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DESIGN CALCULATIONS

VCC-24 thermal-hydraulic analysis

Original

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J.V Massey, Project Manager, reviewer	JVM	12-11-89
Boris Chechelnitsky	BAC	12-20-89
Michael Carr	MDL	1-9-90

INTRODUCTION

VCC Analysis Purpose

The Ventilated Concrete Cask (VCC) was studied to predict the extreme temperatures that the cask materials will see when loaded with fuel. These temperatures are used to check against material temperature limits and to check the structural integrity through thermal stress analysis per WEP-101.2101. the VCC study also provides temperatures on the Multi-Sealed Basket (MSB) surface that are used for the MSB thermal-hydraulics studies reported elsewhere in WEP-101.1301.

Ventilated Fuel Storage Cask Description

The VCC Geometry is shown in Figure 1 [1.1/pg.1]. The design allows ventilation through the annulus between the VCC and MSB to remove most of the heat from the MSB. The VCCs heat transfer characteristics were modeled using the ANSYS/PC-Thermal computer program [2.2] discussed in Appendix A.

Appendix B presents two cases which were not initially included: 125°F, full solar load
75°F, 1/2 inlets is blocked.

VCC THERMAL-HYDRAULICS

Heat Transfer Modes

Heat is generated in the fuel in the MSB which is conducted out through the MSB shell and convected to the air and radiated to the VCC. On a sunny day, additional heat enters the VCC through the surface as solar insolation. All this heat is radiated and convected from the VCC surface.

Radiation from all surfaces are specifically addressed by [2.1, 2.2]:

$$q = \sigma \epsilon \Im A(T_1^4 - T_2^4) \qquad (1)$$

q = Heat flow rate, Btu/hr.
σ = Stefan-Boltzman constant, 1.714×10^{-9} Btu/hr-ft^2-°F
ϵ = emissivity
$\Im$ = radiative geometry view (form) factor.
A = radiating surface area, ft^2
T = Absolute source(1) and target(2) temperatures, °R

Surface emissivities vary with the radiating material and are provided in Table 6. View factors vary with the surface and target geometry relationship. Solar insolation (solar thermal radiation incident on the VCC surface) is constrained by federal regulation [2.9].

Convections from all surfaces are specifically addressed by [2.1, 2.2]:

$$q = hA(T_1 - T_2) \qquad (2)$$

h = Convection coefficient, Btu/hr-ft^2-°F

The 3-D conductions are modeled [2.1, 2.2]

$$\rho C_p(\partial T/\partial t) = \partial /\partial x(k \partial T/\partial x) + \partial q/\partial \underline{v} \qquad (3)$$

k = Thermal conductivity, Btu/hr-ft^2-°F
ρ = density, lbm/ft^3
C_p = specific heat, Btu/lbm-°F
$\partial q/\partial \underline{v}$ = Heat generation rate, Btu/hr-ft^3

All of these modes are addressed in the ANSYS/PC-Thermal (A/PCT) computer program [2.2] and this program was chosen for the thermal-hydraulics analysis. The following sections describe the data used in the A/PCT program.

The ANSYS/PCT Model

The geometry of Fig. 1 is converted the finite element form of ANSYS/PC-Thermal (ANSYS/PCT, Appendix A) as shown in Figure 2. . Detailed listings of node locations and element connectivities are provided (from the A/PCT program) in Tables 2 and 3. Radiation properties (as 'Real Number' input sets) for radiating elements are listed in Table 4. Data for these inputs are discussed in the following sections.
Results of the air flow calculations are presented in Table 1, results of the calculations for area of the radiation elements – in Table 7. Both were done using Lotus 1-2-3.

All units used in the report and the ANSYS/PCT program are consistent: Btu, ft, hr, F, lbm. Two element types are used, the 3-D solid element (STIFF70) and a radiation link element (STIFF31). Thermal properties are specific to the materials and are presented in Tables 5 and 6. Tables 8, 10, 12 and 14 present case-specific data : heat loads and element conventions. Tables 9, 11, 13 and 15 present results for each case.

Fuel Heat Source Strength Definition and Air-Annulus Temperature Distribution

The heat generation rates for the fuel were taken from [1.3] and are summarized in Table 7. These were calculated based on the flue effect caused by the heated air. The heat flow rates were grouped to volume elements twice the size of those per Table (32in vs 16in regions) except for the hottest region. The data for the three cases of +100F, 75°F, -40F are also shown. The air temperatures and heat flow rate calculations are provided in files VCC-MOD.WK1 and FLOW1.WK1. The heat transfer correlation of 2.0 Btu/hr-ft^2-°F was used based on [3.1.2].

Solar Insolation

The solar radiation heat input, used for the 100°F case, is per the federal requirements of [2.9] of 2949 Btu/ft^2 (800gCal/cm^2) solar load for the top surfaces and 1474 Btu/ft^2 (400gCal/cm^2) for curved surfaces. These are converted to rates by taking the daily average as 12hrs/24hrs resulting in heat flux on the top and side surfaces of 123 and 61 Btu/hr-ft^2 respectively.

In the ANSYS/PCT model these heat rates are applied as heat generation rates to allow the even distribution of the heat. The heat generation rate is then calculated as the above heat rate divided over the thickness of a thin shell of material used just for the purpose of adding this heat. These rates are

Heat Rate Btu/hr-ft^3	Region
1966	Steel top, 3/4in thickness
2950	Concrete side, 1/4in thickness
5900	Concrete top, 1/4in thickness

Heat Transfer Properties

The material properties are summarized in Table 5. All properties are isotropic: $K(x) = K(y) = K(z)$. Material property data inputs to ANSYS/PCT are described per Section 7.3 of [2.2/UM-7.3]. The air properties are used only for the air gap above the MSB which is stagnant.

Radiation: radiation is included at all surfaces radiating to the atmosphere and between the annular air-spaces of the VCC. Emissivity data are summarized in Table 6 and the emissivities used in the analysis identified by *.

View factors for all inner surfaces assume a value of 1. The view factor for the cask sides is calculated as 0.14 between the side and the atmosphere based on a cask array of 15ft centers: all casks and the ground are considered at equilibrium. The side factor is calculated based on an average distance to the other casks

Angle	Dist. ft
0-18#	4.2
18-32#	23.1
32-58#	10.4
58-72#	23.1
72-90#	4.2
Avg.	11.87 ft

which is used to enter the correlations of [2.1/pg.248].

Convections

Convections throughout model are taken as 2.0 Btu/hr-ft^2-°F based on [3.1.2]. This value is a conservative value compared to full-scale experimental data from other casks:

$$h = \mathbb{C}\Delta T^{1/3} \qquad (4)$$

h = Convective heat transfer coefficient, Btu/hr-ft^2-°F
$\mathbb{C}$ = Empirical constant for SFS casks.

Assumptions

1. *The model uses a 10° slice to model the entire VCC.* The VCC geometry and temperatures are uniform with angular direction so that the 2-dimensional portrait should be adequate. The 10° slice is small so as to minimize the complexity of the nodalization while still representing the radial distribution of volume.

2. *The air vents are not included in the model.* Because of the low conductivity of concrete the air vents should affect only the region local to the vents. In the existing model, both the incoming low temperatures and the exiting high temperatures are included above and below the heated region to assure that temperature extremes are represented.

3. *A convective coefficient of 2.0 Btu/hr-ft^2-°F is adequate throughout the model.* The convective coefficient of 2.0 is based on full-size cask studies and similar temperatures. This empirical data is thought to more reliable than theoretical correlations which show lower coefficients (of the order of 1 Btu/hr-ft^2-°F). *

4. *Solar insolation is treated as a volumetric heat generation.* Solar insolation appears as a uniformly distributed heat flux on the VCC surfaces. The ANSYS/PCT program allows heat fluxes only at nodes which causes hot-spot nodes on the VCC surface. The use of a thin shell of heated region which of the same heat rate as the solar insolation allows the even application of the solar flux and it's local convection as would actually occur.

* However, ANSYS runs with $h = 1$ Btu/hr-ft^2-F° at the cask surface were made. The result was that the concrete outside surface t increased by ~10°F, but inside surface and the MSB shell temperatures remained the same. Therefore, it only gives lower gradient through the surface and

5. *Cask side radiation view factor.* The side view factor is thought to be quite conservative since it is calculated based on an average surface orientation. Actually, the VCC hot spots are near the top of the VCC where the clear view to ambient is much larger. If we accounted for the distribution of view factors we should expect a more even temperature distribution and lower peak temperatures.

6. *The MSB model is gross.* The MSB is modeled only grossly since it will be modeled in detail in another study. Our interest in the MSB is to get the heat to the VCC reasonably accurately. Axial variations are smoothed by the high conductivity of the low-carbon steel shell and the radiation to the VCC. This means that heat leaves the fuel and MSB almost purely radially based on other SFS cask studies [3.1.2]. The gas head above the fuel and the unheated region are modeled as helium. The heated region fuel is treated as a solid with a conductivity of 2 Btu/hr-ft^2-°F

RESULTS

100°, FULL SOLAR LOADING

The ANSYS/PCT general model was loaded with the temperatures and heat generations discussed above and run to find the steady state temperatures. The heat generations and convections representing a 100° day and full solar loadings are presented in Table 8. The results are shown in Figure 4 and Table 9. The peak temperatures and other representative temperatures are summarized in Table 16.

