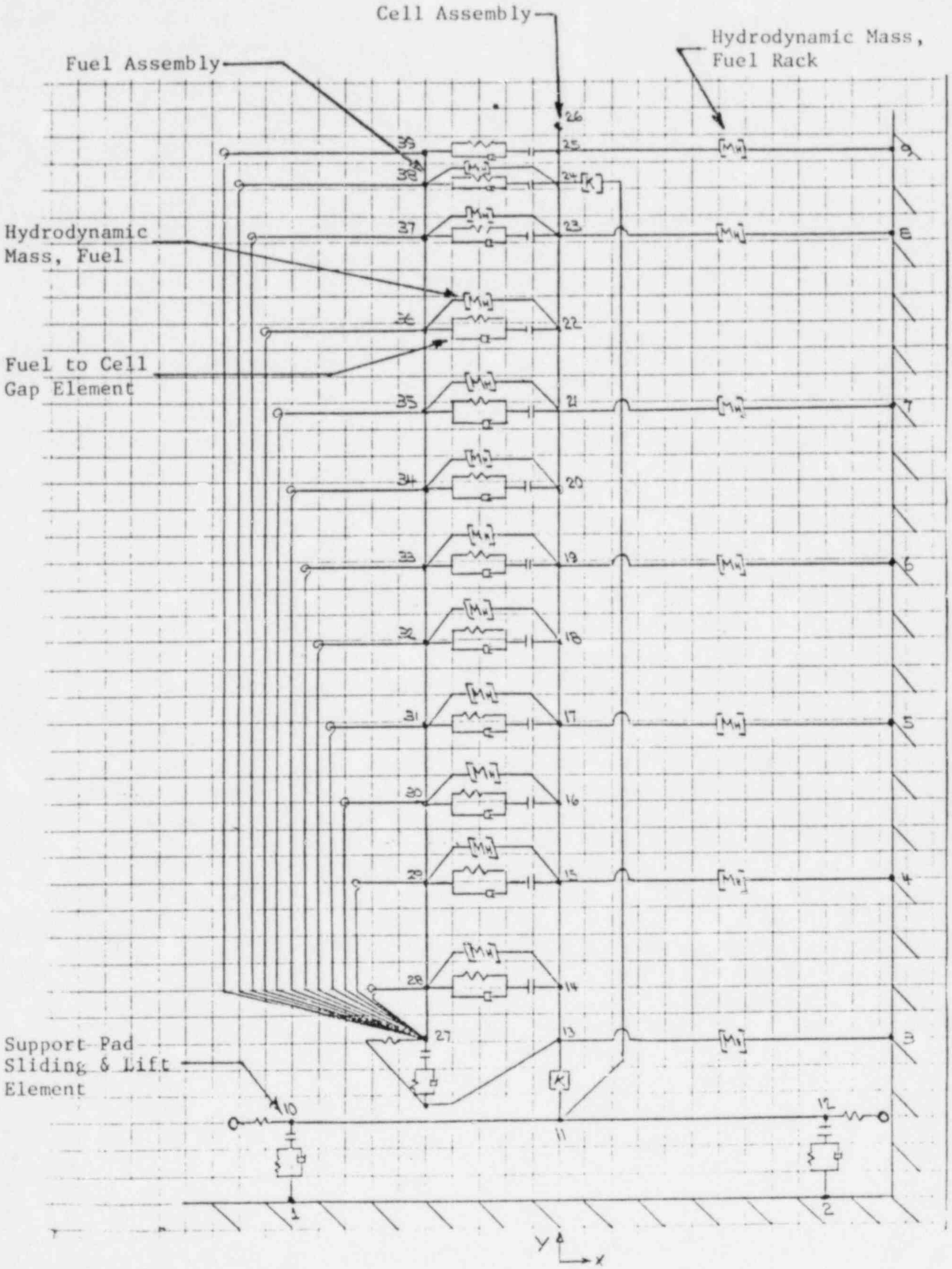
The general matrix, mass, element (STIF27) is an element whose geometry is undefined but whose kinematic response is specified by mass coefficients. This element is used to represent the hydrodynamic mass between the fuel and cell and also between the cell and pool wall.

The three-dimensional dynamic gap element (STIF37) is composed of a gap in series with a parallel combination of impact spring and impact damper. This element is used to model the gap between the fuel and cell.

The two-dimensional rotary spring element (STIF45) is an element which has only one degree of freedom, rotation about the Z axis, and is defined by a rotational stiffness. This element is used to model the rotational stiffness of the fuel assembly grid members.



Arkansas Unit 1, Nonlinear Model Geometry Plot



Arkansas Unit 2, Nonlinear Model Geometry Plot

The structural properties for the rack are specified as real constants in the model inputs. The real constants are listed in the input under the following numbers.

TBL	Component
1	Base Beam
2	Support Pad Sliding and Impact
3	Cell Beam at Top and Bottom Weld Zones
4	Cell Beam Between Top and Bottom Weld Zones
5	Fuel Base Slider and Vertical Impact
6	Fuel Beam
7	Fuel Grid to Rods Rotational Stiffness
8	Fuel Bottom Nozzle Impact
9	Fuel Grid Impact
10	Fuel Top Nozzle Impact

Note: Some of the stiffnesses properties are input through the STIF 27 elements.

STIF 27 (K) - Support Pad Horizontal and Cell-Bottom Grid Rotational Stiffnesses

STIF 27 (K) - Cell-Top Grid Rotational Stiffness

Question 6:

Provide a tabulation of allowable vs computed stresses for the racks.

Response:

The load combinations applicable to spent fuel racks are shown below.

ELASTIC ANALYSIS	ACCEPTANCE LIMITS
(1) D + L	Normal Limits of NF 3231.1a
(2) D + L + E	Normal Limits of NF 3231.1a
(3) $D + L + T_o$	Lesser of 2 S_y and S_u
(4) $D + L + T_o + E$	Lesser of 2 S_y and S_u
(5) $D + L + T_a + E$	Lesser of 2 S_y or S_u
(6) $D + L + T_a + E'$	Faulted Condition Limits of NF 3231.1c

The margin of safety tables on the following pages show case 2 (D + L + E) and case 4 ($D + L + T_o + E$). Case 2 envelopes case 1 (D + L) and case 4 envelopes case 3 ($D + L + T_o$). Thermal loads are caused by differential thermal expansion between the rack and pool floor (which loads are limited by friction between the rack and floor) and by differential thermal expansion between a loaded cell and an empty cell. Both of these loads are the same for T_a and T_o and thus case 5 ($D + L + T_a + E$) is the same as case 4. Thermal loads are self limiting in nature and the fuel rack material is ductile so they are not considered for faulted conditions, case 6 ($D + L + T_a + E'$). The SSE seismic loads are less than twice the OBE loads and since the SSE allowables are twice the OBE allowables the margins of safety for case 6 are greater than for case 2.

The margin of safties for the Unit 1 racks will be of similar magnitude as those shown in the attached tables and will meet all of the above acceptance limits.

MARGINS OF SAFETY

Arkansas Unit 2

Region 1 Rack

		D+L+E			D+L+E+To		
ITEM	TYPE OF STRESS	APPLIED STRESS	ALLOWABLE STRESS	MARGIN OF SAFETY	APPLIED STRESS	ALLOWABLE STRESS	MARGIN OF SAFETY
Cell	Axial	.564*	1.0*	.77*	11160	55000	3.93
Seam Weld	Shear	10095	24000	1.38	10095	31740	2.14
Wrapper Weld	Shear	6483	11000	.70	6483	31740	3.90
Cell to Grid Welds	Shear	16968	24000	.41	22466	31740	.41
Grids							
Top Grid Member	Axial	2296	16500	6.19	2296	55000	23.0
Welds	Shear	5049	24000	3.75	5049	31740	5.29
Belt	Axial	2469	16500	5.68	2469	55000	21.3
Bottom Grid Member	Axial	7370	16500	1.24	7370	55000	6.46
Welds	Shear	12939	24000	.85	12939	31740	1.45
Belt	Axial	10878	16500	.52	10878	55000	4.06
Support Pad and Support Plate See Region 2 Rack							

* Load Combination per ASME III Appendix XVII 2215.1 eqn (22)

MARGINS OF SAFETY

Arkansas Unit 2

Region 2 Rack

ITEM	TYPE OF STRESS	D+L+E APPLIED STRESS	D+L+E ALLOWABLE STRESS	D+L+E MARGIN OF SAFETY	D+L+E+To APPLIED STRESS	D+L+E+To ALLOWABLE STRESS	D+L+E+To MARGIN OF SAFETY
Cell	Axial	.650*	1.0*	.54*	13121	55000	3.19
Seam Weld	Shear	14430	24000	.66	14430	31740	1.20
Wrapper Weld	Shear	8616	11000	.28	8616	31740	2.68
Cell to Cell Welds							
Near Top of Cell	Shear	9620	24000	1.49	16948	31740	.87
At Bottom of Cell	Shear	14066	24000	.71	20335	31740	.58
Support Pad							
Minimum Section	Axial	4542	16500	2.63	4622	55000	10.9
	Shear	1494	11000	6.36	1367	31740	22.2
Bearing Surface	Bearing	6364	24750	2.89	4793	55000	10.5
Threads	Shear	4727	11000	1.33	3597	31740	7.8
Support Plate	Shear	1786	11000	5.16	1500	31740	20.2
Welds	Shear	11580	24000	1.07	10620	31740	1.99

* Load combination per ASME III Appendix XVII 2215.1 eqn (22)

Question 6:

Provide a tabulation of allowable vs. computed stresses for the racks and pool.

Response:

Attached are the appropriate Tables and Figures showing computer models for the pool area only.

TABLE 6-1
Arkansas Power and Light Company
Arkansas Nuclear One - Unit 1
Spent Fuel Storage Facility Evaluation
Tabulation of Controlling Section Resultant Moments [1]

Location	Section Axial Force	Section Resultant Moment[2,4]	Section Allowable Moment[3]	Moment Code Ratio
Pool Floor Slab: (AFPSTA1A2-09)				
East - West Section at South End (Element 320)	-47.58	1005.	1321.	0.76
North - South Section at Mid-span (Element 320)	-35.50	1093.	1869.	0.59
Pool Foundation: (AFPSTA1A2-10)				
South Wall, Horizontal Section at Top (Element 2865)	-17.31	315.7	811.8	0.39
East Wall, Horizontal Section at Top (Element 2877)	-18.30	351.2	827.4	0.42
West Wall, Horizontal Section at Top (Element 2857)	-16.68	391.8	801.7	0.49

Units: Kips/Inch, Kip-inches/Inch

Notes:
1) NUREG-0800 Load Combination ($D + L + T_a + 1.25E'$)
2) Positive moment causes tension on outside surface of walls and lower surface of floor slab.
3) Allowable moment is based on strength design method per ACI 349/80.
4) T_a moments are relieved, maintaining equilibrium and curvature of section.

Table 6-1 (continued)
Arkansas Power and Light Company
Arkansas Nuclear One - Unit 1
Spent Fuel Storage Facility Evaluation
Tabulation of Controlling Section Resultant Moments (1)

Location	Section Axial Force	Section Resultant Moment(2,4)	Section Allowable Moment(3)	Moment Code Ratio
East Pool Wall: (AFPSTA1A2-05)				
Vertical Section at Bottom North Corner (Element 2823)	-35.58	1262.	2235.	0.57
Horizontal Section at Bottom North Corner (Element 2329)	-38.51	1284.	2121.	0.61
Vertical Section at Top Center Span (Average Elements 6324,5824,5324, 4824 - AFPSTA1A2-12)	14.58	219.8	1027.	0.21

Units: Kips/Inch, Kip-inches/Inch

Notes:
1) NUREG-0800 Load Combination ($D + L + T_a + 1.25E'$)
2) Positive moment causes tension on outside surface of walls and lower surface of floor slab.
3) Allowable moment is based on strength design method per ACI 349/80.
4) T_a moments are relieved, maintaining equilibrium and curvature of section.

Table 6-1 (continued)
Arkansas Power and Light Company
Arkansas Nuclear One - Unit 1
Spent Fuel Storage Facility Evaluation
Tabulation of Controlling Section Resultant Moments [1]

Location	Section Axial Force	Section Resultant Moment[2,4]	Section Allowable Moment[3]	Moment Code Ratio
West Pool Wall: (AFPSTA1A2-08)				
Vertical Section at Bottom Mid-span (Element 2306)	-32.89	1298.	2219.	0.58
Horizontal Section near Bottom South End (Element 2808)	-34.82	1217.	2059.	0.59
Vertical Section at Top Mid-span (Average Elements 6304,5804, 5304,4804 - AFPSTA1A2-12)	14.97	205.0	1015.	0.20

Units: Kips/Inch, Kip-inches/Inch

Notes:
1) NUREG-0800 Load Combination ($D + L + T_a + 1.25E'$)
2) Positive moment causes tension on outside surface of walls and lower surface of floor slab.
3) Allowable moment is based on strength design method per ACI 349/80.
4) T_a moments are relieved, maintaining equilibrium and curvature of section.

Table 6-1 (continued)
Arkansas Power and Light Company
Arkansas Nuclear One - Unit 1
Spent Fuel Storage Facility Evaluation
Tabulation of Controlling Section Resultant Moments (1)

Location	Section Axial Force	Section Resultant Moment (2,4)	Section Allowable Moment (3)	Moment Code Ratio
Fuel Transfer Canal Separation Wall: (AFPSTA1A2-07)				
Vertical Section Below Elevation of Bottom of Gate Opening (Element 3313)	-40.93	769.2	1147.	0.67
Horizontal Section at Bottom of Wall (Element 2818)	-31.80	540.0	872.5	0.62
Vertical Section at Top East End (Average Elements 4818,5318,5818,6318 - AFPSTA1A2-12A)	-6.624	166.0	397.6	0.42
Horizontal Section at West End of Wall Above Elevation of Bottom of Gate Opening (Average Elements 4314 thru 4318 - AFPSTA1A2-12A)	-16.58	369.4	587.0	0.63

Units: Kips/Inch, Kip-inches/Inch

Notes:
1) NUREG-0800 Load Combination (D + L + T_a + 1.25E')
2) Positive moment causes tension on outside surface of walls and lower surface of floor slab.
3) Allowable moment is based on strength design method per ACI 349/80.
4) T_a moments are relieved, maintaining equilibrium and curvature of section.

Table 6-1 (continued)
Arkansas Power and Light Company
Arkansas Nuclear One - Unit 1
Spent Fuel Storage Facility Evaluation
Tabulation of Controlling Section Resultant Moments [1]

Location	Section Axial Force	Section Resultant Moment[2,4]	Section Allowable Moment[3]	Moment Code Ratio
Cask Laydown Separation Wall: (AFPSTA1A2-06)				
Vertical Section Below Elevation of Bottom of Gate Opening (Element 3335)	-34.62	466.3	664.6	0.70
Horizontal Section at Bottom Mid-span (Element 2335)	-34.35	396.7	572.4	0.69
Vertical Section at East End of Wall Above Elevation Of Bottom ot Gate Opening (Element 3834)	-13.41	188.4	367.0	0.51

Units: Kips/Inch, Kip-inches/Inch

Notes:
1) NUREG-0800 Load Combination ($D + L + T_a + 1.25E'$)
2) Positive moment causes tension on outside surface of walls and lower surface of floor slab.
3) Allowable moment is based on strength design method per ACI 349/80.
4) T_a moments are relieved, maintaining equilibrium and curvature of section.