The results show reasonable concrete temperatures on the VCC surface below 160° representing the solar insolation. The inner concrete temperatures vary from 198° (MSB bottom) to 161° (VCC top) just inside the inner steel liner, peaking at a high temperature of 220° across from the heated fuel region. VCC steel shell temperatures are essentially the same as the adjoining concrete temperatures. The results were examined using ANSYS/PCTs graphical display capabilities and the expected temperature distributions were observed.

-40°, NO SOLAR LOADING

The ANSYS/PCT general model was loaded with the temperatures and heat generations representing a -40° day with no solar loading. The heat generations and convections are presented in Table 10. The results are shown in Figure 5 and Table 11. The peak temperatures and other representative temperatures are summarized in Table 16.

With no solar loading the external concrete temperature is just slightly above ambient and generally due to the low conductivity of concrete. The concrete just inside the VCC liner shell varies from 52° (below the MSB) to -5° (at the VCC top), peaking at 45° just across from the heated fuel region.

75°, NO SOLAR LOADING

The heat generations and elements convections are presented in Table 12. The results are shown in Figure 6 and Table 13. The peak temperatures and other representative temperatures are summarized in Table 16.

The concrete temperatures inside the liner shell are from 168° (below the MSB) to 114° (VCC top).

The peak concrete temperature is 186°F.

75°, NO SOLAR LOADING, INLETS PLUGGED.

The heat generations and el. convections are presented in Table 14. The results are shown in Figure 7 and Table 15. Summary is presented in Table 16. The peak concrete temperature is 201°F.

REFERENCES

1.N Provided by SNC

1.1 Dimensional Information (data package provided 10/15/88).

1.1.1 Dimensional Sketch of VCC-21 and MSB-24

1.1.2 "Fig.2.2-2 Concrete Cask Drawing, Sheet 1"

1.1.3 "Figure 4-6 Westinghouse Fuel Assembly, 17x17"

1.1.4 "Table 4-2 Westinghouse Fuel Design Evolution Summary"

1.1.5 "Figure 4-1 Westinghouse Fuel Assembly, 14x14"

1.1.6 "Figure 4-4 Westinghouse Fuel Assembly, Surrey 15x15"

1.1.7 "Fig.2.2-2 Concrete Cask Drawing, Sheet 1"

1.1.8 "Fig.2.2-2 Concrete Cask Drawing, Sheet 2"

1.1.9 "Reinforcement Details" (otherwise untitled)

1.1.10 "Fig.2.2-1 MSB Drawings, Sheet 1"

1.1.11 "Fig.2.2-1 MSB Drawings, Sheet 2"

1.1.12 "Basket Support Front View"

1.1.13 "Figure 2.3-2 Transfer Cask Drawings, Sheet 1"

1.1.14 "Figure 2.3-2 Transfer Cask Drawings, Sheet 2"

1.1.15 "Figure 2.3-1 Hydraulically Lifting Roller Skid"

1.2 VCC Annulus Heat Convection Estimates (data provided 10/17/88). Includes fuel heat generations.

1.3 Solar Loadings Estimates (J.M. data provided 10/17/88).

2.N Standard References

2.1 F. Krieth, "Principles of Heat Transfer", 3rd Ed., Intext Press, NY, 1973.

2.2 ANSYS/PC-Thermal 4.3, Program documentation: 3 volumes. Swanson Analysis Systems, Inc.

2.3 ASME Section III, Division 1, Appendices, Table I-4.0, 1983.

2.4 ASHRAE Handbook, "Fundamentals", ASHRAE, NY, 1977

2.5 E.M. Sparrow and R.D. Ross, "Radiation Heat Transfer", Aug. Ed., McGraw-Hill, NY, 1978.

2.6 W.M. Rohsenow, J.P. Hartnett, E.N. Ganic, "Handbook of Heat Transfer", 2nd Ed., McGraw-Hill, NY, 1985.

2.7 F. Krieth, M.S. Bohn, "Principles of Heat Transfer", 4th Ed., Revised Ed., Harper & Row, NY, 1986.

2.8 Mark's et. al., "Mark's Standard Handbook for Mechanical Engineers", 8th Ed, McGraw-Hill, NY, 1978

2.9 Code of Federal Regulations, 10CFR-71.71.

3.N Records of Conversation (Chron. Files)

3.1 Sierra Nuclear (J. Massey) and B.R.Strong

3.1.1 10/24/88: 10CFR71.71 for insolation.

3.1.2 10/28/88: Use 2.0 for surface convections.

NORMAL FLOW PATH	D(H)	A	L	F	K	A**2	K/A**2	VEL	Re
1. INLET SNOW SKIRT with screens		11.87000			0.77000	140.89690	0.00546	1.31297	
2. INLET SECTION DOWN OUTSIDE	0.66700	11.87000	3.00000	0.04000	0.17991	140.89690	0.00128	1.31297	4.825E+0
3. BEND & ENTER. SKID CHANNELS		4.68000			1.38000	21.90240	0.06301	3.33012	
4. SKID CHANNELS	1.08000	4.68000	5.11833	0.03000	0.14218	21.90240	0.00649	3.33012	1.982E+0
5. BEND INTO 12 IN SQ TUBE		4.00000			2.16000	16.00000	0.13500	3.89624	
6. BENDS AT CHANNEL AND INLET ASSY		4.00000			0.38700	16.00000	0.02419	3.89624	
7. STRAIGHT SECTION	1.00000	4.00000	1.33333	0.02600	0.03467	16.00000	0.00217	3.89624	2.147E+0
8. INLET ASSEMBLY AND BEND INTO ANN.		4.47200			1.38400	19.99878	0.06920	3.48501	
9. SUDDEN EXPANSION INTO ANNULUS		5.76000			0.05000	33.17760	0.00151	2.70572	
10. FLOW UP ANNULUS	0.66600	5.76000	14.16667	0.03300	0.70195	33.17760	0.02116	2.70572	9.928E+0
11. BEND&CNTRCT INTO 3" by 52" SLIT		4.33333			1.20000	18.77778	0.06391	3.59653	
12. Z - BEND		4.33333			2.78000	18.77778	0.14805	3.59653	
13. OUTLET STRAIGHT SECTION	1.89083	4.33333	2.66667	0.02600	0.03667	18.77778	0.00195	3.59653	3.747E+0
14. DISCHARGE with screens		4.33333**			1.14000	18.77778	0.06071	3.59653	

SUM K/A**2	0.60408	SUM K/A**2	0.60408
INLET TEMP	75.00000	INLET TEMP	-40.00000
OUTLET TEMP	162.93500	OUTLET TEMP	29.15000
AVG TEMP	118.96750	AVG TEMP	-5.42500
DRAFT HEIGHT	15.00000	DRAFT HEIGHT	15.00000
GUESS DT=	87.93500	GUESS DT=	69.15000
HEAT =	81888.00000	HEAT =	81888.00000
CP=	0.24100	CP=	0.24100
M=(HEAT BALENCE)	1.07334	M=(HEAT BAL)	1.36492
AVG DENSITY	0.06887	AVG DENSITY	0.08751
DP FLOW=	0.15691	DP FLOW=	0.19969
DP STACK=	0.15690	DP STACK=	0.19969
DT CALC	87.93500	DT CALC	69.15000
M=(DP FLOW)	1.07334	M=(DP FLOW)	1.36492
AVG Q/IN	568.66667	AVG Q/IN	568.66667

X POSITION	f RELATIVE POWER	Q(x) POWER/IN	QX	DT TEMP	AIR TEMPERATURE	AIR TEMPERATURE	DT TEMP
0					75.00000	-40.00000	
0-16	0.69000000	392.38000	6270.08000	6.76977	81.76977	-34.67641	5.32359
16-32	1.08000000	614.16000	9826.56000	10.59617	92.36594	-26.34384	8.33258
32-48	1.20000000	682.40000	10918.40000	11.77352	104.13946	-17.08542	9.25842
48-64	1.19000000	676.71333	10827.41333	11.67541	115.81487	-7.90416	9.18126
64-80	1.17000000	665.34000	10645.44000	11.47918	127.29405	1.12280	9.02696
80-96	1.12000000	636.90667	10190.50667	10.98862	138.28267	9.76399	8.64119
96-112	1.05000000	597.10000	9553.60000	10.30183	148.58450	17.86510	8.10111
112-128	0.90000000	511.80000	8188.80000	8.83014	157.41464	24.80892	6.94381
128-144	0.60000000	341.20000	5459.20000	5.88676	163.30140	29.43813	4.62921

Table 1

Air flow calculations

75° F, -40° F

NORMAL FLOW PATH	D(H)	A	L	f	K	A**2	K/A**2	VEL	Re	% K/
1. INLET SNOW SKIRT with screens		11.87000			0.77000	140.89690	0.00546	1.31288	0.000E+00	0
2. INLET SECTION DOWN OUTSIDE	0.66700	11.87000	3.00000	0.04000	0.17991	140.89690	0.00128	1.31288	4.420E+03	0
3. BEND & ENTER. SKID CHANNELS		4.68000			1.38000	21.90240	0.06301	3.32989	0.000E+00	10
4. SKID CHANNELS	1.08000	4.68000	5.11833	0.03000	0.14218	21.90240	0.00649	3.32989	1.815E+04	1
5. BEND INTO 12 IN SQ TUBE		4.00000			2.16000	16.00000	0.13500	3.89597	0.000E+00	27
6. BENDS AT CHANNEL AND INLET ASSY		4.00000			0.38700	16.00000	0.02419	3.89597	0.000E+00	4
7. STRAIGHT SECTION	1.00000	4.00000	1.33333	0.02600	0.03467	16.00000	0.00217	3.89597	1.966E+04	0
8. INLET ASSEMBLY AND BEND INTO ANN.		4.47200			1.38400	19.99878	0.06920	3.48477	0.000E+00	11
9. SUDDEN EXPANSION INTO ANNULUS		5.76000			0.05000	33.17760	0.00151	2.70554	0.000E+00	0
10. FLOW UP ANNULUS	0.66600	5.76000	14.16667	0.03300	0.70195	33.17760	0.02116	2.70554	9.094E+03	3
11. BEND&CNTRCT INTO 3" by 52" SLIT		4.33333			1.20000	18.77778	0.06391	3.59628	0.000E+00	10
12. Z - BEND		4.33333			2.78000	18.77778	0.14805	3.59628	0.000E+00	23
13. OUTLET STRAIGHT SECTION	1.89000	4.33333	2.66667	0.02600	0.03668	18.77778	0.00195	3.59628	3.431E+04	0
14. DISCHARGE with screens		4.33333			1.14000	18.77778	0.06071	3.59628	0.000E+00	10

SUM K/A**2	0.60408	SUM K/A**2	0.60408
INLET TEMP	125.00000	INLET TEMP	100.00000
OUTLET TEMP	221.00000	OUTLET TEMP	191.85000
AVG TEMP	173.00000	AVG TEMP	145.92500
DRAFT HEIGHT	15.00000	DRAFT HEIGHT	15.00000
GUESS DT=	96.00000	GUESS DT=	91.85000
HEAT =	81888.00000	HEAT =	81888.00000
CP=	0.24100	CP=	0.24100
M=(HEAT BALENCE)	0.98317	M=(HEAT BAL)	1.02759
AVG DENSITY	0.06309	AVG DENSITY	0.06599
DP FLOW=	0.14372	DP FLOW=	0.15011
DP STACK=	0.14352	DP STACK=	0.15004
DT CALC	96.00000	DT CALC	91.85000
M=(DP FLOW)	0.98317	M=(DP FLOW)	1.02759
AVG Q/IN	568.66667	AVG Q/IN	568.66667

X POSITION	f RELATIVE POWER	Q(x) POWER/IN	QX	DT TEMP	AIR TEMPERATURE	AIR TEMPERATURE	DT TEMP
0					125.00000	100.00000	
0-16	0.69000000	392.38000	6278.08000	7.39067	132.39067	107.07117	7.07117
16-32	1.08000000	614.16000	9826.56000	11.56800	143.95867	118.13910	11.06793
32-48	1.20000000	682.40000	10918.40000	12.85333	156.81200	130.43679	12.29769
48-64	1.19000000	676.71333	10827.41333	12.74622	169.55822	142.63201	12.19521
64-80	1.17000000	665.34000	10645.44000	12.53200	182.09022	154.62226	11.99025
80-96	1.12000000	636.90667	10190.50667	11.99644	194.08667	166.10211	11.47785
96-112	1.05000000	597.10000	9553.60000	11.24667	205.33333	176.86059	10.76048
112-128	0.90000000	511.80000	8188.80000	9.64000	214.97333	186.08386	9.22327
128-144	0.60000000	341.20000	5459.20000	6.42667	221.40000	192.23271	6.14885

Table 1 (cont-d)

Air flow: 125°F, 100°F

2 INLET 2 OUTLET	D(E)	A	L	F	K	A**2	K/A**2	VELOCITY	%d
Inlets blocked									
1. INLET THROUGH OUTLET SCREEN		2.16667			1.60000	4.69444	0.34083		
2. OUT THROUGH 2 OUTLETS w/SCREENS		2.16667			1.14000	4.69444	0.24284		
3. STRAIGHT SECTION	0.23500	2.16667	5.33334	0.02600	0.59007	4.69444	0.12570	4.37	
4. Z-BEND		2.16667			5.56300	4.69444	1.18502		
5. BEND&CONTRACT IN SLIT		2.16667			1.20480	4.69444	0.25664		
6. BEND AND EXPAND FROM SLIT		2.16667			1.74004	4.69444	0.37066		
7. FLOW DOWN ANNULUS	0.66667	2.87980	14.16667	0.03300	0.70125	8.29325	0.08456	3.29	
8. FLOW UP ANNULUS	0.66667	2.87980	14.16667	0.03300	0.70125	8.29325	0.08456	3.29	

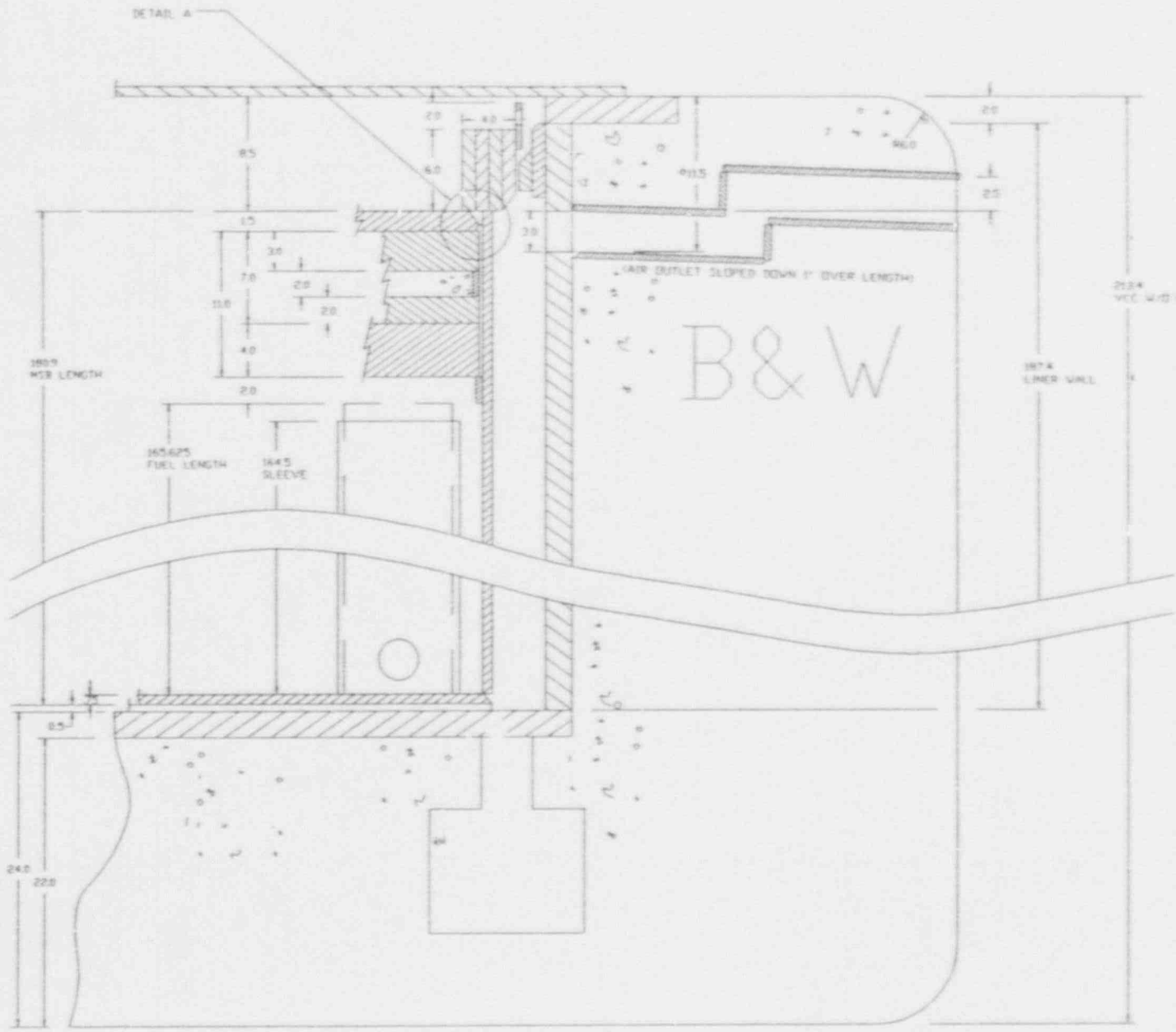
% down flow:		
20.00000	236.30000	Max Temp
25.00000	232.50000	
30.00000	230.40000	
35.00000	229.20000	
40.00000	228.60000	
45.00000	228.20000	
50.00000	228.10000	
55.00000	228.20000	
60.00000	228.60000	
65.00000	229.20000	
70.00000	230.40000	
75.00000	232.50000	
80.00000	236.30000	