Table 6-1 (continued)
Arkansas Power and Light Company
Arkansas Nuclear One - Unit 1
Spent Fuel Storage Facility Evaluation
Tabulation of Controlling Section Resultant Moments (1)

Location	Section Axial Force	Section Resultant Moment (2,4)	Section Allowable Moment (3)	Moment Code Ratio
Pool North Wall: ([illegible]A1A2-11)				
Vertical Section at Middle West Edge (Element 3839)	-3.483	292.1	433.5	0.67
Horizontal Section at Middle West Edge (Element 3839)	-38.50	1002.	1384.	0.72
Vertical Section at Top West End (Average Elements 6339,5839,5339,4839 - AFPSTA1A2-12)	0.496	170.2	307.3	0.55

Units: Kips/Inch, Kip-inches/Inch

Notes:
1) NUREG-0800 Load Combination (D + L + T_a + 1.25E')
2) Positive moment causes tension on outside surface of walls and lower surface of floor slab.
3) Allowable moment is based on strength design method per ACI 349/80.
4) T_a moments are relieved, maintaining equilibrium and curvature of section.

TABLE 6-1
Arkansas Power and Light Company
Arkansas Nuclear One - Unit 2
Spent Fuel Storage Facility Evaluation
Tabulation of Controlling Section Resultant Moments (1)

Location	Section Axial Force	Section Resultant Moment (2,4)	Section Allowable Moment (3)	Moment Code Ratio
Pool Floor Slab: (AFPSTA2A2-11)				
East - West Section at 1/3 span (Element 330)	-49.67	893.5	1646.	0.54
North - South Section at Mid-span (Element 320)	-29.67	810.5	1670.	0.49
Pool Foundation: (AFPSTA2A2-12)				
North Wall, Horizontal Section at Top (Element 1367)	-15.40	-165.4	-904.5	0.18
East Wall, Horizontal Section at Top (Element 2878)	-7.222	181.1	599.2	0.30
West Wall, Horizontal Section at Top (Element 2857)	-27.69	315.4	869.7	0.36

Units: Kips/Inch, Kip-inches/Inch

Notes:
1) NUREG-0800 Load Combination ($D + L + T_a + 1.25E'$)
2) Positive moment causes tension on outside surface of walls and lower surface of floor slab.
3) Allowable moment is based on strength design method per ACI 349/80.
4) T_a moments are relieved, maintaining equilibrium and curvature of section.

Structural Dynamics Technology

Table 6-1 (continued)
Arkansas Power and Light Company
Arkansas Nuclear One - Unit 2
Spent Fuel Storage Facility Evaluation
Tabulation of Controlling Section Resultant Moments (1)

Location	Section Axial Force	Section Resultant Moment (2,4)	Section Allowable Moment (3)	Moment Code Ratio
West Pool Wall: (AFPSTA2A2-10)				
Vertical Section at Bottom Mid-span (Element 2305)	-20.80	849.6	1771.	0.48
Horizontal Section near Bottom North End (Element 2808)	-32.17	922.6	1935.	0.48
Vertical Section at Top Mid-span (Average Elements 6304,5804 5304,4804 - AFPSTA2A2-14)	13.88	206.8	879.7	0.24

Units: Kips/Inch, Kip-inches/Inch

Notes:
1) NUREG-0800 Load Combination ($D + L + T_a + 1.25E'$)
2) Positive moment causes tension on outside surface of walls and lower surface of floor slab.
3) Allowable moment is based on strength design method per ACI 349/80.
4) T_a moments are relieved, maintaining equilibrium and curvature of section.

SDT Structural Dynamics Technology

Table 6-1 (continued)
Arkansas Power and Light Company
Arkansas Nuclear One - Unit 2
Spent Fuel Storage Facility Evaluation
Tabulation of Controlling Section Resultant Moments (1)

Location	Section Axial Force	Section Resultant Moment (2,4)	Section Allowable Moment (3)	Moment Code Ratio
East Pool Wall: (AFPSTA2A2-07)				
Vertical Section at Bottom Mid-span (Element 2327)	-44.48	901.5	1750.	0.52
Horizontal Section at Bottom South Corner (Element 2329)	-32.00	902.4	1711.	0.53
Vertical Section at Top Center Span (Average Elements 6326,5826, 5326,4826 - AFPSTA2A2-14)	14.18	234.2	875.2	0.27

Units: Kips/Inch, Kip-inches/Inch

Notes:
1) NUREG-0800 Load Combination ($D + L + T_a + 1.25E'$)
2) Positive moment causes tension on outside surface of walls and lower surface of floor slab.
3) Allowable moment is based on strength design metnod per ACI 349/80.
4) T_a moments are relieved, maintaining equilibrium and curvature of section.

Table 6-1 (continued)
Arkansas Power and Light Company
Arkansas Nuclear One - Unit 2
Spent Fuel Storage Facility Evaluation
Tabulation of Controlling Section Resultant Moments (1)

Location	Section Axial Force	Section Resultant Moment (2,4)	Section Allowable Moment (3)	Moment Code Ratio
Fuel Transfer Canal Separation Wall: (AFPSTA2A2-09)				
Vertical Section Below Elevation of Bottom of Gate Opening (Element 3313)	-40.95	518.4	768.3	0.68
Horizontal Section at Bottom of Wall (Element 2813)	-23.83	403.9	758.3	0.56
Vertical Section at West End of Wall Above Elevation of Bottom of Gate Opening (Element 3818)	-11.63	267.8	447.7	0.60
Horizontal Section at West End of Wall Above Elevation of Bottom of Gate Opening (Element 3818)	-26.31	379.2	680.7	0.56

Units: Kips/Inch, Kip-inches/Inch

Notes:
1) NUREG-0800 Load Combination ($D + L + T_a + 1.25E'$)
2) Positive moment causes tension on outside surface of walls and lower surface of floor slab.
3) Allowable moment is based on strength design method per ACI 349/80.
4) T_a moments are relieved, maintaining equilibrium and curvature of section.

SDT Structural Dynamics Technology

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Table 6-1 (continued)
Arkansas Power and Light Company
Arkansas Nuclear One - Unit 2
Spent Fuel Storage Facility Evaluation
Tabulation of Controlling Section Resultant Moments (1)

Location	Section Axial Force	Section Resultant Moment(2,4)	Section Allowable Moment(3)	Moment Code Ratio
Cask Laydown Separation Wall: (AFPSTA2A2-08)				
Vertical Section Below Elevation of Bottom of Gate Opening (Element 3335)	-36.39	469.1	653.9	0.72
Horizontal Section at Bottom Mid-span (Element 2335)	-35.86	405.7	689.7	0.59
Vertical Section at East End of Wall Above Elevation Of Bottom of Gate Opening (Element 3834)	-13.99	205.3	392.2	0.52

Units: Kips/Inch, Kip-inches/Inch

Notes:
1) NUREG-0800 Load Combination ($D + L + T_a + 1.25E'$)
2) Positive moment causes tension on outside surface of walls and lower surface of floor slab.
3) Allowable moment is based on strength design method per ACI 349/80.
4) T_a moments are relieved, maintaining equilibrium and curvature of section.

Structural Dynamics Technology

Table 6-1 (continued)
Arkansas Power and Light Company
Arkansas Nuclear One - Unit 2
Spent Fuel Storage Facility Evaluation
Tabulation of Controlling Section Resultant Moments (1)

Location	Section Axial Force	Section Resultant Moment(2,4)	Section Allowable Moment(3)	Moment Code Ratio
Pool South Wall: (AFPSTA2A2-13)				
Vertical Section at Bottom East Corner (Element 2338)	-15.77	745.8	1787.	0.42
Horizontal Section at Bottom East Corner (Element 2338)	-31.36	837.8	1703.	0.49
Vertical Section at Top West End (Average Elements 6339,5839,5339,4839 - AFPSTA2A2-15)	6.866	127.7	1543.	0.08

Units: Kips/Inch, Kip-inches/Inch

Notes:
1) NUREG-0800 Load Combination ($D + L + T_a + 1.25E'$)
2) Positive moment causes tension on outside surface of walls and lower surface of floor slab.
3) Allowable moment is based on strength design method per ACI 349/80.
4) T_a moments are relieved, maintaining equilibrium and curvature of section.

Structural Dynamics Technology

Question 7:

Are any modifications to the pool structure or liner contemplated?

Response:

No modifications are planned.

Question 8:

In the seismic analysis, describe the methods for estimating effects due to fluid motion on both the pool structure and racks.

Response:

For the pool structure the earthquake response of the pool water is defined based on the methodology outlined in TID-7024, Appendix F. The hydrodynamic loads are calculated as pressure profiles over the pool wetted surface and distributed to each node based on nodal tributary area. The resulting nodal forces were summed to determine the net resulting hydrodynamic forces in orthogonal directions, and these force resultants were verified using additional methodology in TID-7024, which defines the integrated pressure resultants.

The effect of water upon the dynamic response of submerged structures is significant. Two major items of concern are the virtual mass, which affects the structural frequency, and the fluid structural coupling of adjacent bodies, which affects the loads. In order to include both these effects, a hydrodynamic mass matrix element is used in the mathematical model.

The hydrodynamic mass matrix is composed of 4 terms. The M_{11} term is the virtual mass of the fluid on the racks and is calculated such that the kinetic energy of the virtual mass is the same as the kinetic energy of the moving fluid. The M_{12} and M_{21} terms represent interaction between the racks and the pool walls. The M_{22} term has a similar meaning to the M_{11} but applies to the spent fuel pool. Both horizontal flow (around the racks) and vertical flow (over the racks) are considered in the calculation. The proximity of the pool walls to the racks is also considered. The calculation is based on potential flow theory, reference "The Effects of Liquids on the Dynamic Motions of Immersed Solids," R. J. Fritz, Journal of Engineering for Industry, February 1972.

QUESTIONS RELATING TO THE NUCLEAR PHYSICS AREA

Question 1:

Provide the calculated value of K_{eff} for Region 1 as well as the maximum enrichment assumed and the values of all biases and 95/95 uncertainties.

Response:

The maximum enrichment assumed in the analysis is 4.10 w/o U-235. The K_{eff} for the Region 1 rack is determined in the following manner:

$$K_{eff} = K_{nominal} + B_{method} + B_{part} + \left[(ks_{nominal})^2 + (ks_{method})^2 + (ks_{mech})^2\right]^{\frac{1}{2}}$$

where:

$K_{nominal}$ = nominal case KENO K_{eff}

B_{method} = method bias determined from benchmarch critical comparisons

B_{part} = bias to account for poison particle self-shielding

$ks_{nominal}$ = 95/95 uncertainty in the nominal case KENO K_{eff}

ks_{method} = 95/95 uncertainty in the method bias

ks_{mech} = 95/95 uncertainty due to construction and material tolerances.

Substituting calculated values in the order listed above, the result is:

$$K_{eff} = 0.9169 + 0.0025 + [(.00388)^2 + (.013)^2 + (.0171)^2]^{\frac{1}{2}}$$
$$= 0.9412 \text{ - For Unit 1 B \& W 15 x 15 Fuel}$$

$$K_{eff} = 0.9260 + 0.0025 + [(0.00388)^2 + (.013)^2 + (.00904)^2]^{\frac{1}{2}}$$
$$= 0.9448 \text{ - For Unit 2 CE 16 x 16 Fuel}$$

Question 2:

Provide the calculated values of K_{eff} for Region 2 for the checkerboard storage configuration with 4.1 w/o enrichment assemblies and for any other configuration used to determine the final K_{eff} as well as the values of all biases and 95/95 uncertainties.

Response:

The K_{eff} for Region 2 with the checkerboard configuration and 4.1 w/o U-235 is determined in the following manner:

$$K_{eff} = K_{nominal} + B_{method} + \left[(ks)^2_{nominal} + (ks)^2_{method} + (ks)^2_{mech} + (ks)^2_{asym}\right]^{1/2}$$

where:

$K_{nominal}$ = nominal case KENO K_{eff}

B_{method} = method bias determined from benchmark critical comparisons

$ks_{nominal}$ = 95/95 uncertainty in the nominal case KENO K_{eff}

ks_{method} = 95/95 uncertainty in the method bias

ks_{mech} = 95/95 uncertainty to account for tolerances in thickness

ks_{asym} = 95/95 uncertainty to account for asymmetric assembly position

Substituting calculated values in the order listed above, the result is:

$$K_{eff} = 0.9068 + 0.0 + \left[(.0059)^2 + (.013)^2 + (.0288)^2 + (.009)^2\right]^{1/2}$$

$= 0.9402$ - For Unit 1 B & W 15 x 15 Fuel

$$K_{eff} = 0.8860 + 0.0 + \left[(.0064)^2 + (.013)^2 + (.0212)^2 + (.0173)^2\right]^{1/2}$$

$= 0.9169$ - For Unit 2 CE 16 x 16 Fuel

The second configuration used to determine the final K_{eff} consists of spent fuel assemblies in every cell of the rack. The final K_{eff} for spent fuel in Region 2 is constructed according to the following formula:

$$K_{eff} = K_{nom} + B_{method} + \left[(ks_{meth})^2 + (ks_{nom})^2 + (ks_{mech})^2 + (ks_{asym})^2 + (ks_{pu})^2 + (ks_{bu})^2\right]^{\frac{1}{2}}$$

where:

- K_{nom} = the nominal case KENO eigenvalue
- B_{meth} = the bias in the method
- ks_{meth} = the method uncertainty (95/95)
- ks_{nom} = the uncertainty (95/95) on the nominal eigenvalue
- ks_{mech} = the uncertainty (95/95) due to construction and material tolerance
- ks_{asym} = the uncertainty (95/95) due to asymmetric assembly positioning within the cell
- ks_{pu} = the uncertainty on the plutonium reactivity
- ks_{bu} = the uncertainty on the reactivity as a function of irradiation.

Substituting calculated values in the equation of Attachment 1 for spent fuel in the rack results in:

$$K_{eff} = 0.8892 + 0.0 + [(.013)^2 + (.00332)^2 + (.01212)^2 + (.01137)^2 + (.009)^2 + (.009)^2]^{\frac{1}{2}}$$

$= 0.914$ - For Unit 1 B & W 15 x 15 Fuel

$$K_{eff} = 0.9068 + 0.00 + [(.013)^2 + (.00391)^2 + (.01341)^2 + (.00948)^2 + (.009)^2 + (.009)^2]^{\frac{1}{2}}$$

$= 0.9316$ - For Unit 2 CE 16 x 16 Fuel

As can be seen from comparing the K_{eff} formulas in the licensing submittal with those used in the response to questions 1 and 2, the term used to account for construction and material tolerances is included as an uncertainty term in lieu of a direct bias. The same is true for the term used for the potential placement of the assemblies asymmetrically in the can. Both of these phenomenon occur randomly and are not biased in any one direction.

Please amend the original submittal to reflect these changes in both Region 1 and Region 2 K_{eff} formulas and definition of terms. Attached are pages 29, 30, 36, 37 and 38 which have been corrected to reflect these changes.

between the four cans is reduced. The reactivity increase of this configuration is found and is included as an uncertainty term in calculating the K_{eff} of the rack.

Some mechanical tolerances are not included in the analysis because worst case assumptions are used in the nominal case analysis. An example of this is eccentric assembly position. Calculations were performed which show that the most reactive condition is the assembly centered in the can which is assumed in the nominal case. Another example is the reduced width of the poison plates. No bias is included here since the nominal KENO case models the reduced width explicitly.