SUM K/A**2	2.69080	SUM K/A**2	2.69080
INLET TEMP	75.00000	INLET TEMP	-40.00000
OUTLET TEMP	227.46500	OUTLET TEMP	80.82000
AVG TEMP	151.23250	AVG TEMP	20.41000
DRAFT HEIGHT	15.00000	DRAFT HEIGHT	15.00000
GUESS DT=	152.46500	GUESS DT=	120.82000
HEAT =	81888.00000	HEAT =	81888.00000
CP=	0.24100	CP=	0.24100
M=(HEAT BALANCE)	0.61906	M=(HEAT BAL)	0.78120
AVG DENSITY	0.06542	AVG DENSITY	0.08222
DP FLOW=	0.24477	DP FLOW=	0.31014
DP STACK=	0.24477	DP STACK=	0.31015
DT CALC	152.46500	DT CALC	120.82000
M=(DP FLOW)	0.61906	M=(DP FLOW)	0.78120
AVG Q/IN	568.66667	AVG Q/IN	568.66667

X POSITION	f RELATIVE POWER	Q(x) POWER/IN	QX	DT TEMP	AIR TEMPERATURE	AIR TEMPERATURE	DT TEMP
144 (in)					75.00000	-40.00000	
144-128	0.60000000	170.60000	2729.60000	5.10334	80.10334	-35.95589	4.04411
128-112	0.90000000	255.90000	4094.40000	7.65501	87.75836	-29.88972	6.06617
112-96	1.05000000	298.55000	4776.80000	8.93085	96.68921	-22.81252	7.07720
96-80	1.12000000	318.45333	5095.25333	9.52624	106.21544	-15.26350	7.54901
80-64	1.17000000	332.67000	5322.72000	9.95152	116.16696	-7.37748	7.88602
64-48	1.19000000	338.35667	5413.70667	10.12163	126.28859	0.64334	8.02083
48-32	1.20000000	341.20000	5459.20000	10.20668	136.49528	8.73157	8.08823
32-16	1.08000000	307.08000	4913.28000	9.18602	145.68129	16.01098	7.27941
16-0	0.69000000	196.19000	3139.04000	5.86884	151.55014	20.66171	4.65073
0-16	0.69000000	196.19000	3139.04000	5.86884	157.41898	25.31244	4.65073
16-32	1.08000000	307.08000	4913.28000	9.18602	166.60500	32.59184	7.27941
32-48	1.20000000	341.20000	5459.20000	10.20668	176.81168	40.68007	8.08823
48-64	1.19000000	338.35667	5413.70667	10.12163	186.93331	48.70090	8.02083
64-80	1.17000000	332.67000	5322.72000	9.95152	196.88483	56.58692	7.88602
80-96	1.12000000	318.45333	5095.25333	9.52624	206.41107	64.13593	7.54901
96-112	1.05000000	298.55000	4776.80000	8.93085	215.34191	71.21313	7.07720
112-128	0.90000000	255.90000	4094.40000	7.65501	222.99693	77.27930	6.06617
128-144	0.60000000	170.60000	2729.60000	5.10334	228.10027	81.32342	4.04411
144 (out)					228.10027	81.32342	

Figure 1

VSC-24 geometry



Full size dwg is in block "Full-size"

Figure 2. VCC-24 FE model

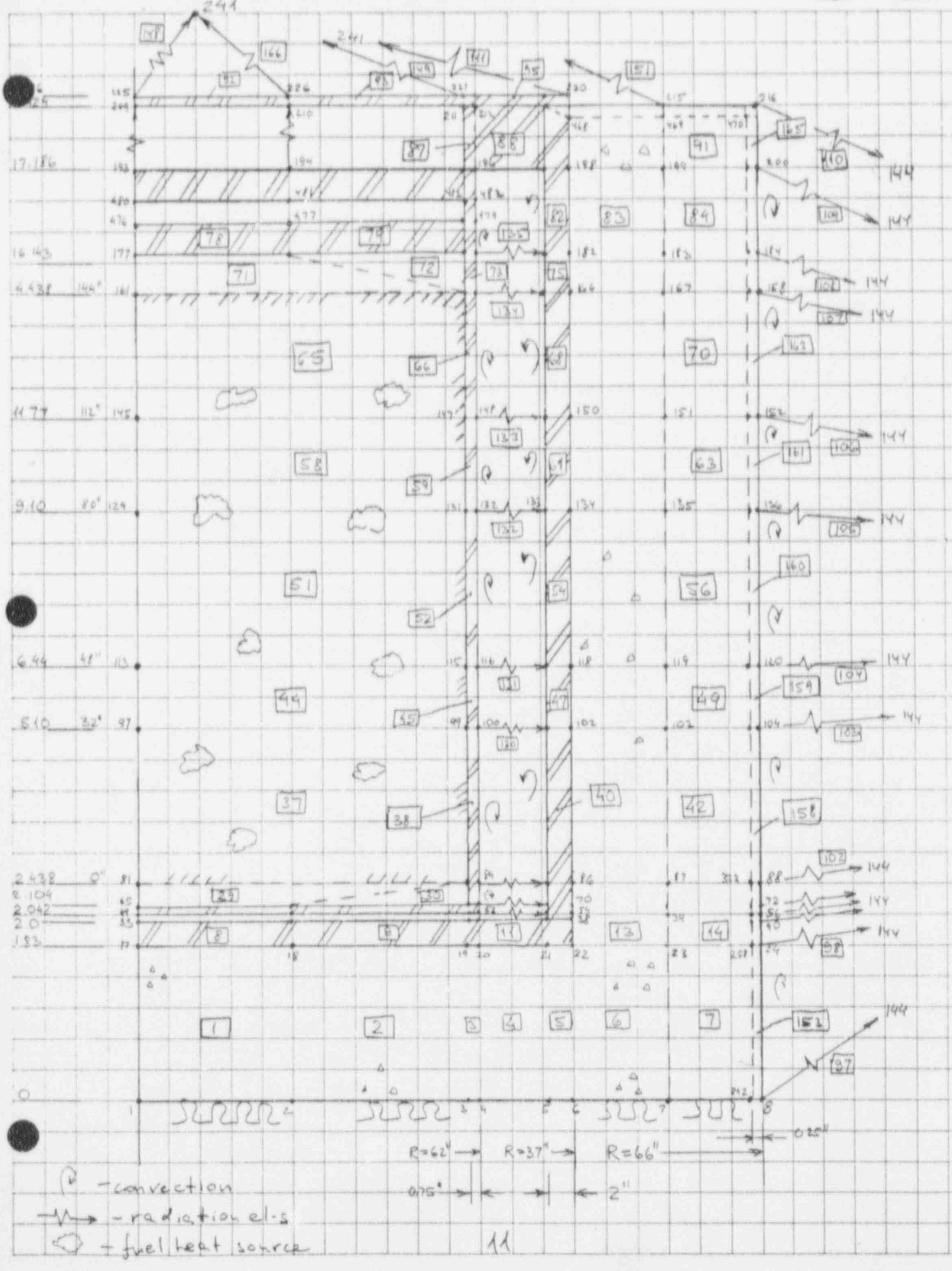


Table 2 Node locations

LIST ALL SELECTED NODE DSYS= 0

NODE	X	Y	Z	THXY	THYZ	THXZ
1	0.00000E+00	0.00000E+00	0.00000E+00	0.00	0.00	0.00
2	1.2500	0.00000E+00	0.00000E+00	0.00	0.00	0.00
3	2.5208	0.00000E+00	0.00000E+00	0.00	0.00	0.00
4	2.5830	0.00000E+00	0.00000E+00	0.00	0.00	0.00
5	2.9170	0.00000E+00	0.00000E+00	0.00	0.00	0.00
6	3.0833	0.00000E+00	0.00000E+00	0.00	0.00	0.00
7	4.2708	0.00000E+00	0.00000E+00	0.00	0.00	0.00
8	5.5000	0.00000E+00	0.00000E+00	0.00	0.00	0.00
9	1.2310	0.21706	0.00000E+00	0.00	0.00	0.00
10	2.4825	0.43773	0.00000E+00	0.00	0.00	0.00
11	2.5438	0.44853	0.00000E+00	0.00	0.00	0.00
12	2.8727	0.50653	0.00000E+00	0.00	0.00	0.00
13	3.0365	0.53541	0.00000E+00	0.00	0.00	0.00
14	4.2059	0.74162	0.00000E+00	0.00	0.00	0.00
15	5.4164	0.95506	0.00000E+00	0.00	0.00	0.00
17	0.00000E+00	0.00000E+00	1.8333	0.00	0.00	0.00
18	1.2500	0.00000E+00	1.8333	0.00	0.00	0.00
19	2.5208	0.00000E+00	1.8333	0.00	0.00	0.00
20	2.5830	0.00000E+00	1.8333	0.00	0.00	0.00
21	2.9170	0.00000E+00	1.8333	0.00	0.00	0.00