The final result of the uncertainty analysis is that the criticality design criteria are met when the calculated effective multiplication factor, plus the total uncertainty (TU) and any biases, is less than 0.95.

These methods conform with ANSI N18.2-1973, "Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants," Section 5.7, Fuel Handling System; ANSI N210-1976, "Design Objectives for LWR Spent Fuel Storage Facilities at Nuclear Power Stations," Section 5.1.12; ANSI N16.9-1975, "Validation of Calculational Methods for Nuclear Criticality Safety;" NRC Standard Review Plan, Section 9.1.2, "Spent Fuel Storage;" and the NRC Guidance, "NRC Position for Review and Acceptance of Spent Fuel Storage and Handling Applications."

4.25 Rack Modification

For normal operation and using the method described in the above sections, the K_{eff} for the rack is determined in the following manner:

$$K_{eff} = K_{nominal} + B_{method} + B_{part} + \left[(ks_{nominal})^2 + (ks_{method})^2 + (ks_{mech})^2\right]^{\frac{1}{2}}$$

where:

$K_{nominal}$ = nominal case KENO K_{eff}

B_{method} = method bias determined from benchmark critical comparisons

B_{part} = bias to account for poison particle self-shielding.

$ks_{nominal}$ = 95/95 uncertainty in the nominal case KENO K_{eff}.

ks_{method} = 95/95 uncertainty in the method bias.

ks_{mech} = 95/95 uncertainty due to construction and material tolerances.

The presence of the approximately 1600 ppm boron in the pool water will decrease reactivity by approximately 30% ΔK. Thus, $K_{eff} \leq$ 0.95 can be easily met for postulated accidents, since any reactivity increase will be much less than the negative worth of the dissolved boron.

For fuel storage applications, water is usually present. However, accidental criticality when fuel assemblies are stored in the dry condition is also accounted for. For this case, possible sources of moderation, such as those that could arise during fire fighting operations, are included in the analysis.

This "optimum moderation" accident is not a problem in fuel storage racks because possible water densities are too low (^{1} 0.01 gm/cm^3) to yield K_{eff} values higher than for full density water and the rack design prevents the preferential reduction of water density between the cells of a rack (e.g., boiling between cells).

4.3.5 Manufacturing Biases

The construction tolerances for the spacer pocket racks allow for the nominal center-to-center spacing to be randomly reduced for individual cells. This change will result in an increase in K_{eff}

which will be treated as an uncertainty. The effect of the tolerances on pocket height and material thicknesses also result in an increase in K_{eff} which will be treated as an uncertainty.

Another center-to-center spacing reduction can be caused by the asymmetric assembly position within the storage cell. The inside dimensions of a nominal storage cell are such that if a fuel assembly is loaded into the corner of the cell, the assembly centerline will be displaced from the cell centerline. This means that adjacent asymmetric fuel assemblies would have their center-to-center distance reduced from the nominal. Analysis shows this reduction may increase reactivity. This will be treated as an uncertainty because the asymmetric positioning of assemblies within storage cells will be random.

The final K_{eff} for Region 2 is constructed according to the following formula:

$$K_{eff} = K_{nom} + B_{meth} + [(ks_{mech})^2 + (ks_{asym})^2 + (ks_{meth})2 + (ks_{nom})^2 + (ks_{pu})^2 + (ks_{bu})^2]^{\frac{1}{2}}$$

where:

K_{nom} is the eigenvalue from KENO for the nominal storage configuration,

B_{meth} is the bias in the method,

ks_{meth} is the method uncertainty (95/95),

ks_{nom} is the uncertainty (95/95) on the nominal eigenvalue,

ks_{mech} is the uncertainty (95/95) due to construction and material tolerance.

ks_{asym} is the uncertainty (95/95) due to asymmetric assembly positioning within the cell.

ks_{pu} is the uncertainty on the plutonium reactivity, and

ks_{bu} is the uncertainty on reactivity as a function of irradiation.

While it may be argued that ks_{bu} and ks_{pu} are not independent and should not be combined statistically, it should be considered that the reactivity of fuel as a function of burnup depends implicitly on the production rate of plutonium. The two uncertainties are so closely related that accounting for them twice is a conservative form of double accounting.

QUESTIONS RELATED TO RADWASTE AREA

Question 1:

What is the average annual volume of solid radwastes shipped off-site from Units No. 1 and 2?

Response:

Arkansas Nuclear One's average annual volume of solid radwastes shipped off-site from 1978 to 1982 is 24,199 cubic feet. However, we believe that a realistic average annual volume of solid radwaste shipments for future years will range between 30,000 - 35,000 cubic ft.

Question 2:

What is the approximate volume of old fuel assembly racks to be disposed with and without volume reduction?

Response:

The estimated volume of old fuel assembly racks to be disposed of without any volume reduction is 18,700 cubic ft. It is estimated that this can be reduced to approximately 950 cubic feet (95% volume reduction) through dismantling and decontamination by electropolishing.

Question 3:

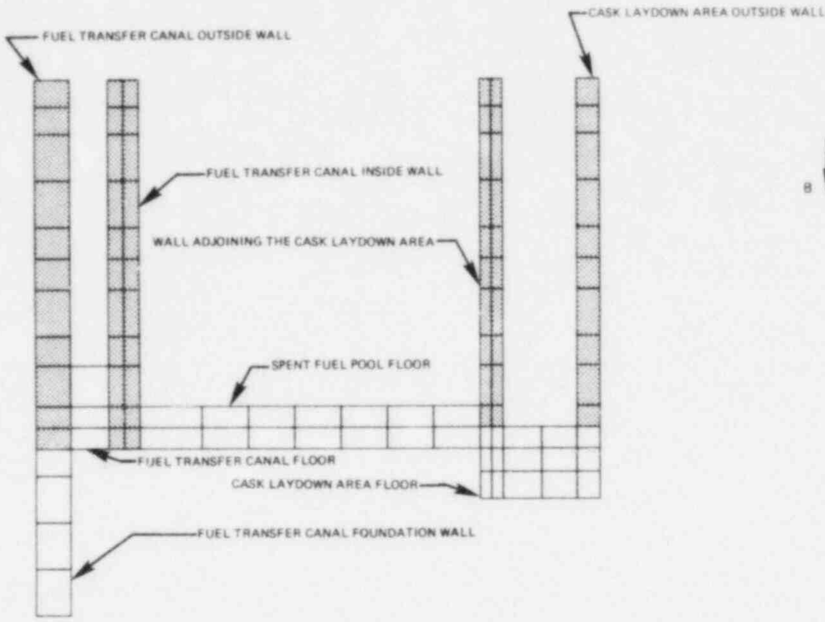
What is the average design burnup in MWD/MTU for Unit No. 2?

Response:

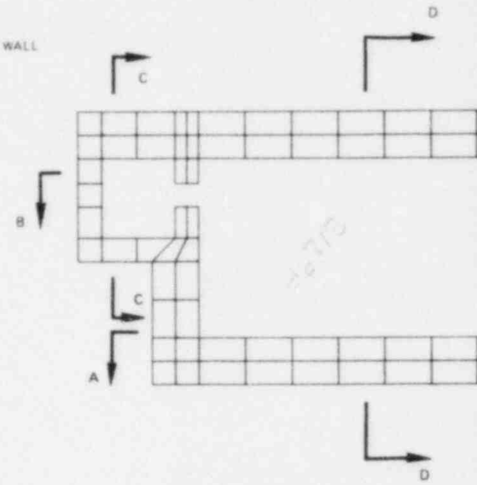
Currently Unit No. 2's average design Batch burnup is expected to be approximately 34,000 MWD/MTU. However, this value may be increased when fuel test programs have demonstrated that it is safe to do so.

ARKANSAS NUCLEA

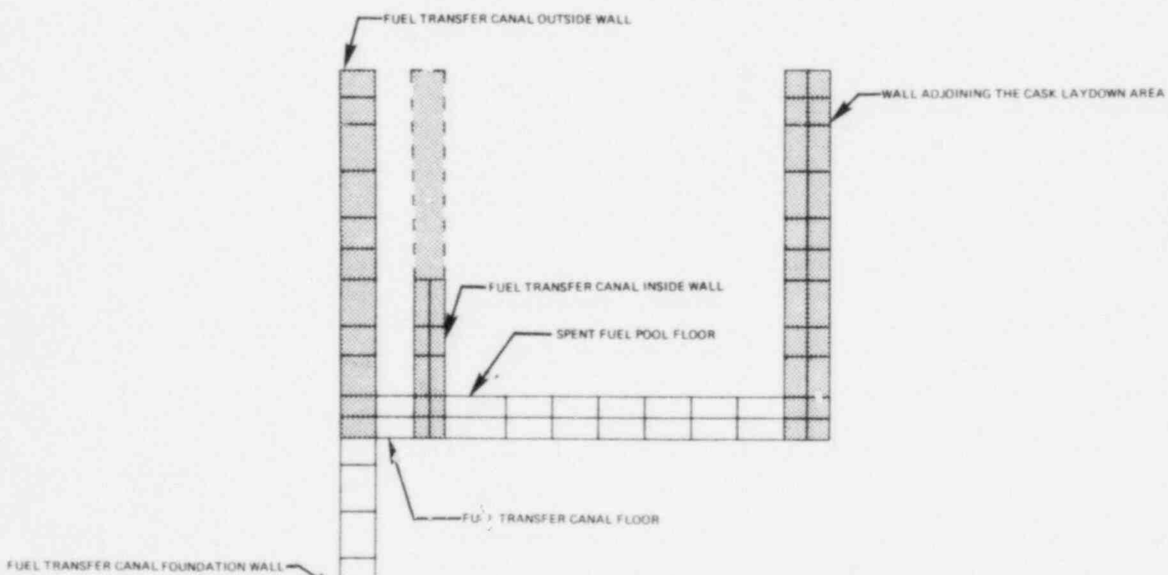
SPENT FUEL STORAGE FACIL



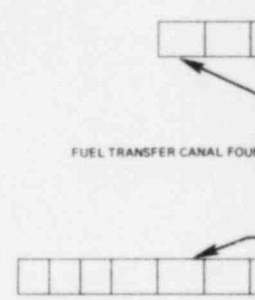
SECTION B-B



PLAN AT ELEVATION 40



SECTION A-A



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ENCLOSURE

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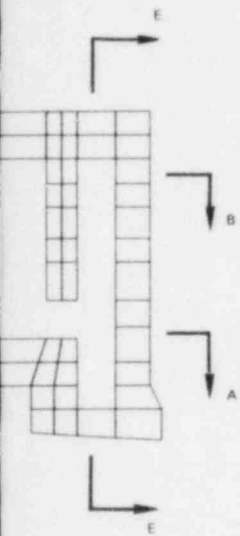

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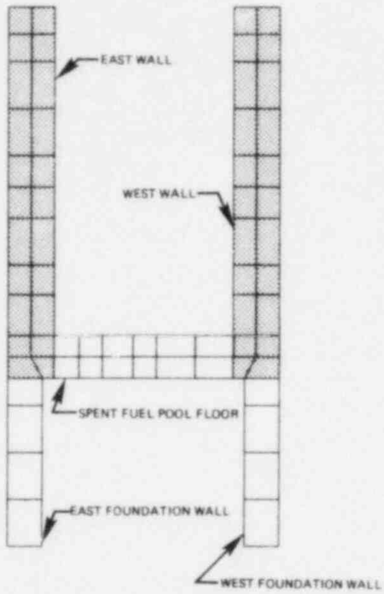
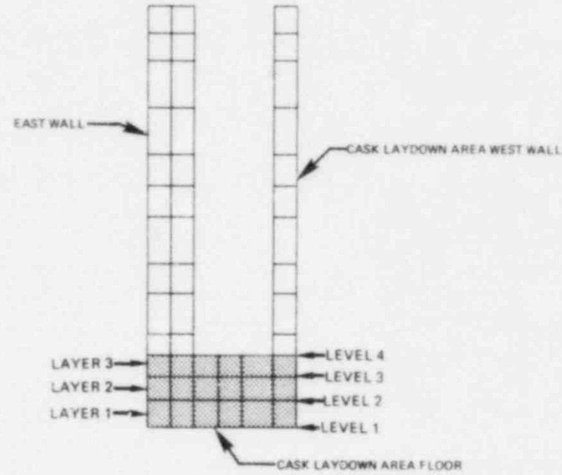
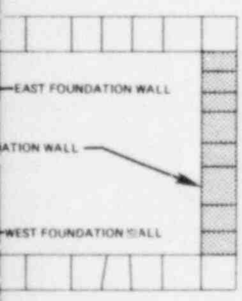
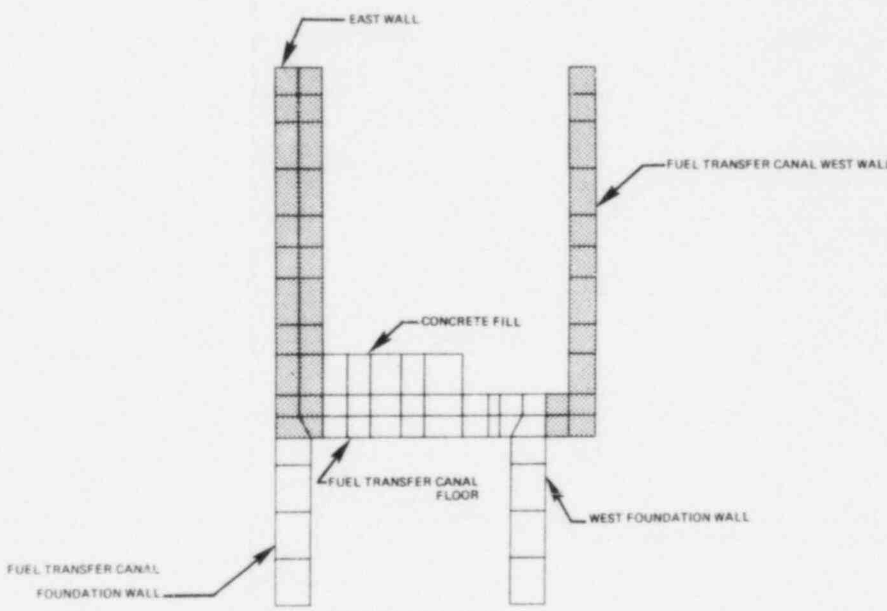