NODE	X	Y	Z	THXY	THYZ	THXZ
22	3.0833	0.00000E+00	1.8333	0.00	0.00	0.00
23	4.2708	0.00000E+00	1.8333	0.00	0.00	0.00
24	5.5000	0.00000E+00	1.8333	0.00	0.00	0.00
25	1.2310	0.21706	1.8333	0.00	0.00	0.00
26	2.4825	0.43773	1.8333	0.00	0.00	0.00
27	2.5438	0.44853	1.8333	0.00	0.00	0.00
28	2.8727	0.50653	1.8333	0.00	0.00	0.00
29	3.0365	0.53541	1.8333	0.00	0.00	0.00
30	4.2059	0.74162	1.8333	0.00	0.00	0.00
31	5.4164	0.95506	1.8333	0.00	0.00	0.00
33	0.00000E+00	0.00000E+00	2.0000	0.00	0.00	0.00
34	1.2500	0.00000E+00	2.0000	0.00	0.00	0.00
35	2.5208	0.00000E+00	2.0000	0.00	0.00	0.00
36	2.5830	0.00000E+00	2.0000	0.00	0.00	0.00
37	2.9170	0.00000E+00	2.0000	0.00	0.00	0.00
38	3.0833	0.00000E+00	2.0000	0.00	0.00	0.00
39	4.2708	0.00000E+00	2.0000	0.00	0.00	0.00
40	5.5000	0.00000E+00	2.0000	0.00	0.00	0.00
41	1.2310	0.21706	2.0000	0.00	0.00	0.00
42	2.4825	0.43773	2.0000	0.00	0.00	0.00

NODE	X	Y	Z	THXY	THYZ	THXZ
43	2.5438	0.44853	2.0000	0.00	0.00	0.00
44	2.8727	0.50653	2.0000	0.00	0.00	0.00
45	3.0365	0.53541	2.0000	0.00	0.00	0.00
46	4.2059	0.74162	2.0000	0.00	0.00	0.00
47	5.4164	0.95506	2.0000	0.00	0.00	0.00
49	0.00000E+00	0.00000E+00	2.0417	0.00	0.00	0.00
50	1.2500	0.00000E+00	2.0417	0.00	0.00	0.00
51	2.5208	0.00000E+00	2.0417	0.00	0.00	0.00
52	2.5830	0.00000E+00	2.0417	0.00	0.00	0.00
53	2.9170	0.00000E+00	2.0417	0.00	0.00	0.00
54	3.0833	0.00000E+00	2.0417	0.00	0.00	0.00

Table 2 (cont-d)

NODE	X	Y	Z	THXY	THYZ	THXZ
55	4.2708	0.00000E+00	2.0417	0.00	0.00	0.00
56	5.5000	0.00000E+00	2.0417	0.00	0.00	0.00
57	1.2310	0.21706	2.0417	0.00	0.00	0.00
58	2.4825	0.43773	2.0417	0.00	0.00	0.00
59	2.5438	0.44853	2.0417	0.00	0.00	0.00
60	2.8727	0.50653	2.0417	0.00	0.00	0.00
61	3.0365	0.53541	2.0417	0.00	0.00	0.00
62	4.2059	0.74162	2.0417	0.00	0.00	0.00
63	5.4164	0.95506	2.0417	0.00	0.00	0.00

NODE	X	Y	Z	THXY	THYZ	THXZ
65	0.00000E+00	0.00000E+00	2.1040	0.00	0.00	0.00
66	1.2500	0.00000E+00	2.1040	0.00	0.00	0.00
67	2.5208	0.00000E+00	2.1040	0.00	0.00	0.00
68	2.5830	0.00000E+00	2.1040	0.00	0.00	0.00
69	2.9170	0.00000E+00	2.1040	0.00	0.00	0.00
70	3.0833	0.00000E+00	2.1040	0.00	0.00	0.00
71	4.2708	0.00000E+00	2.1040	0.00	0.00	0.00
72	5.5000	0.00000E+00	2.1040	0.00	0.00	0.00
73	1.2310	0.21706	2.1040	0.00	0.00	0.00
74	2.4825	0.43773	2.1040	0.00	0.00	0.00
75	2.5438	0.44853	2.1040	0.00	0.00	0.00
76	2.8727	0.50653	2.1040	0.00	0.00	0.00
77	3.0365	0.53541	2.1040	0.00	0.00	0.00
78	4.2059	0.74162	2.1040	0.00	0.00	0.00
79	5.4164	0.95506	2.1040	0.00	0.00	0.00
81	0.00000E+00	0.00000E+00	2.4375	0.00	0.00	0.00
83	2.5208	0.00000E+00	2.4375	0.00	0.00	0.00
84	2.5830	0.00000E+00	2.4375	0.00	0.00	0.00
85	2.9170	0.00000E+00	2.4375	0.00	0.00	0.00
86	3.0833	0.00000E+00	2.4375	0.00	0.00	0.00

NODE	X	Y	Z	THXY	THYZ	THXZ
87	4.2708	0.00000E+00	2.4375	0.00	0.00	0.00
88	5.5000	0.00000E+00	2.4375	0.00	0.00	0.00
90	2.4825	0.43773	2.4375	0.00	0.00	0.00
91	2.5438	0.44853	2.4375	0.00	0.00	0.00
92	2.8727	0.50653	2.4375	0.00	0.00	0.00
93	3.0365	0.53541	2.4375	0.00	0.00	0.00
94	4.2059	0.74162	2.4375	0.00	0.00	0.00
95	5.4164	0.95506	2.4375	0.00	0.00	0.00
97	0.00000E+00	0.00000E+00	5.1042	0.00	0.00	0.00
99	2.5208	0.00000E+00	5.1042	0.00	0.00	0.00
100	2.5830	0.00000E+00	5.1042	0.00	0.00	0.00
101	2.9170	0.00000E+00	5.1042	0.00	0.00	0.00
102	3.0833	0.00000E+00	5.1042	0.00	0.00	0.00
103	4.2708	0.00000E+00	5.1042	0.00	0.00	0.00
104	5.5000	0.00000E+00	5.1042	0.00	0.00	0.00
106	2.4825	0.43773	5.1042	0.00	0.00	0.00
107	2.5438	0.44853	5.1042	0.00	0.00	0.00
108	2.8727	0.50653	5.1042	0.00	0.00	0.00
109	3.0365	0.53541	5.1042	0.00	0.00	0.00
110	4.2059	0.74162	5.1042	0.00	0.00	0.00

NODE	X	Y	Z	THXY	THYZ	THXZ
111	5.4164	0.95506	5.1042	0.00	0.00	0.00
113	0.00000E+00	0.00000E+00	6.4376	0.00	0.00	0.00
115	2.5208	0.00000E+00	6.4376	0.00	0.00	0.00
116	2.5830	0.00000E+00	6.4376	0.00	0.00	0.00
117	2.9170	0.00000E+00	6.4376	0.00	0.00	0.00

Table 2 (cont-d)

118	3.0833	0.00000E+00	6.4376	0.00	0.00	0.00
119	4.2708	0.00000E+00	6.4376	0.00	0.00	0.00
120	5.5000	0.00000E+00	6.4376	0.00	0.00	0.00
122	2.4825	0.43773	6.4376	0.00	0.00	0.00
123	2.5438	0.44853	6.4376	0.00	0.00	0.00
124	2.8727	0.50653	6.4376	0.00	0.00	0.00
125	3.0365	0.53541	6.4376	0.00	0.00	0.00
126	4.2059	0.74162	6.4376	0.00	0.00	0.00
127	5.4164	0.95506	6.4376	0.00	0.00	0.00
129	0.00000E+00	0.00000E+00	9.1043	0.00	0.00	0.00
131	2.5208	0.00000E+00	9.1043	0.00	0.00	0.00
132	2.5830	0.00000E+00	9.1043	0.00	0.00	0.00
133	2.9170	0.00000E+00	9.1043	0.00	0.00	0.00
134	3.0833	0.00000E+00	9.1043	0.00	0.00	0.00
135	4.2708	0.00000E+00	9.1043	0.00	0.00	0.00

NODE	X	Y	Z	THXY	THYZ	THXZ
136	5.5000	0.00000E+00	9.1043	0.00	0.00	0.00
138	2.4825	0.43773	9.1043	0.00	0.00	0.00
139	2.5438	0.44853	9.1043	0.00	0.00	0.00
140	2.8727	0.50653	9.1043	0.00	0.00	0.00
141	3.0365	0.53541	9.1043	0.00	0.00	0.00
142	4.2059	0.74162	9.1043	0.00	0.00	0.00
143	5.4164	0.95506	9.1043	0.00	0.00	0.00
144	7.9696	0.69725	9.1043	0.00	0.00	0.00
145	0.00000E+00	0.00000E+00	11.771	0.00	0.00	0.00
147	2.5208	0.00000E+00	11.771	0.00	0.00	0.00
148	2.5830	0.00000E+00	11.771	0.00	0.00	0.00
149	2.9170	0.00000E+00	11.771	0.00	0.00	0.00
150	3.0833	0.00000E+00	11.771	0.00	0.00	0.00
151	4.2708	0.00000E+00	11.771	0.00	0.00	0.00
152	5.5000	0.00000E+00	11.771	0.00	0.00	0.00
154	2.4825	0.43773	11.771	0.00	0.00	0.00
155	2.5438	0.44853	11.771	0.00	0.00	0.00
156	2.8727	0.50653	11.771	0.00	0.00	0.00
157	3.0365	0.53541	11.771	0.00	0.00	0.00
158	4.2059	0.74162	11.771	0.00	0.00	0.00