SECTION D-D



SECTION C-C





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SECTION E-E

RE 1

SECTIONS

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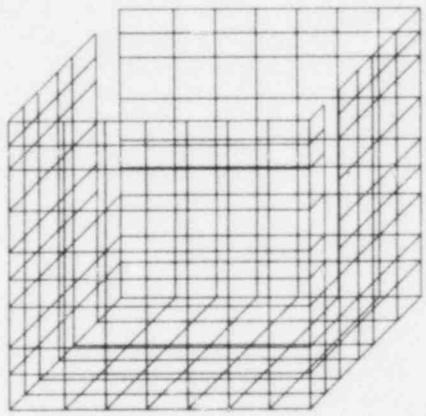
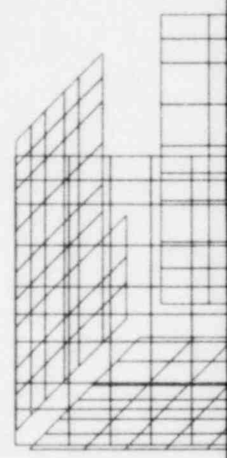
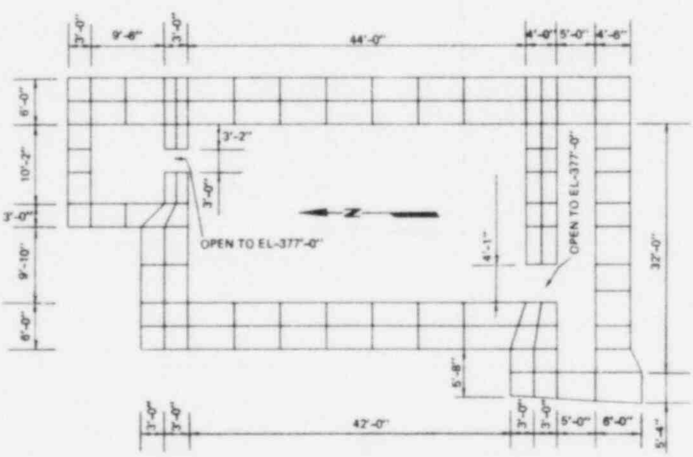
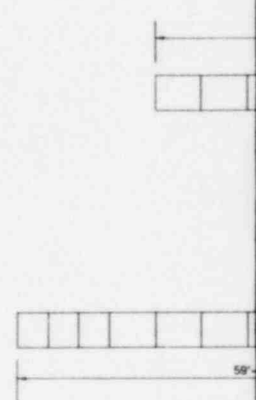


INSIDE MEMBRANES



MIDDLE





PLAN AT ELEV

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ENCLOSURE

PLAN AT ELEVATION 404'-0"

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ILITY FINITE ELEMENT MODEL

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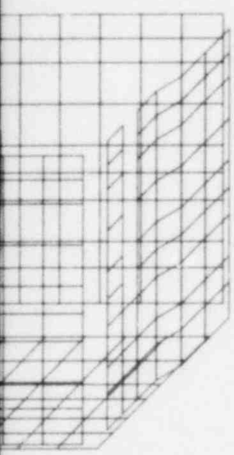
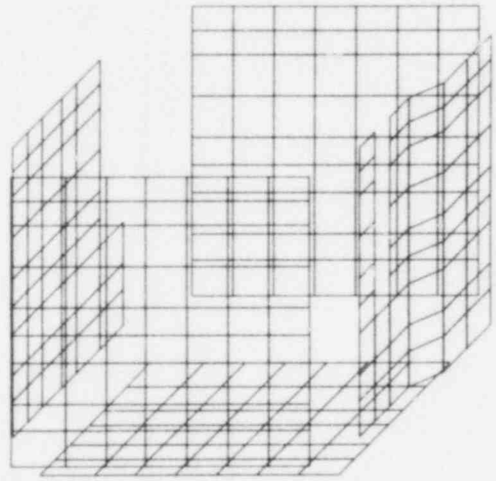
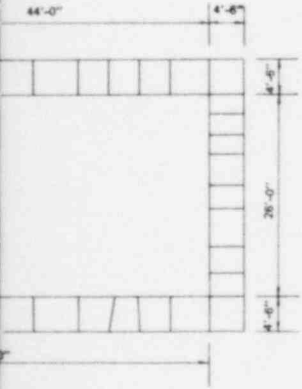


MEMBRANES



OUTSIDE MEMBRANES



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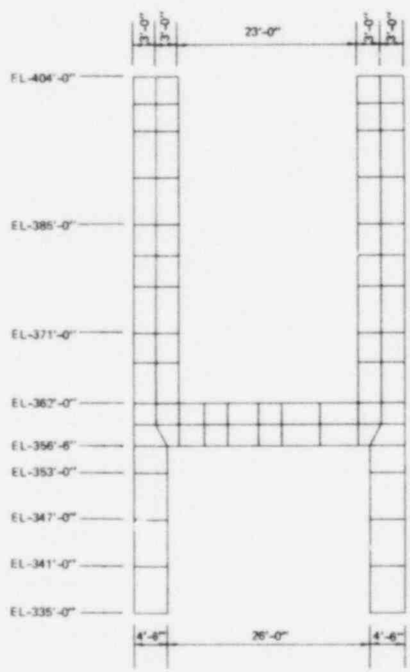

SECTION D-D

FIGURE 2

AMS AND DIMENSIONS

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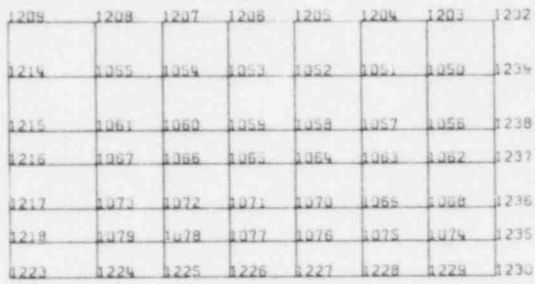
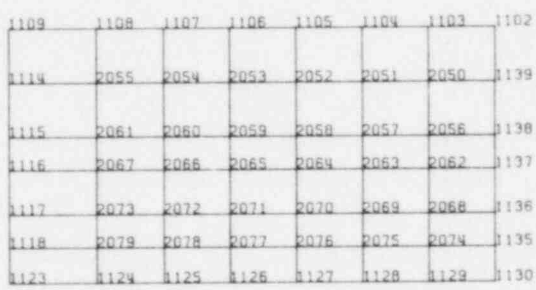
SPENT FUEL STORAGE FACIL

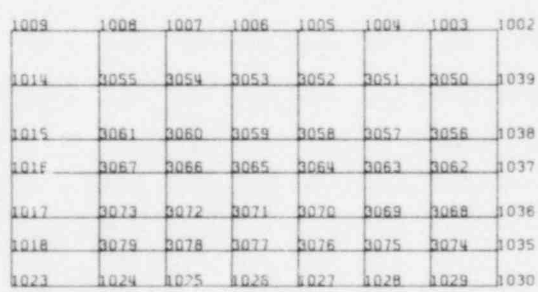
NODE NUMBERS



INSIDE SURFACE



MIDDLE SURFACE



OUTSIDE SURFACE

CUBE EL

206	205	204
213	212	211
220	219	218
227	226	225
234	233	232
241	240	239

INSIDE

406	405	404
413	412	411
420	419	418
427	426	425
434	433	432
441	440	439

OUTSID

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ENCLOSURE

FIGU

FLOOR ELEMENT A

AR ONE-UNIT ONE

TY FINITE ELEMENT MODEL

EMENTS

03	202	201	200
10	209	208	207
17	216	215	214
24	223	222	221
31	230	229	228
38	237	236	235

LAYER

03	402	401	400
10	409	408	407
17	416	415	414
24	423	422	421
31	430	429	428
38	437	436	435

E LAYER

SURFACE MEMBRANE ELEMENTS

106	105	104	103	102	101	100
113	112	111	110	109	108	107
120	119	118	117	116	115	114
127	126	125	124	123	122	121
134	133	132	131	130	129	128
141	140	139	138	137	136	135

INSIDE SURFACE

306	305	304	303	302	301	300
313	312	311	310	309	308	307
320	319	318	317	316	315	314
327	326	325	324	323	322	321
334	333	332	331	330	329	328
341	340	339	338	337	336	335

MIDDLE SURFACE

506	505	504	503	502	501	500
513	512	511	510	509	508	507
520	519	518	517	516	515	514
527	526	525	524	523	522	521
534	533	532	531	530	529	528
541	540	539	538	537	536	535

OUTSIDE SURFACE

RE 3

ND NODE NUMBERS

Structural Dynamics Technology, Inc.

ARKANSAS NUCLE

SPENT FUEL STORAGE FACI

CUBE E

827	829	6433	6230	6229	6228	6227	6226	6225	6224	6223	6222	6419	9013
815	817	5933	5730	5729	5728	5727	5726	5725	5724	5723	5722	5919	8913
803	805	5433	5230	5229	5228	5227	5226	5225	5224	5223	5222	5419	8813
791	793	4933	4730	4729	4728	4727	4726	4725	4724	4723	4722	4919	8713
779	781	4433	4230	4229	4228	4227	4226	4225	4224	4223	4222	4419	8613
767	769	3933	3730	3729	3728	3727	3726	3725	3724	3723	3722	3919	8513
755	757	3433	3230	3229	3228	3227	3226	3225	3224	3223	3222	3419	8413
743	745	2933	2730	2729	2728	2727	2726	2725	2724	2723	2722	2919	8313
731	733	2433	2230	2229	2228	2227	2226	2225	2224	2223	2222	2419	8213
719	721	1933	1730	1729	1728	1727	1726	1725	1724	1723	1722	1919	8113
		1433	1230	1229	1228	1227	1226	1225	1224	1223	1222	1419	8013

INSIDE LAYER

SURFACE MEMB

6129	6128	6127	6126	6125	6124	6123
5629	5628	5627	5626	5625	5624	5623
5129	5128	5127	5126	5125	5124	5123
4629	4628	4627	4626	4625	4624	4623
4129	4128	4127	4126	4125	4124	4123
3629	3628	3627	3626	3625	3624	3623
3129	3128	3127	3126	3125	3124	3123
2629	2628	2627	2626	2625	2624	2623
2129	2128	2127	2126	2125	2124	2123

INSIDE SURFACE

6329	6328	6327
5829	5828	5827
5329	5328	5327
4829	4828	4827
4329	4328	4327
3829	3828	3827
3329	3328	3327
2829	2828	2827
2329	2328	2327

MIDD

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FIGU

EAST WALL EL

AR ONE-UNIT ONE

LITY FINITE ELEMENT MODEL

LEMENTS

828	830	6432	6430	6429	6428	6427	6426	6425	6424	6423	6422	6420	9065
816	818	5932	5930	5929	5928	5927	5926	5925	5924	5923	5922	5920	8965
804	806	5432	5430	5429	5428	5427	5426	5425	5424	5423	5422	5420	8865
792	794	4932	4930	4929	4928	4927	4926	4925	4924	4923	4922	4920	8765
780	782	4432	4430	4429	4428	4427	4426	4425	4424	4423	4422	4420	8665
768	770	3932	3930	3929	3928	3927	3926	3925	3924	3923	3922	3920	8565
756	758	3432	3430	3429	3428	3427	3426	3425	3424	3423	3422	3420	8465
744	746	2932	2930	2929	2928	2927	2926	2925	2924	2923	2922	2920	8365
732	734	2432	2430	2429	2428	2427	2426	2425	2424	2423	2422	2420	8265
720	722	1932	1930	1929	1928	1927	1926	1925	1924	1923	1922	1920	8165
		1432	1430	1429	1428	1427	1426	1425	1424	1423	1422	1420	8065

OUTSIDE LAYER

RANE ELEMENTS

326	6325	6324	6323
826	5825	5824	5823
326	5325	5324	5323
826	4825	4824	4823
326	4325	4324	4323
826	3825	3824	3823
326	3325	3324	3323
826	2825	2824	2823
326	2325	2324	2323

LE SURFACE

6529	6528	6527	6526	6525	6524	6523
6029	6028	6027	6026	6025	6024	6023
5529	5528	5527	5526	5525	5524	5523
5029	5028	5027	5026	5025	5024	5023
4529	4528	4527	4526	4525	4524	4523
4029	4028	4027	4026	4025	4024	4023
3529	3528	3527	3526	3525	3524	3523
3029	3028	3027	3026	3025	3024	3023
2529	2528	2527	2526	2525	2524	2523

OUTSIDE SURFACE

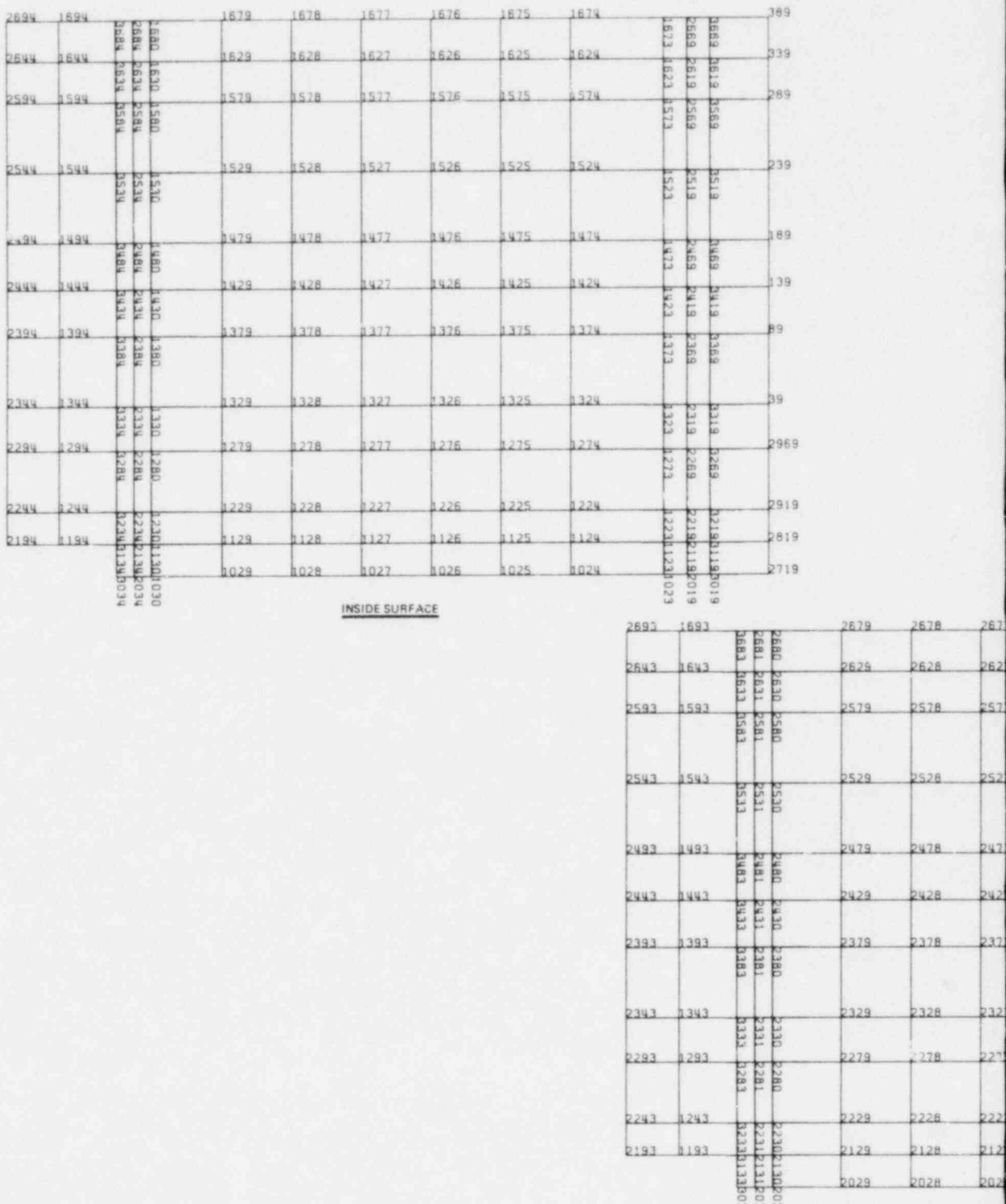
RE 4

EMENT NUMBERS

Structural Dynamics Technology, Inc.