NODE	X	Y	Z	THXY	THYZ	THXZ
159	5.4164	0.95506	11.771	0.00	0.00	0.00
161	0.00000E+00	0.00000E+00	14.438	0.00	0.00	0.00
163	2.5208	0.00000E+00	14.438	0.00	0.00	0.00
164	2.5830	0.00000E+00	14.438	0.00	0.00	0.00
165	2.9170	0.00000E+00	14.438	0.00	0.00	0.00
166	3.0833	0.00000E+00	14.438	0.00	0.00	0.00
167	4.2708	0.00000E+00	14.438	0.00	0.00	0.00
168	5.5000	0.00000E+00	14.438	0.00	0.00	0.00
170	2.4825	0.43773	14.438	0.00	0.00	0.00
171	2.5438	0.44853	14.438	0.00	0.00	0.00
172	2.8727	0.50653	14.438	0.00	0.00	0.00
173	3.0365	0.53541	14.438	0.00	0.00	0.00
174	4.2059	0.74162	14.438	0.00	0.00	0.00
175	5.4164	0.95506	14.438	0.00	0.00	0.00
177	0.00000E+00	0.00000E+00	16.143	0.00	0.00	0.00
178	1.2500	0.00000E+00	16.143	0.00	0.00	0.00
179	2.5208	0.00000E+00	16.143	0.00	0.00	0.00
180	2.5830	0.00000E+00	16.143	0.00	0.00	0.00
181	2.9170	0.00000E+00	16.143	0.00	0.00	0.00
182	3.0833	0.00000E+00	16.143	0.00	0.00	0.00

Table 2 (cont-d)

NODE	X	Y	Z	THXY	THYZ	THXZ
183	4.2708	0.00000E+00	16.143	0.00	0.00	0.00
184	5.5000	0.00000E+00	16.143	0.00	0.00	0.00
185	1.2310	0.21706	16.143	0.00	0.00	0.00
186	2.4825	0.43773	16.143	0.00	0.00	0.00
187	2.5438	0.44853	16.143	0.00	0.00	0.00
188	2.8727	0.50653	16.143	0.00	0.00	0.00
189	3.0365	0.53541	16.143	0.00	0.00	0.00
190	4.2059	0.74162	16.143	0.00	0.00	0.00
191	5.4164	0.95506	16.143	0.00	0.00	0.00
193	0.00000E+00	0.00000E+00	17.186	0.00	0.00	0.00
194	1.2500	0.00000E+00	17.186	0.00	0.00	0.00
195	2.5208	0.00000E+00	17.186	0.00	0.00	0.00
196	2.5830	0.00000E+00	17.186	0.00	0.00	0.00
197	2.9170	0.00000E+00	17.186	0.00	0.00	0.00
198	3.0833	0.00000E+00	17.186	0.00	0.00	0.00
199	4.2708	0.00000E+00	17.186	0.00	0.00	0.00
200	5.5000	0.00000E+00	17.186	0.00	0.00	0.00
201	1.2310	0.21706	17.186	0.00	0.00	0.00
202	2.4825	0.43773	17.186	0.00	0.00	0.00
203	2.5438	0.44853	17.186	0.00	0.00	0.00

NODE	X	Y	Z	THXY	THYZ	THXZ
204	2.8727	0.50653	17.186	0.00	0.00	0.00
205	3.0365	0.53541	17.186	0.00	0.00	0.00
206	4.2059	0.74162	17.186	0.00	0.00	0.00
207	5.4164	0.95506	17.186	0.00	0.00	0.00
209	0.00000E+00	0.00000E+00	17.724	0.00	0.00	0.00
210	1.2500	0.00000E+00	17.724	0.00	0.00	0.00
211	2.5208	0.00000E+00	17.724	0.00	0.00	0.00
212	2.5830	0.00000E+00	17.724	0.00	0.00	0.00
213	2.9170	0.00000E+00	17.724	0.00	0.00	0.00
214	3.0833	0.00000E+00	17.724	0.00	0.00	0.00
215	4.2708	0.00000E+00	17.724	0.00	0.00	0.00
216	5.5000	0.00000E+00	17.724	0.00	0.00	0.00
217	1.2310	0.21706	17.724	0.00	0.00	0.00
218	2.4825	0.43773	17.724	0.00	0.00	0.00
219	2.5438	0.44853	17.724	0.00	0.00	0.00
220	2.8727	0.50653	17.724	0.00	0.00	0.00
221	3.0365	0.53541	17.724	0.00	0.00	0.00
222	4.2059	0.74162	17.724	0.00	0.00	0.00
223	5.4164	0.95506	17.724	0.00	0.00	0.00
225	0.00000E+00	0.00000E+00	17.786	0.00	0.00	0.00

NODE	X	Y	Z	THXY	THYZ	THXZ
226	1.2500	0.00000E+00	17.786	0.00	0.00	0.00
227	2.5208	0.00000E+00	17.786	0.00	0.00	0.00
228	2.5830	0.00000E+00	17.786	0.00	0.00	0.00
229	2.9170	0.00000E+00	17.786	0.00	0.00	0.00
230	3.0833	0.00000E+00	17.786	0.00	0.00	0.00
233	1.2310	0.21706	17.786	0.00	0.00	0.00
234	2.4825	0.43773	17.786	0.00	0.00	0.00
235	2.5438	0.44853	17.786	0.00	0.00	0.00
236	2.8727	0.50653	17.786	0.00	0.00	0.00
237	3.0365	0.53541	17.786	0.00	0.00	0.00
241	1.7999	0.15708E-01	19.500	0.00	0.00	0.00
242	5.4800	0.00000E+00	0.00000E+00	0.00	0.00	0.00
243	5.3967	0.95159	0.00000E+00	0.00	0.00	0.00
258	5.4800	0.00000E+00	1.8330	0.00	0.00	0.00
259	5.3967	0.95159	1.8330	0.00	0.00	0.00

Table 2 (cont-d)

274	5.4800	0.00000E+00	2.0000	0.00	0.00	0.00
275	5.3967	0.95159	2.0000	0.00	0.00	0.00
290	5.4800	0.00000E+00	2.0417	0.00	0.00	0.00
291	5.3967	0.95159	2.0417	0.00	0.00	0.00
306	5.4800	0.00000E+00	2.1040	0.00	0.00	0.00

NODE	X	Y	Z	THXY	THYZ	THXZ
307	5.3967	0.95159	2.1040	0.00	0.00	0.00
322	5.4800	0.00000E+00	2.4375	0.00	0.00	0.00
323	5.3967	0.95159	2.4375	0.00	0.00	0.00
338	5.4800	0.00000E+00	5.1042	0.00	0.00	0.00
339	5.3967	0.95159	5.1042	0.00	0.00	0.00
354	5.4800	0.00000E+00	6.4375	0.00	0.00	0.00
355	5.3967	0.95159	6.4375	0.00	0.00	0.00
370	5.4800	0.00000E+00	9.1042	0.00	0.00	0.00
371	5.3967	0.95159	9.1042	0.00	0.00	0.00
386	5.4800	0.00000E+00	11.771	0.00	0.00	0.00
387	5.3967	0.95159	11.771	0.00	0.00	0.00
402	5.4800	0.00000E+00	14.437	0.00	0.00	0.00
403	5.3967	0.95159	14.437	0.00	0.00	0.00
418	5.4800	0.00000E+00	16.143	0.00	0.00	0.00
419	5.3967	0.95159	16.143	0.00	0.00	0.00
434	5.4800	0.00000E+00	17.185	0.00	0.00	0.00
435	5.3967	0.95159	17.185	0.00	0.00	0.00
450	5.4800	0.00000E+00	17.724	0.00	0.00	0.00
451	5.3967	0.95159	17.724	0.00	0.00	0.00
468	3.0833	0.00000E+00	17.703	0.00	0.00	0.00

NODE	X	Y	Z	THXY	THYZ	THXZ
469	4.2708	0.00000E+00	17.703	0.00	0.00	0.00
470	5.4800	0.00000E+00	17.703	0.00	0.00	0.00
471	5.5000	0.00000E+00	17.703	0.00	0.00	0.00
472	3.0365	0.53541	17.703	0.00	0.00	0.00
473	4.2059	0.74162	17.703	0.00	0.00	0.00
474	5.3967	0.95159	17.703	0.00	0.00	0.00
475	5.4164	0.95506	17.703	0.00	0.00	0.00
476	0.00000E+00	0.00000E+00	16.643	0.00	0.00	0.00
477	1.2500	0.00000E+00	16.643	0.00	0.00	0.00
478	2.5208	0.00000E+00	16.643	0.00	0.00	0.00
479	2.5830	0.00000E+00	16.643	0.00	0.00	0.00
480	0.00000E+00	0.00000E+00	16.809	0.00	0.00	0.00
481	1.2500	0.00000E+00	16.809	0.00	0.00	0.00
482	2.5208	0.00000E+00	16.809	0.00	0.00	0.00
483	2.5830	0.00000E+00	16.809	0.00	0.00	0.00
484	1.2310	0.21706	16.643	0.00	0.00	0.00
485	2.4825	0.43773	16.643	0.00	0.00	0.00
486	2.5438	0.44853	16.643	0.00	0.00	0.00
487	1.2310	0.21706	16.809	0.00	0.00	0.00
488	2.4825	0.43773	16.809	0.00	0.00	0.00

NODE	X	Y	Z	THXY	THYZ	THXZ
489	2.5438	0.44853	16.809	0.00	0.00	0.00

Table 3 Elements

LIST ALL ELEMENT TYPES

NO.	STIF	KEYOPT VALUES										INOTPR
	70	0	0	0	0	0	0	0	0	0	0	ISOPAR. SOLID THERMAL
	31	0	0	0	0	0	0	0	0	0	0	RADIATION LINK

LIST ALL SELECTED ELEMENTS. (LIST NODES)

ELEM	MAT	TYP	REL	NODES							
1	2	1	168	1	2	9	9	17	18	25	25
2	2	1	2	2	3	10	9	18	19	26	25
3	2	1	3	3	4	11	10	19	20	27	26
4	2	1	4	4	5	12	11	20	21	28	27
5	2	1	5	5	6	-13	12	21	22	29	28
6	2	1	6	6	7	14	13	22	23	30	29
7	2	1	7	7	242	243	14	23	258	259	30
8	1	1	8	17	18	25	25	33	34	41	41
9	1	1	9	18	19	26	25	34	35	42	41
10	1	1	10	19	20	27	26	35	36	43	42
11	1	1	11	20	21	28	27	36	37	44	43
12	1	1	12	21	22	29	28	37	38	45	44
13	2	1	13	22	23	30	29	38	39	46	45
14	2	1	14	23	258	259	30	39	274	275	46
15	2	1	15	33	34	41	41	49	50	57	57
16	2	1	16	34	35	42	41	50	51	58	57
17	1	1	17	35	36	43	42	51	52	59	58
19	1	1	19	37	38	45	44	53	54	61	60
20	2	1	20	38	39	46	45	54	55	62	61
21	2	1	21	39	274	275	46	55	290	291	62

ELEM	MAT	TYP	REL	NODES							
22	1	1	22	49	50	57	57	65	66	73	73
23	1	1	23	50	51	58	57	66	67	74	73
24	1	1	24	51	52	59	58	67	68	75	74
26	1	1	26	53	54	61	60	69	70	77	76
27	2	1	27	54	55	62	61	70	71	78	77
28	2	1	28	55	290	291	62	71	306	307	78
29	5	1	29	65	66	73	73	81	83	90	90
30	5	1	30	73	74	90	90	66	67	83	83
31	1	1	31	67	68	75	74	83	84	91	90
33	1	1	33	69	70	77	76	85	86	93	92
34	2	1	34	70	71	78	77	86	87	94	93
35	2	1	35	71	306	307	78	87	322	323	94
37	4	1	37	81	83	90	90	97	99	106	106
38	1	1	38	83	84	91	90	99	100	107	106
40	1	1	40	85	86	93	92	101	102	109	108
41	2	1	41	86	87	94	93	102	103	110	109
42	2	1	42	87	322	323	94	103	338	339	110
44	4	1	44	97	99	106	106	113	115	122	122
45	1	1	45	99	100	107	106	115	116	123	122
47	1	1	47	101	102	109	108	117	118	125	124

ELEM	MAT	TYP	REL	NODES							
48	2	1	48	102	103	110	109	118	119	126	125
49	2	1	49	103	338	339	110	119	354	355	126
51	4	1	51	113	115	122	122	129	131	138	138

Table 3 (cont-d)

52	1	1	52	115	116	123	122	131	132	139	138
54	1	1	54	117	118	125	124	133	134	141	140
55	2	1	55	118	119	126	125	134	135	142	141
56	2	1	56	119	354	355	126	135	370	371	142
58	4	1	58	129	131	138	138	145	147	154	154
59	1	1	59	131	132	139	138	147	148	155	154
61	1	1	61	133	134	141	140	149	150	157	156
62	2	1	62	134	135	142	141	150	151	158	157
63	2	1	63	135	370	371	142	151	386	387	158
65	4	1	65	145	147	154	154	161	163	170	170
66	4	1	65	147	148	155	154	163	164	171	170
68	1	1	68	149	150	157	156	165	166	173	172
69	2	1	69	150	151	158	157	166	167	174	173
70	2	1	70	151	386	387	158	167	402	403	174
71	5	1	71	161	163	170	170	177	178	185	185
72	5	1	72	185	170	186	186	178	163	179	179
73	1	1	73	163	164	171	170	179	180	187	186

ELEM	MAT	TYP	REL	NODES							
75	1	1	75	165	166	173	172	181	182	189	188
76	2	1	76	166	167	174	173	182	183	190	189
77	2	1	77	167	402	403	174	183	418	419	190
78	1	1	78	177	178	185	185	476	477	484	484
79	1	1	78	178	179	186	185	477	478	485	484
80	1	1	78	179	180	187	186	478	479	486	485
82	1	1	82	181	182	189	188	197	198	205	204
83	2	1	83	182	183	190	189	198	199	206	205
84	2	1	84	183	418	419	190	199	434	435	206
85	3	1	85	193	194	201	201	209	210	217	217
86	3	1	86	194	195	202	201	210	211	218	217
87	1	1	87	195	196	203	202	211	212	219	218
88	1	1	88	196	197	204	203	212	213	220	219
89	1	1	89	197	198	205	204	213	468	472	220
90	2	1	90	198	199	206	205	468	469	473	472
91	2	1	91	199	434	435	206	469	470	474	473
92	1	1	92	209	210	217	217	225	226	233	233
93	1	1	93	210	211	218	217	226	227	234	233
94	1	1	94	211	212	219	218	227	228	235	234
95	1	1	95	212	213	220	219	228	229	236	235

ELEM	MAT	TYP	REL	NODES							
96	1	1	96	213	214	221	220	229	230	237	236
97	3	2	97	8	144						
98	3	2	98	24	144						
99	3	2	99	40	144						
100	3	2	100	56	144						
101	3	2	101	72	144						
102	3	2	102	88	144						
103	3	2	103	104	144						
104	3	2	104	120	144						
105	3	2	105	136	144						
106	3	2	106	152	144						
107	3	2	107	168	144						
108	3	2	108	184	144						
109	3	2	109	200	144						
110	3	2	110	216	144						
111	3	2	111	230	241						
112	3	2	97	15	144						

Table 3 (cont-d)

113	3	2	98	31	144
114	3	2	99	47	144
115	3	2	100	63	144

ELEM	MAT	TYP	REL		
116	3	2	101	79	144
117	3	2	102	95	144
118	3	2	103	111	144
119	3	2	104	127	144
120	3	2	105	143	144
121	3	2	106	159	144
122	3	2	107	175	144
123	3	2	108	191	144
124	3	2	109	207	144
125	3	2	110	223	144
126	3	2	111	237	241
127	3	2	127	52	53
128	3	2	128	68	69
129	3	2	129	84	85
130	3	2	130	100	101
131	3	2	131	116	117
132	3	2	132	132	133
133	3	2	133	148	149
134	3	2	134	164	165
135	3	2	135	180	181

ELEM	MAT	TYP	REL								
136	3	2	127	59	60						
137	3	2	128	75	76						
138	3	2	129	91	92						
139	3	2	130	107	108						
140	3	2	131	123	124						
141	3	2	132	139	140						
142	3	2	133	155	156						
143	3	2	134	171	172						
144	3	2	135	187	188						
145	3	2	145	193	209						
146	3	2	146	194	210						
147	3	2	146	201	217						
148	3	2	148	225	241						
149	3	2	149	227	241						
150	3	2	149	234	241						
151	3	2	151	215	241						
152	3	2	151	222	241						
153	2	1	168	242	8	15	243	258	24	31	259
154	2	1	168	258	24	31	259	274	40	47	275
155	2	1	168	274	40	47	275	290	56	63	291

ELEM	MAT	TYP	REL								
156	2	1	168	290	56	63	291	306	72	79	307
157	2	1	168	306	72	79	307	322	88	95	323
158	2	1	168	322	88	95	323	338	104	111	339
159	2	1	168	338	104	111	339	354	120	127	355
160	2	1	168	354	120	127	355	370	136	143	371
161	2	1	168	370	136	143	371	386	152	159	387
162	2	1	168	386	152	159	387	402	168	175	403
163	2	1	168	402	168	175	403	418	184	191	419

Table 3 (cont'd)

ELEM	MAT	TYP	REL	NODES							
164	2	1	168	418	184	191	419	434	200	207	435
165	2	1	168	434	200	207	435	450	216	223	451
166	3	2	166	226	241						
167	3	2	166	233	241						
168	3	2	168	214	241						
169	3	2	168	221	241						
170	1	1	170	221	472	220	220	214	468	213	213
171	2	1	171	468	469	473	472	214	215	222	221
172	2	1	172	469	470	474	473	215	450	451	222
173	2	1	173	470	471	475	474	450	216	223	451
174	10	1	170	476	477	484	484	480	481	487	487
175	10	1	170	477	478	485	484	481	482	488	487
176	1	1	170	478	479	486	485	482	483	489	488
177	1	1	170	480	481	487	487	193	194	201	201
178	1	1	170	481	482	488	487	194	195	202	201
179	1	1	170	482	483	489	488	195	196	203	202