ARKANSAS NUCLE

SPENT FUEL STORAGE FACI



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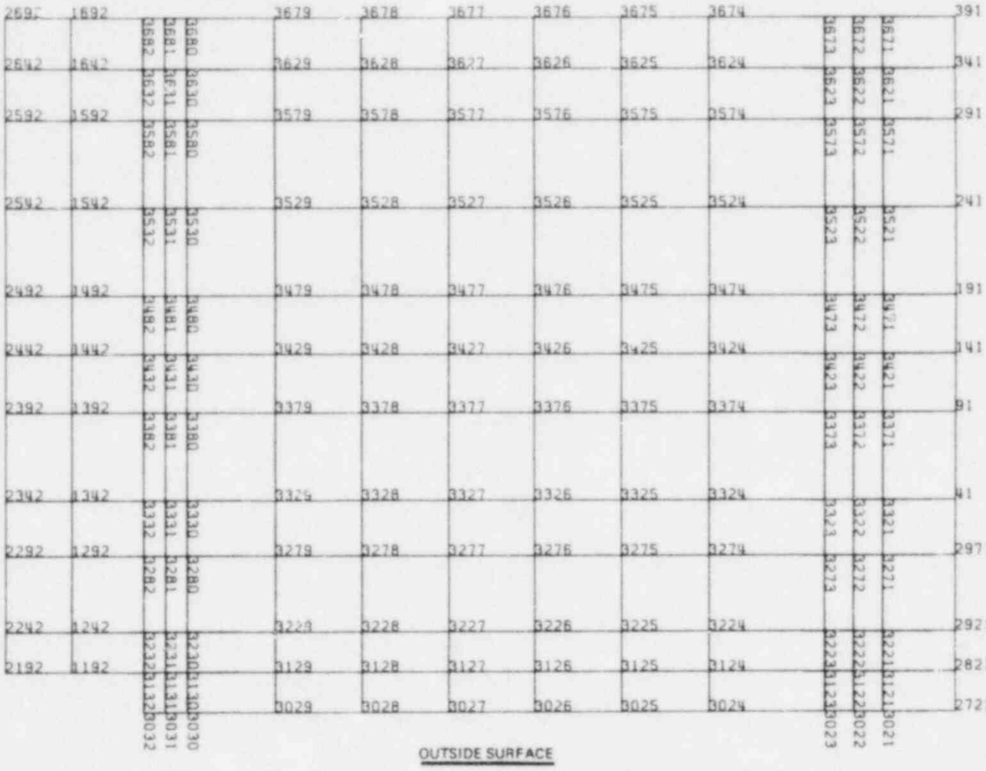
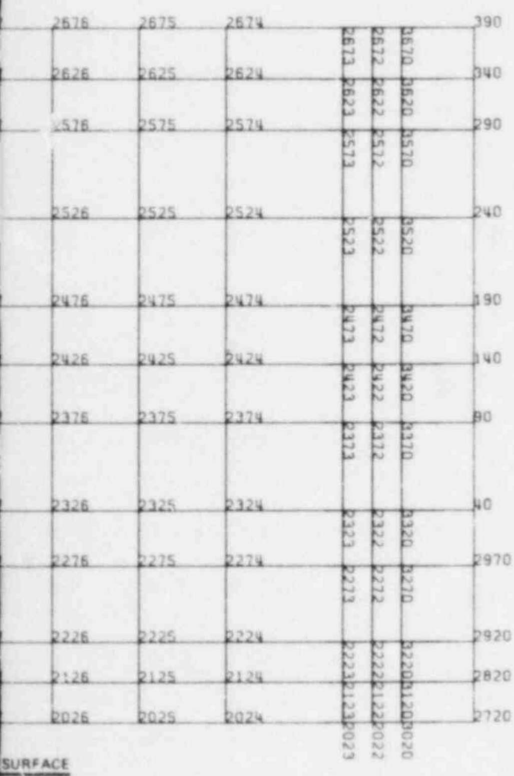
FIGU

EAST WALL N

AR ONE-UNIT ONE

LITY FINITE ELEMENT MODEL





URE 5

ODE NUMBERS

Structural Dynamics Technology, Inc.

ARKANSAS NUCLE

SPENT FUEL STORAGE FACIL

CUBE E

6209	6208	6207	6206	6205	6204	6203	6202	6201
5709	5708	5707	5706	5705	5704	5703	5702	5701
5209	5208	5207	5206	5205	5204	5203	5202	5201
4709	4708	4707	4706	4705	4704	4703	4702	4701
4209	4208	4207	4206	4205	4204	4203	4202	4201
3709	3708	3707	3706	3705	3704	3703	3702	3701
3209	3208	3207	3206	3205	3204	3203	3202	3201
2709	2708	2707	2706	2705	2704	2703	2702	2701
2209	2208	2207	2206	2205	2204	2203	2202	2201
1709	1708	1707	1706	1705	1704	1703	1702	1701
1209	1208	1207	1206	1205	1204	1203	1202	1201

INSIDE LAYER

SURFACE MEMB

6108	6107	6106	6105	6104	6103	6102
5608	5607	5606	5605	5604	5603	5602
5108	5107	5106	5105	5104	5103	5102
4608	4607	4606	4605	4604	4603	4602
4108	4107	4106	4105	4104	4103	4102
3608	3607	3606	3605	3604	3603	3602
3108	3107	3106	3105	3104	3103	3102
2608	2607	2606	2605	2604	2603	2602
2108	2107	2106	2105	2104	2103	2102

INSIDE SURFACE

6308	6307	6306
5808	5807	5806
5308	5307	5306
4808	4807	4806
4308	4307	4306
3808	3807	3806
3308	3307	3306
2808	2807	2806
2308	2307	2306

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FIGU

WEST WALL ELE

AR ONE-UNIT ONE

ITY FINITE ELEMENT MODEL

LEMENTS

6410	6409	6408	6407	6406	6405	6404	6403	6402	6401	6400
5910	5909	5908	5907	5906	5905	5904	5903	5902	5901	5900
5410	5409	5408	5407	5406	5405	5404	5403	5402	5401	5400
4910	4909	4908	4907	4906	4905	4904	4903	4902	4901	4900
4410	4409	4408	4407	4406	4405	4404	4403	4402	4401	4400
3910	3909	3908	3907	3906	3905	3904	3903	3902	3901	3900
3410	3409	3408	3407	3406	3405	3404	3403	3402	3401	3400
2910	2909	2908	2907	2906	2905	2904	2903	2902	2901	2900
2410	2409	2408	2407	2406	2405	2404	2403	2402	2401	2400
1910	1909	1906	1907	1906	1905	1904	1903	1902	1901	1900
1410	1409	1408	1407	1406	1405	1404	1403	1402	1401	1400

OUTSIDE LAYER

RANE ELEMENTS

6305	6304	6303	6302
5805	5804	5803	5802
5305	5304	5303	5302
4805	4804	4803	4802
4305	4304	4303	4302
3805	3804	3803	3802
3305	3304	3303	3302
2805	2804	2803	2802
2305	2304	2303	2302

LE SURFACE

6508	6507	6506	6505	6504	6503	6502
6008	6007	6006	6005	6004	6003	6002
5508	5507	5506	5505	5504	5503	5502
5008	5007	5006	5005	5004	5003	5002
4508	4507	4506	4505	4504	4503	4502
4008	4007	4006	4005	4004	4003	4002
3508	3507	3506	3505	3504	3503	3502
3008	3007	3006	3005	3004	3003	3002
2508	2507	2506	2505	2504	2503	2502

OUTSIDE SURFACE

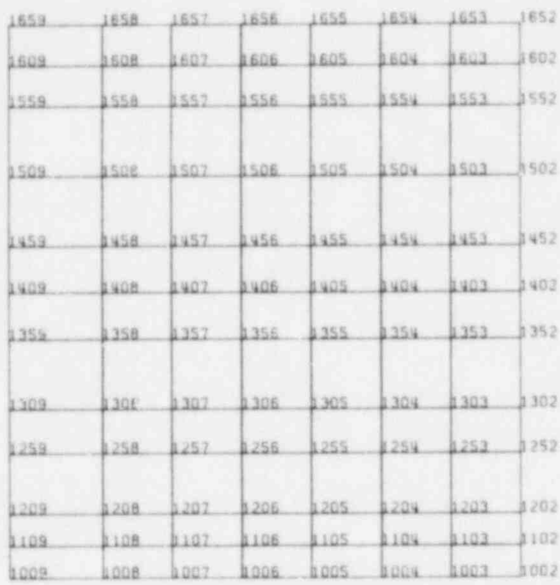
RE 6

MENT NUMBERS

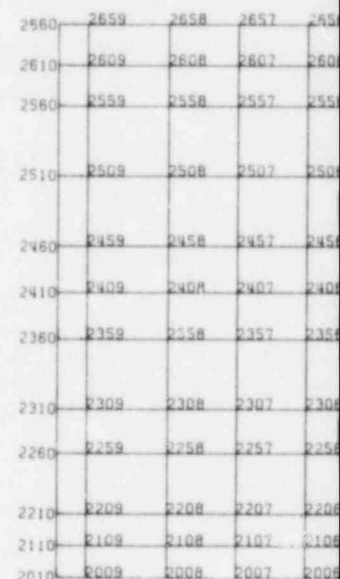
SDT Structural Dynamics Technology, Inc.

ARKANSAS NUCLE

SPENT FUEL STORAGE FACIL



INSIDE SURFACE



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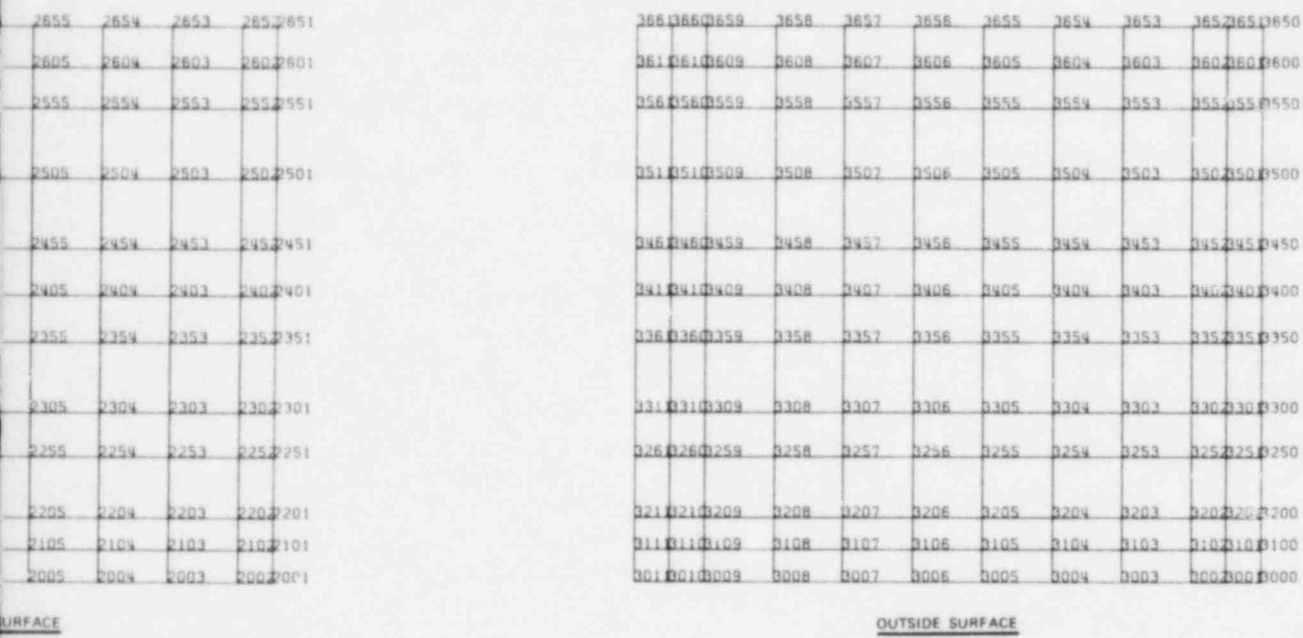
FIGU

WEST WALL N

AR ONE-UNIT ONE

ITY FINITE ELEMENT MODEL



RE 7

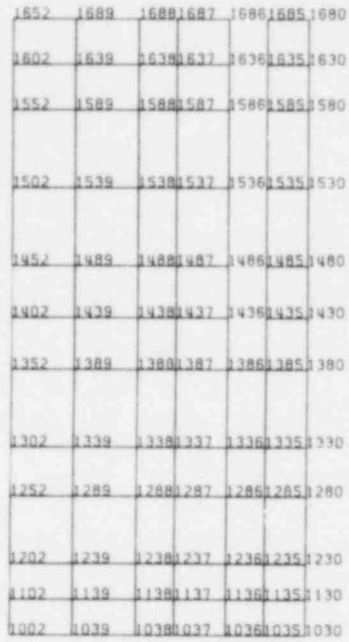
ODE NUMBERS

Structural Dynamics Technology, Inc.

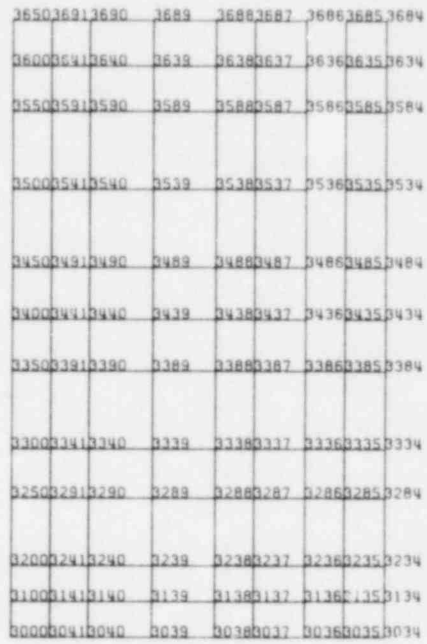
ARKANSAS NUCLEA

SPENT FUEL STORAGE FACIL

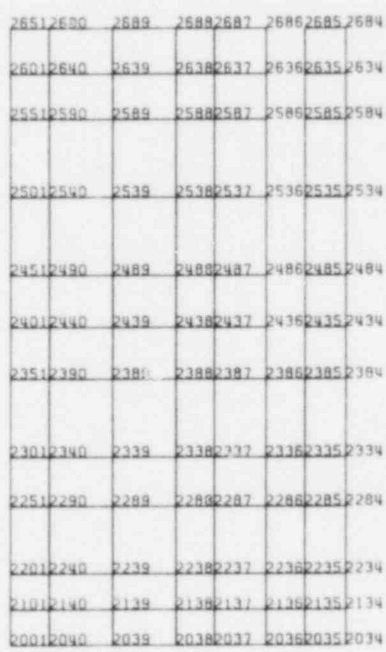
NODE NUMBERS



INSIDE SURFACE



OUTSIDE SURFACE



MIDDLE SURFACE

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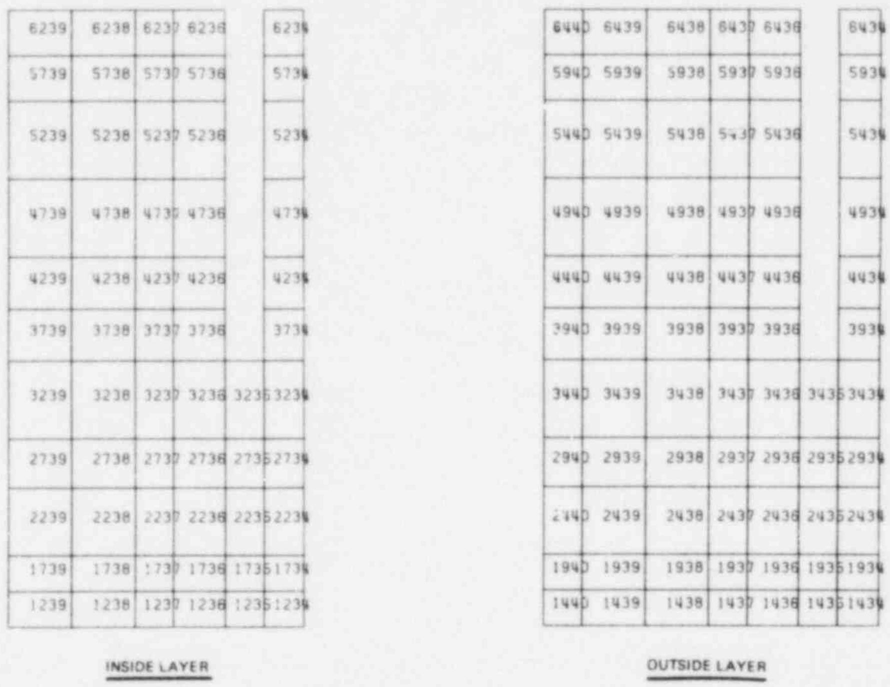
FIGU

POOL WALL ADJOINING THE CASK LAYD

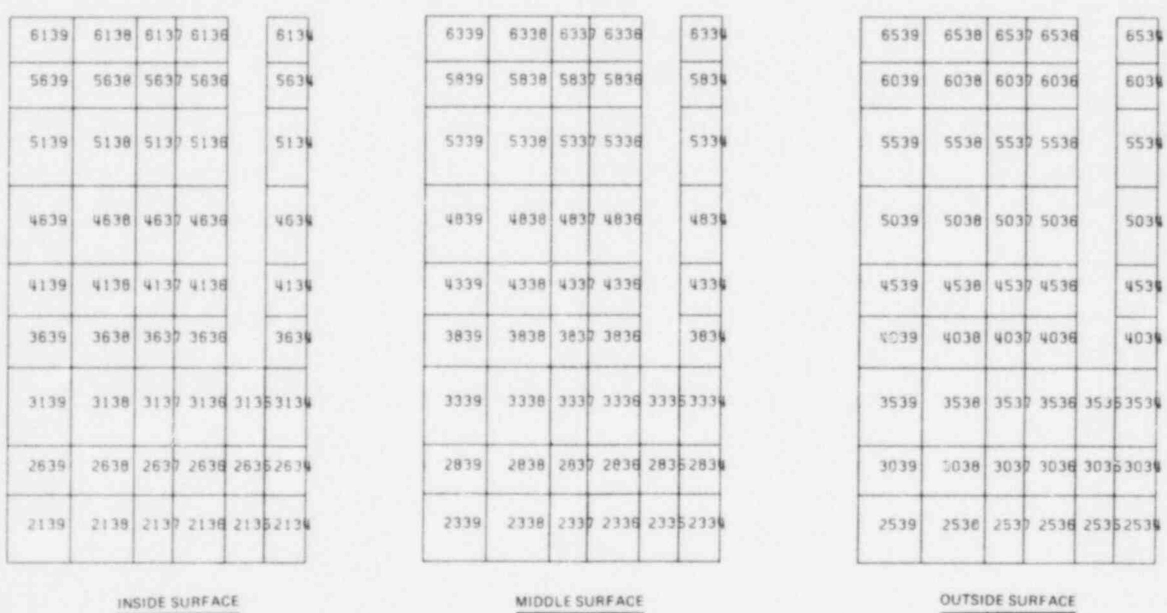
AR ONE-UNIT ONE

ITY FINITE ELEMENT MODEL

CUBE ELEMENTS



SURFACE MEMBRANE ELEMENTS



RE 8

OWN AREA ELEMENT AND NODE NUMBERS

Structural Dynamics Technology, Inc.

ARKANSAS NUCLE

SPENT FUEL STORAGE FACIL

NODE NUMBERS

INSIDE SURFACE

OUTSIDE SURFACE

MIDDLE SURFACE

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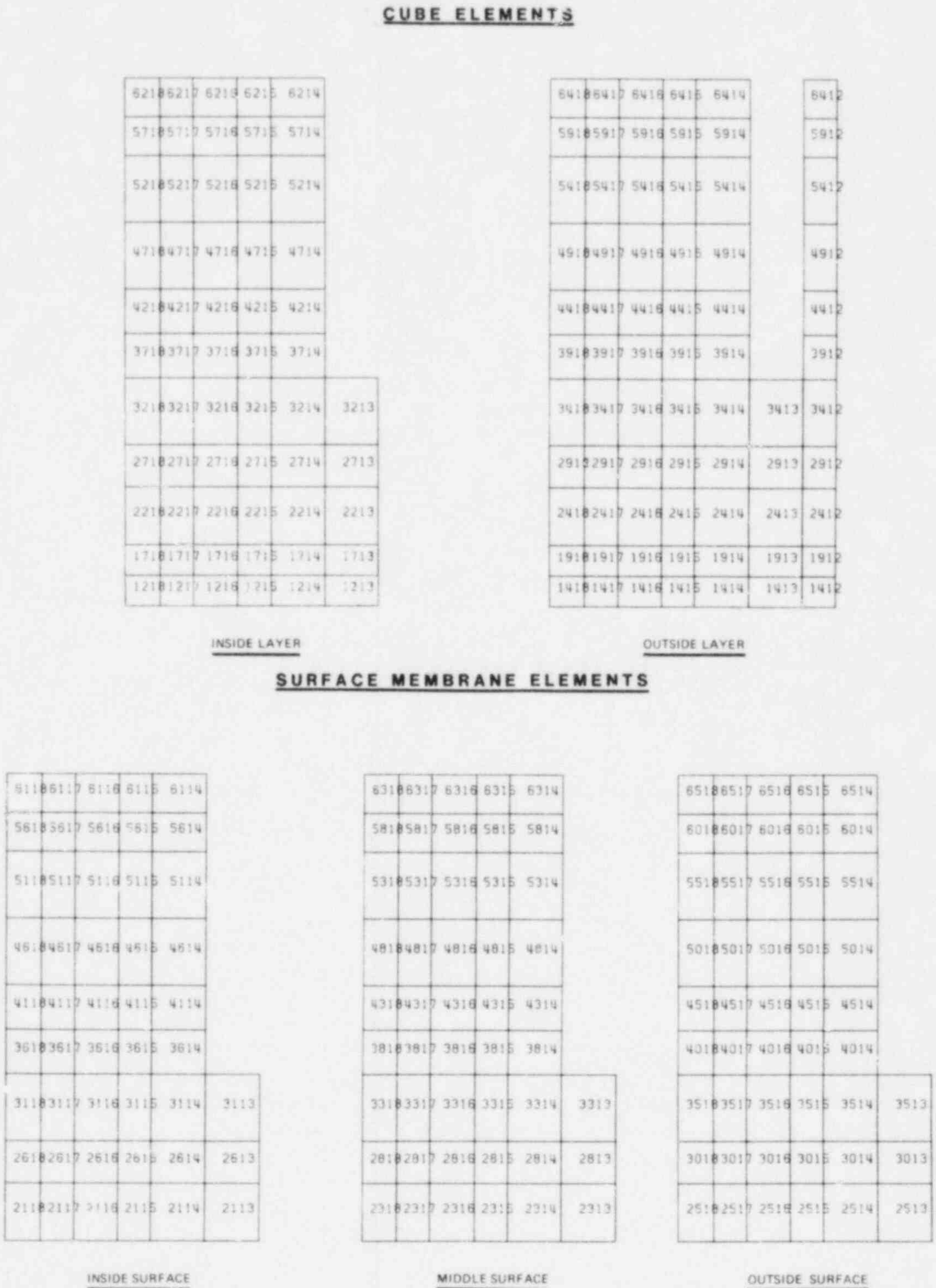
FIGU

FUEL TRANSFER CANAL INSIDE W

AR ONE-UNIT ONE

TY FINITE ELEMENT MODEL



RE 9

ALL ELEMENT AND NODE NUMBERS

Structural Dynamics Technology, Inc.

ARKANSAS NUCLE

SPENT FUEL STORAGE FACIL

WEST FOUNDATION WALL

2861	2860	2859	2858	2857	2856	2855	2854	2853	2852	2851	2850
2361	2360	2359	2358	2357	2356	2355	2354	2353	2352	2351	2350
1861	1860	1859	1858	1857	1856	1855	1854	1853	1852	1851	1850
1361	1360	1359	1358	1357	1356	1355	1354	1353	1352	1351	1350

INSIDE MEMBRANES

3061	3060	3059	3058	3057	3056	3055	3054	3053	3052	3051	3050
2561	2560	2559	2558	2557	2556	2555	2554	2553	2552	2551	2550
2061	2060	2059	2058	2057	2056	2055	2054	2053	2052	2051	2050
1561	1560	1559	1558	1557	1556	1555	1554	1553	1552	1551	1550

OUTSIDE MEMBRANES

2962	2961	2960	2959	2958	2957	2956	2955	2954	2953	2952	2951	2950
2462	2461	2460	2459	2458	2457	2456	2455	2454	2453	2452	2451	2450
1962	1961	1960	1959	1958	1957	1956	1955	1954	1953	1952	1951	1950
1462	1461	1460	1459	1458	1457	1456	1455	1454	1453	1452	1451	1450

CUBE ELEMENTS

FUEL TRANFER CANA

2871	2870	2869	2868
2371	2370	2369	2368
1871	1870	1869	1868
1371	1370	1369	1368

INSIDE

3071	3070	3069	3068
2571	2570	2569	2568
2071	2070	2069	2068
1571	1570	1569	1568

OUTSIDE M

2971	2970	2969	2968
2471	2470	2469	2468
1971	1970	1969	1968
1471	1470	1469	1468

CUBE

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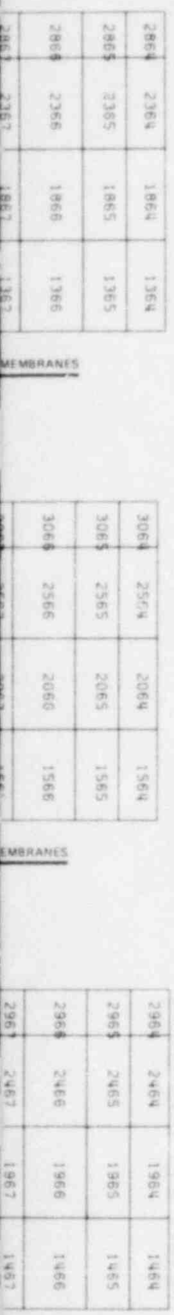
FIGUR

FOUNDATION WALLS

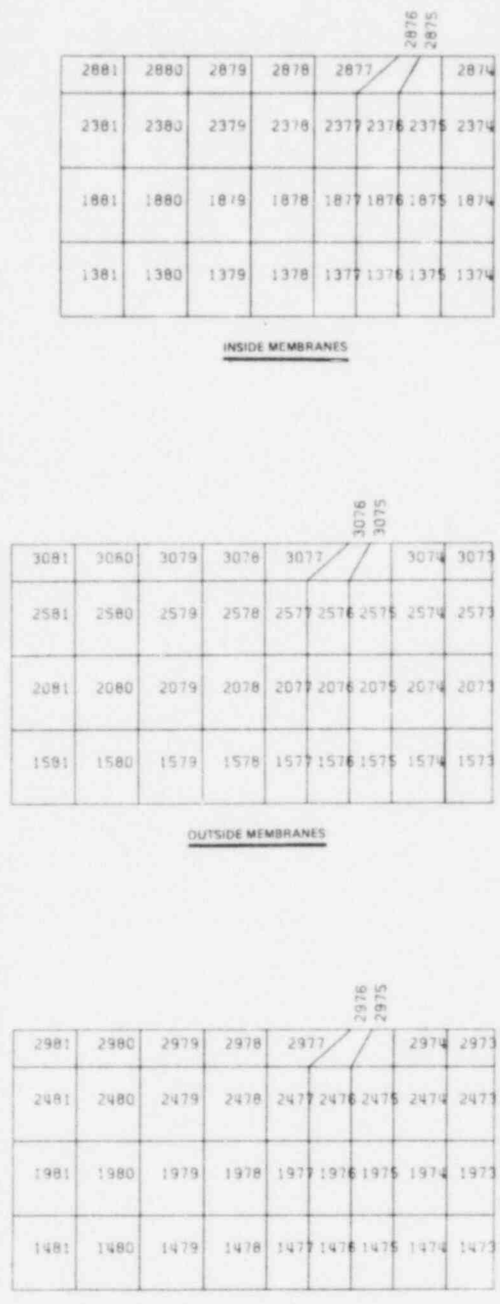
AR ONE-UNIT ONE

ITY FINITE ELEMENT MODEL

L FOUNDATION WALL



EAST FOUNDATION WALL



RE 10

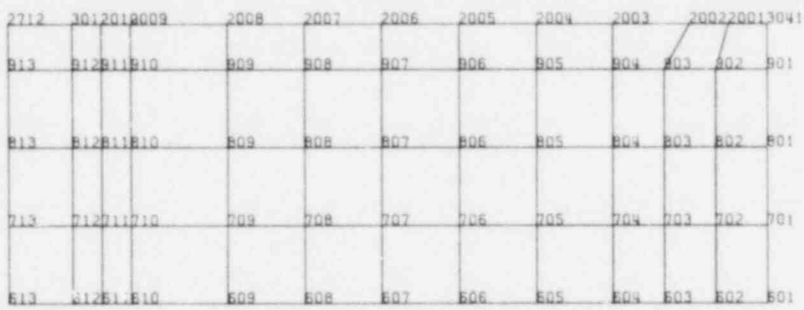
ELEMENT NUMBERS

Structural Dynamics Technology, Inc.

ARKANSAS NUCLEA

SPENT FUEL STORAGE FACIL

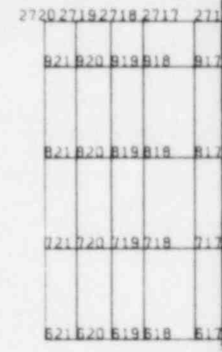
WEST FOUNDATION WALL



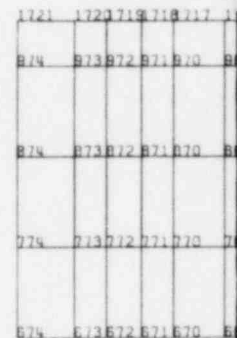
INSIDE SURFACE NODE NUMBERS

OUTSIDE SURFACE NODE NUMBERS

FUEL TRANSFER CANA



INSIDE SURFACE



OUTSIDE SURFA

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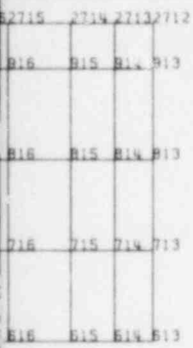
FIGUR

FOUNDATION WAL

AR ONE-UNIT ONE

ITY FINITE ELEMENT MODEL

L FOUNDATION WALL

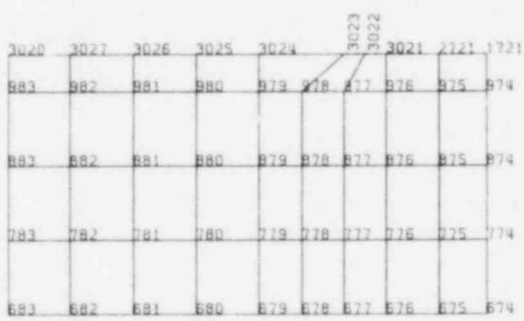


NODE NUMBERS

EAST FOUNDATION WALL

INSIDE SURFACE NODE NUMBERS

E NODE NUMBERS



OUTSIDE SURFACE NODE NUMBERS

RE 11

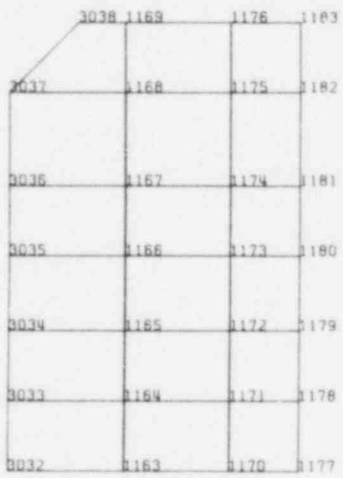
LS NODE NUMBERS

Structural Dynamics Technology, Inc.

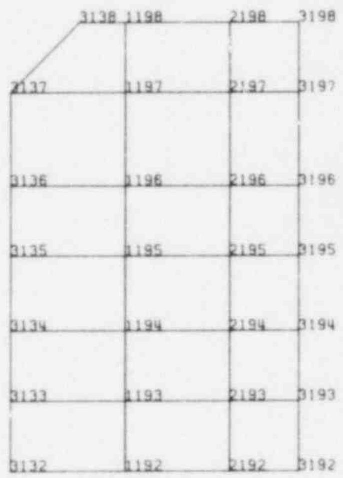
NODE NUMBERS

LEVEL 1

LEVEL 2



LEVEL 3



LEVEL 4

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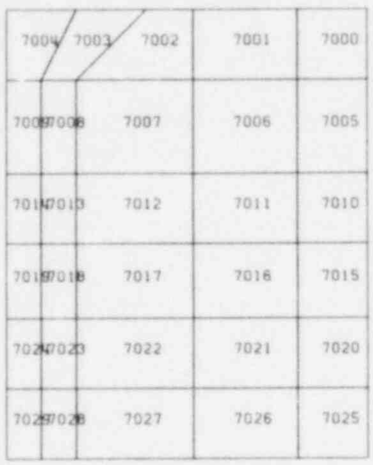
FIGUR

CASK LAYDOWN AREA FLOOR

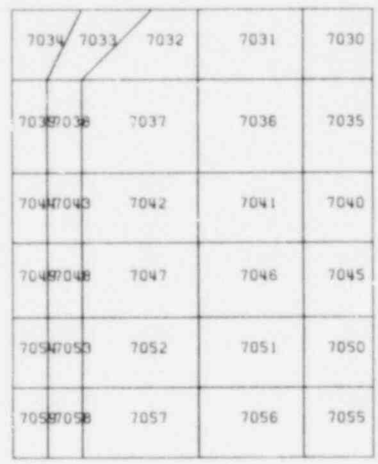
AR ONE-UNIT ONE

TY FINITE ELEMENT MODEL

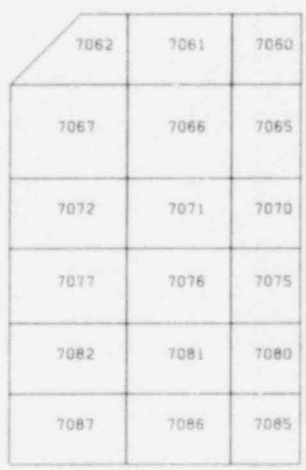
CUBE ELEMENTS



LAYER 1



LAYER 2



LAYER 3

E 12

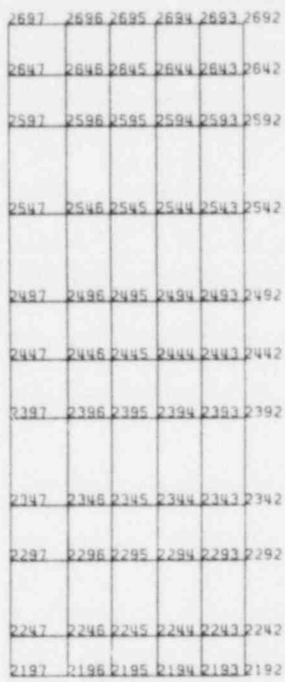
ELEMENT AND NODE NUMBERS

Structural Dynamics Technology, Inc.

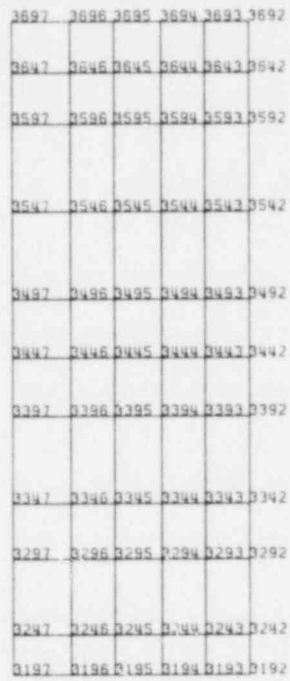
ARKANSAS NUCLEA

SPENT FUEL STORAGE FACIL

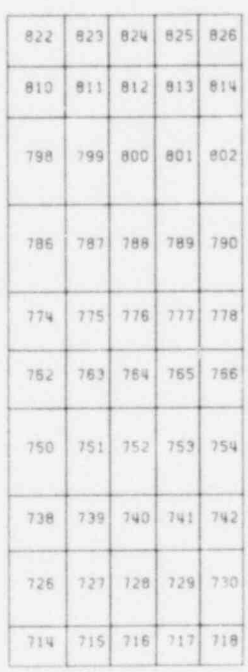
CASK LAYDOWN AREA OUTSIDE WALL



INSIDE SURFACE NODE NUMBERS



OUTSIDE SURFACE NODE NUMBERS



CUBE ELEMENTS

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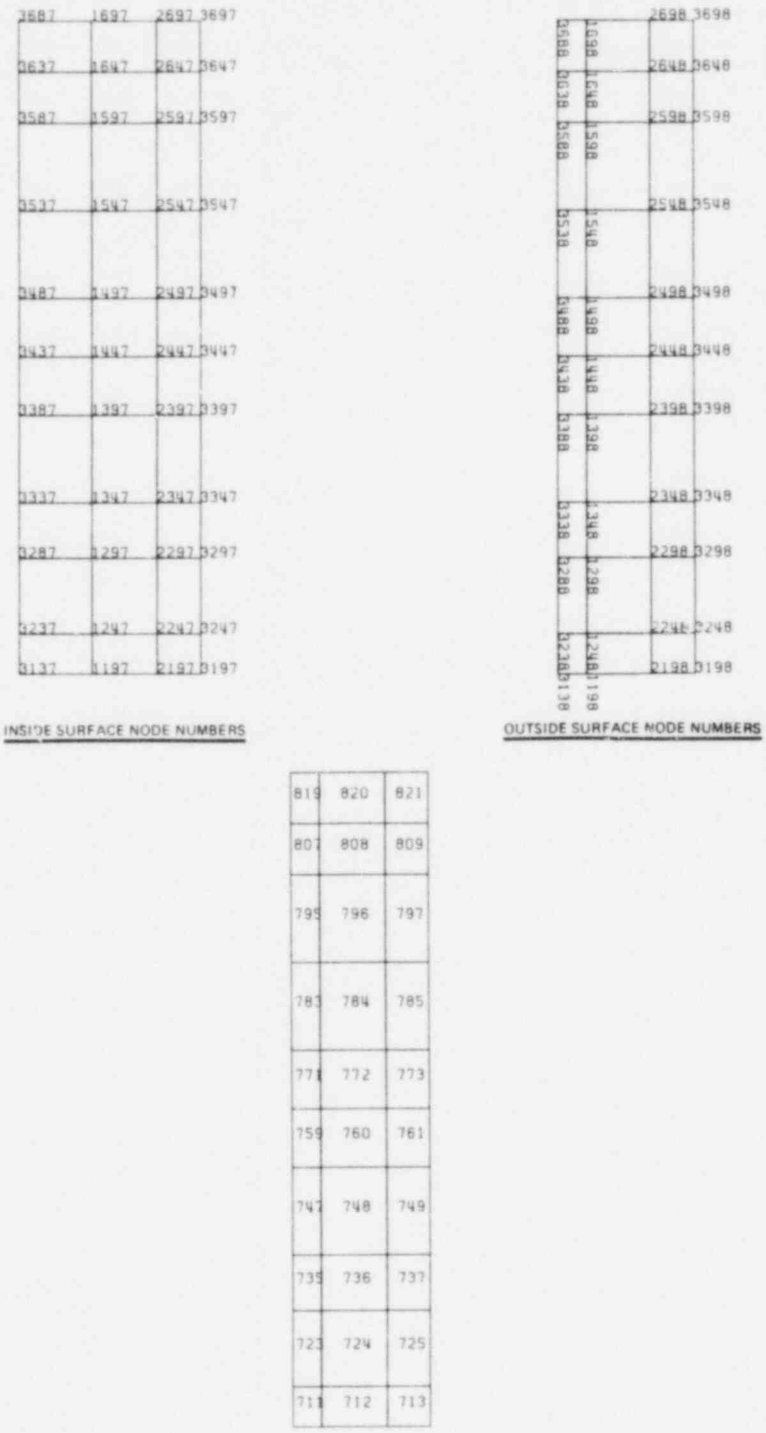
FIGU

CASK LAYDOWN AREA WALLS

R ONE-UNIT ONE

ITY FINITE ELEMENT MODEL

WEST WALL



INSIDE SURFACE NODE NUMBERS

OUTSIDE SURFACE NODE NUMBERS

CUBE ELEMENTS

RE 13

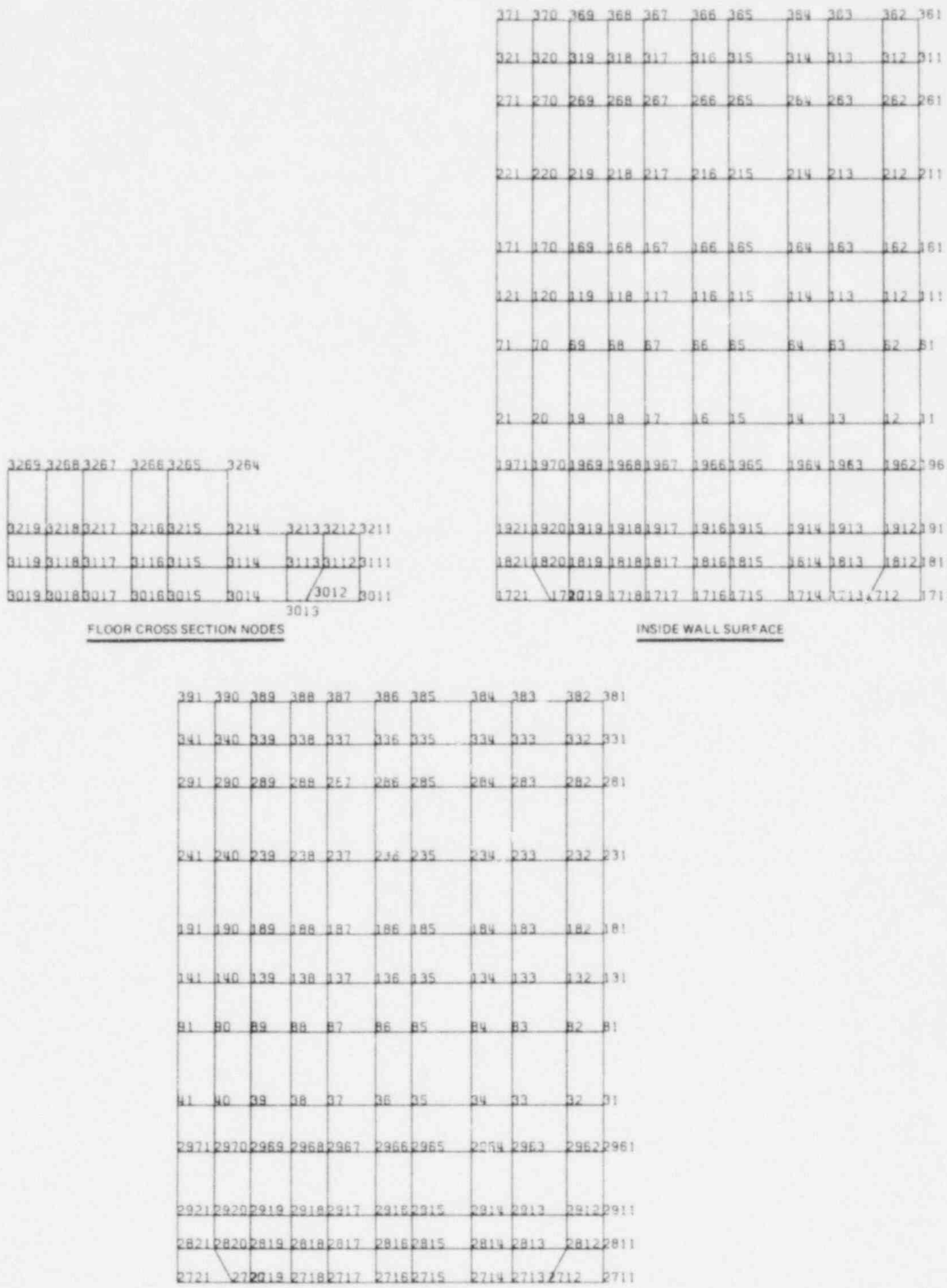
ELEMENT AND NODE NUMBERS

Structural Dynamics Technology, Inc.

ARKANSAS NUCLE

SPENT FUEL STORAGE FACIL

NODE NUMBERS



FLOOR CROSS SECTION NODES

INSIDE WALL SURFACE

OUTSIDE WALL SURFACE

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REVISION 1
JUNE 7, 1982
ENCLOSURE

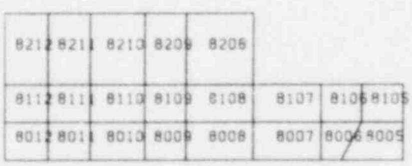
FIGU

FUEL TRANSFER CANAL O
ELEMENT AND

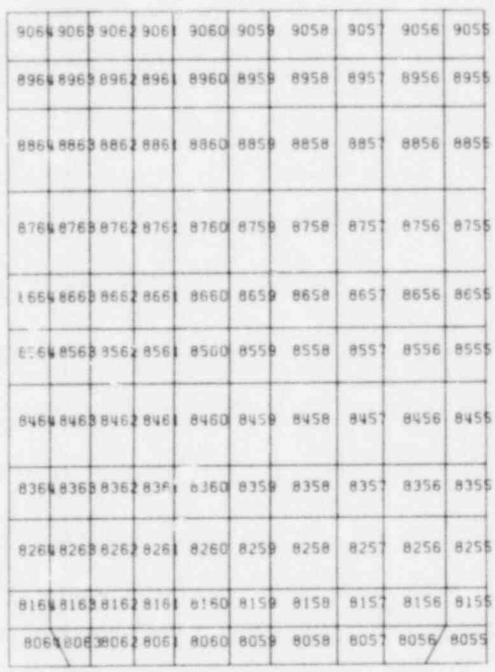
AR ONE-UNIT ONE

ITY FINITE ELEMENT MODEL

CUBE ELEMENTS



FLOOR CROSS SECTION ELEMENTS



FUEL TRANSFER CANAL OUTSIDE WALL

RE 14

UTSIDE WALL AND FLOOR

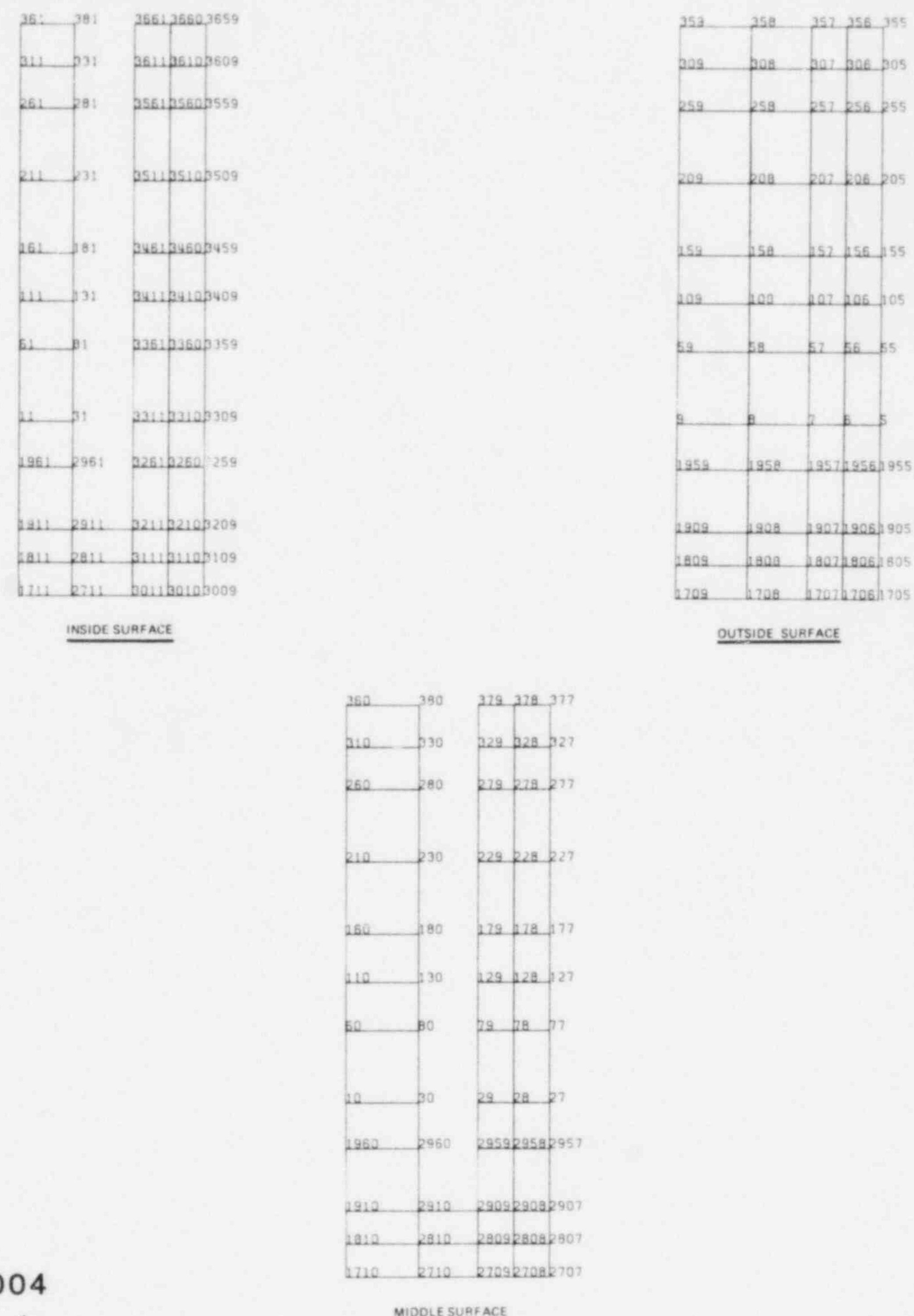
NODE NUMBERS

Structural Dynamics Technology, Inc.

ARKANSAS NUCLE

SPENT FUEL STORAGE FACIL

NODE NUMBERS



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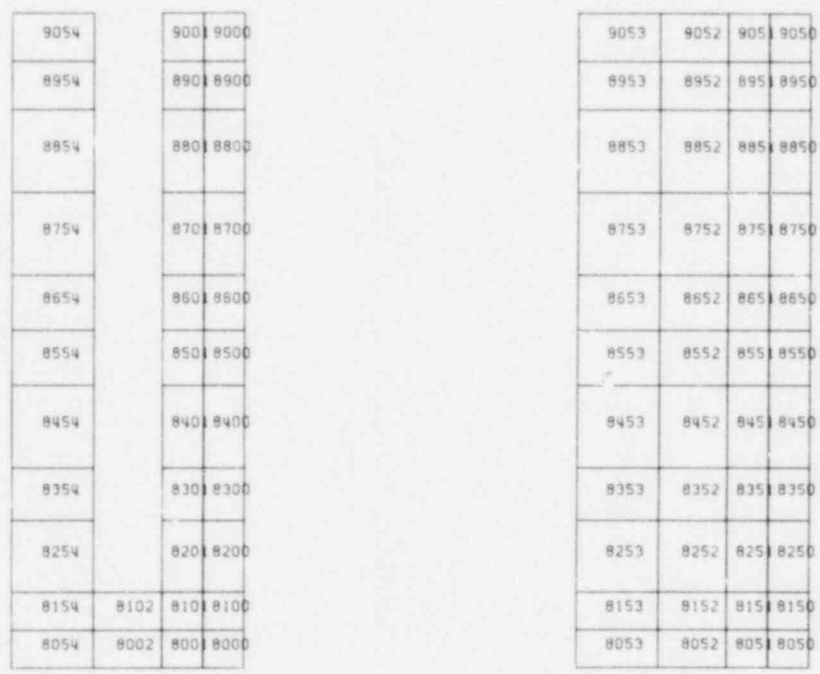
FIGUR

FUEL TRANSFE
WEST WALL ELEMENT

AR ONE-UNIT ONE

ITY FINITE ELEMENT MODEL

CUBE ELEMENTS



INSIDE LAYER

OUTSIDE LAYER

E 15

R CANAL AREA

AND NODE NUMBERS

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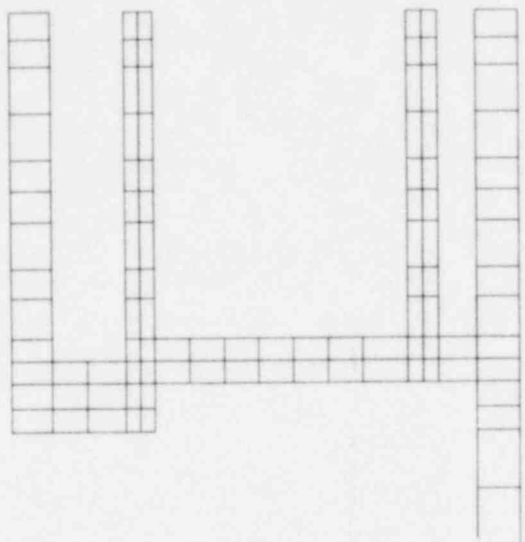
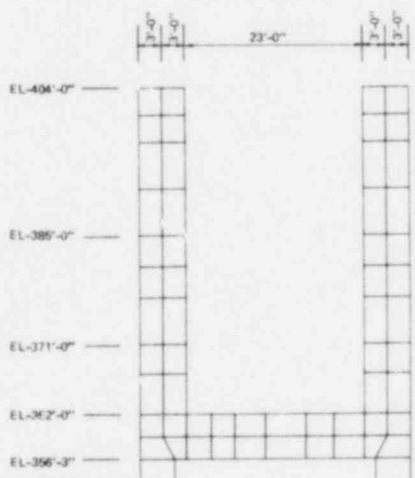
ARKANSAS NUCLEA

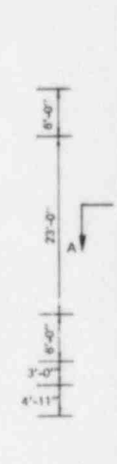
SPENT FUEL STORAGE FACIL



SECTION A-A



SECTION B-B



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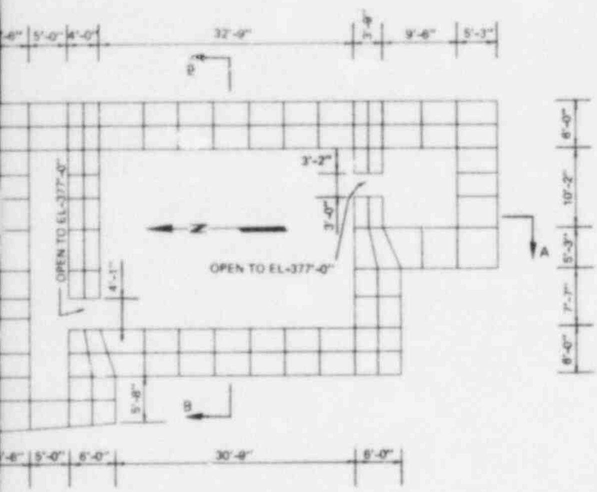
FIGU

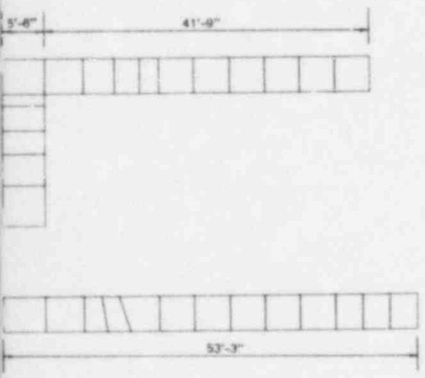
KEY DIAGRAMS

AR ONE-UNIT TWO

ITY FINITE ELEMENT MODEL



PLAN AT ELEVATION 404'-0"



PLAN AT ELEVATION 335'-0"

RE 1

AND DIMENSIONS

NOTES:

DRAWINGS OF ANO - UNIT 1 FROM SDT LETTER APL-01-004 ENCLOSURE SHALL BE USED FOR ANO - UNIT 2 FINITE ELEMENT MODEL, EXCEPT AS NOTED:

1. ALL UNIT 1 PLOTS REPRESENT THE MIRROR IMAGE OF THE ACTUAL PLOTS FOR ANO - UNIT 2 FINITE ELEMENT MODEL.

2. FOR DIMENSIONS, ELEVATIONS AND ORIENTATION OF UNIT 2 MODEL, SEE FIGURE 1.

3. EAST FOUNDATION WALL SHOWN IN FIGURE 2 WILL REPLACE THE PLOTS OF THIS WALL SHOWN IN FIGURES 10 AND 11 OF THE UNIT 1 DRAWINGS.

4. OPENING IN FUEL TRANSFER CANAL FOUNDATION WALL FOR UNIT 2 WAS REPRESENTED BY ADJUSTING ELEVATIONS OF NODES AS SHOWN IN FIGURE 1, SECTION B-B, AND REMOVING CUBE ELEMENTS 1464 THROUGH 1466, 1964 THROUGH 1966, AND THEIR CORRESPONDING SURFACE MEMBRANE ELEMENTS FROM THE UNIT 1 MODEL (SEE FIGURE 10 OF UNIT 1 DRAWINGS).

5. CONCRETE FILL IN FUEL TRANSFER CANAL HAS BEEN REMOVED.

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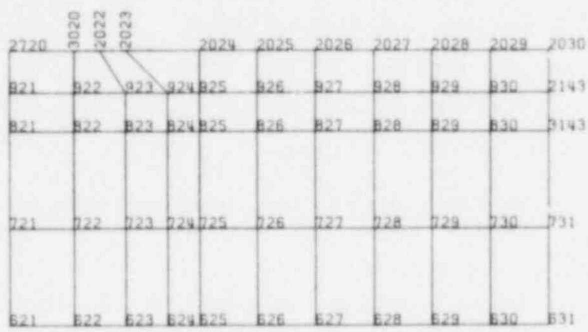
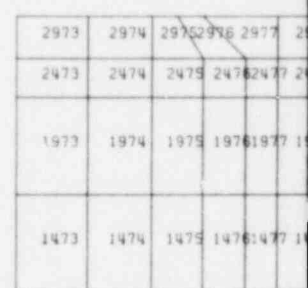
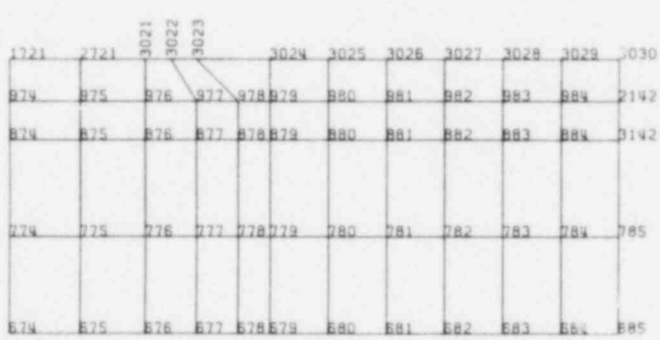
NODE NUMBERS



INSIDE SURFACE

CUBE E





OUTSIDE SURFACE

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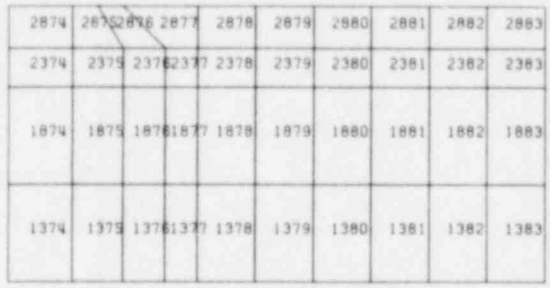
FIGU

EAST FOUNDATION WALL E

AR ONE-UNIT TWO

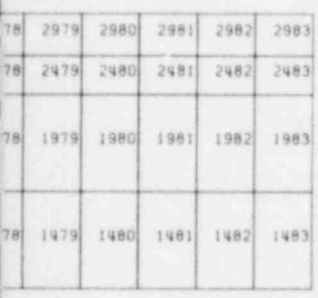
LITY FINITE ELEMENT MODEL

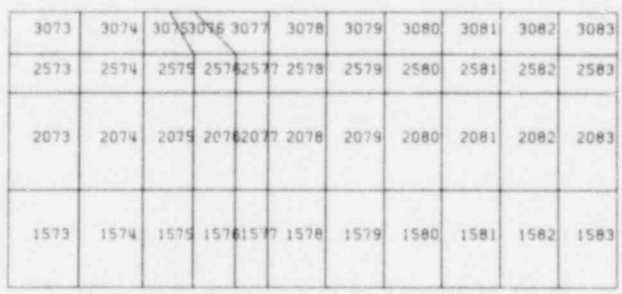
SURFACE MEMBRANE ELEMENTS



INSIDE SURFACE

LEMENTS





OUTSIDE SURFACE

RE 2

LEMENT AND NODE NUMBERS

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