Table 4 Real constants

LIST ALL REAL SETS

REAL CONSTANT SET 97	ITEMS 1 TO 6				
0.44000	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 98	ITEMS 1 TO 6				
0.48000	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 99	ITEMS 1 TO 6				
0.50000E-01	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 100	ITEMS 1 TO 6				
0.25000E-01	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 101	ITEMS 1 TO 6				
0.95000E-01	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 102	ITEMS 1 TO 6				
0.71880	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 103	ITEMS 1 TO 6				
0.96000	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 104	ITEMS 1 TO 6				
0.96000	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 105	ITEMS 1 TO 6				
1.2793	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 106	ITEMS 1 TO 6				
1.2810	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 107	ITEMS 1 TO 6				
1.0500	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 108	ITEMS 1 TO 6				
0.65900	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 109	ITEMS 1 TO 6				
0.37940	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 110	ITEMS 1 TO 6				
0.12900	0.14000	0.90000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 111	ITEMS 1 TO 6				
0.48950E-01	1.0000	0.80000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 127	ITEMS 1 TO 6				
0.16500E-01	1.0000	0.80000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 128	ITEMS 1 TO 6				
0.44600E-01	1.0000	0.80000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 129	ITEMS 1 TO 6				
0.33800	1.0000	0.80000	0.17140E-08	0.00000E+00	0.00000E+00
REAL CONSTANT SET 130	ITEMS 1 TO 6				
0.45100	1.0000	0.80000	0.17140E-08	0.00000E+00	0.00000E+00

Table 4 (cont-d)

REAL CONSTANT SET 131 ITEMS 1 TO 6
0.45100 1.0000 0.80000 0.17140E-08 0.00000E+00 0.00000E+00

REAL CONSTANT SET 132 ITEMS 1 TO 6
0.60000 1.0000 0.80000 0.17140E-08 0.00000E+00 0.00000E+00

REAL CONSTANT SET 133 ITEMS 1 TO 6
0.60200 1.0000 0.80000 0.17140E-08 0.00000E+00 0.00000E+00

REAL CONSTANT SET 134 ITEMS 1 TO 6
0.49300 1.0000 0.80000 0.17140E-08 0.00000E+00 0.00000E+00

REAL CONSTANT SET 135 ITEMS 1 TO 6
0.42700 1.0000 0.80000 0.17140E-08 0.00000E+00 0.00000E+00

REAL CONSTANT SET 145 ITEMS 1 TO 6
0.60600E-01 1.0000 0.80000 0.17140E-08 0.00000E+00 0.00000E+00

REAL CONSTANT SET 146 ITEMS 1 TO 6
0.24700 1.0000 0.80000 0.17140E-08 0.00000E+00 0.00000E+00

REAL CONSTANT SET 148 ITEMS 1 TO 6
0.60600E-01 1.0000 0.80000 0.17140E-08 0.00000E+00 0.00000E+00

REAL CONSTANT SET 149 ITEMS 1 TO 6
0.17400 1.0000 0.80000 0.17140E-08 0.00000E+00 0.00000E+00

REAL CONSTANT SET 151 ITEMS 1 TO 6
0.66500 1.0000 0.90000 0.17140E-08 0.00000E+00 0.00000E+00

REAL CONSTANT SET 166 ITEMS 1 TO 6
0.16200 1.0000 0.80000 0.17140E-08 0.00000E+00 0.00000E+00

REAL CONSTANT SET 168 ITEMS 1 TO 6
0.24000 1.0000 0.90000 0.17140E-08 0.00000E+00 0.00000E+00

Calculations of Average C_p and ρ for fuel Region

C_p He = 1.24 Btu/lbm°F $C_p UO_2$ = 0.06 Btu/lbm°F

ρ_{fuel} = 525 lbm/ft³

C_p Steel = 0.11 Btu/lbm°F ρ_{steel} = (0.281 lbm/in³)

ρ_{He} = 0.0064

Wt. steel in MSB = 10,678 lbm

wt fuel in MSB = (24 ASSY)(1516 lbm/ASSY) = 36384 lbm

MSB internal Volume = $\frac{\pi}{4}(60.5)^2(160)\left(\frac{1}{12 \cdot 144}\right)$ = 266.18 ft³

fuel Volume = 36384 lbm / 525 lbm/ft³ = 69.303 ft³

Steel Volume = (10678)/(0.281 × 12 × 144) = 21.99 ft³

He volume = 266.18 − 69.303 − 21.99 = 174.9 ft³

wt He in MSB = (0.0064 lbm/ft³)(174.9 ft³) = 1.05 lbm

$$\bar{C}_p = \frac{(36384)(0.06) + (10678)(0.11) + (1.05)(1.24)}{(36384 + 10678 + 1.05)}$$

$\bar{C}_p$ = 0.0715 Btu/lbm°F

$$\bar{\rho} = \frac{(36384 + 10678 + 1.05)}{(266.18)}$$

$\bar{\rho}$ = 176.8 lbm/ft³

~~$\bar{K}$ = 0.6 Btu/hr ft °F~~

BAC 1/9/90
The K is calculated on the page 24.

Calc of Fuel Region effective K

$q_r'' = K \nabla T \Rightarrow K = q_r'' / \nabla T$

$q_r'' = \frac{Q}{A_s} = \frac{Q}{2\pi R L_1}$

$\nabla T = \frac{\partial T}{\partial r} = \frac{\Delta T}{R}$

$K = \frac{Q}{2\pi R L} \cdot \frac{R}{\Delta T} = \frac{Q}{2\pi L \Delta T}$

$\Delta T = 698 - 242 = 456°F$

$Q = (24\ KW)(3412\ \frac{KW}{BTU/HR}) = 81888\ Btu/HR$

$L = 12\ ft$

$\therefore K = \frac{(81888\ BTU/HR)}{2\pi (12\ FT)(456°F)} = 2.382\ \frac{Btu}{hr\,ft\,°F}$

Table 5. Static Heat Transfer Properties

Steel: (Low Carbon [3.1.2], assumed at 1%C) Material 1.

c_p=0.11 (Btu/lbm-°F) [2.7/pg.646], ρ=490.0 (lbm/ft^3) [2.7/pg.634], K=26.0 Btu/hr°F-ft, as average over 32 to 600F

Concrete: Material 2

K (Btu/hr°F-ft)	ρ (lbm/ft^3)	c_p (Btu/lbm°F)		
0.867	140.0	-	(Dense)	[2.6/pg.9-9])
0.540	144.0	0.20	(Stone)	[2.1/pg.635])
0.750	140.0	0.22	(Oven dried sand and gravel)	[2.4/pg.22.15])
Avg. 0.719	141.3	0.21	* Used in analysis	

Air: Material 3.

Temp. (°F)	K (Btu/hr°F-ft)	ρ (lbm/ft^3)	c_p (Btu/lbm°F)	(All [2.1/pg.636])
<-50	0.0114	0.094	0.2385	[2.2/pg.7-14]
-50	0.0114	0.094	0.2385	(extrapolated)
0	0.0130	0.086	0.239	
32	0.0140	0.081	0.240	
100	0.0154	0.071	0.240	
200	0.0174	0.060	0.241	
300	0.0193	0.052	0.243	
500	0.0231	0.412	0.247	
700	0.0268	0.373	0.253	
>700	0.0268	0.373	0.253	[2.2/pg.7-14]

Heated Fuel Region: Material 4.

c_p=0.071 (Btu/lbm-°F), ρ=176.8 (lbm/ft^3) (as Helium), K=2.38 Btu/hr°F-ft, to represent a mix of metal, helium and fuel.

See calculations on pages

Helium Top and Bottom: Material 5.

c_p=1.24 (Btu/lbm-°F), ρ=.0064 (lbm/ft^3), K=0.10 Btu/hr°F-ft, [2.1/pg.637]

Rx-277 : Material 10

C_p = 0.22 (Btu/lbm-°F), ρ = 106 lbm/ft^3, K_x = 0.3 Btu/hr°F-ft

Continued on the next pages

Table 5. Materials
(continued)

```
LIST ALL MATERIALS  PROPERTY= ALL

PROPERTY TABLE C      MAT=   1  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.11000        2300.0      0.11000

PROPERTY TABLE DENS   MAT=   1  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00  490.00        2300.0       490.00

PROPERTY TABLE KXX    MAT=   1  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00  26.200        2300.0       26.200

PROPERTY TABLE EMIS   MAT=   1  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.80000        2300.0      0.80000

PROPERTY TABLE KXX    MAT=   2  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.71900        2300.0      0.71900

PROPERTY TABLE DENS   MAT=   2  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00  141.30        2300.0       141.30

PROPERTY TABLE C      MAT=   2  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.21000        2300.0      0.21000

PROPERTY TABLE EMIS   MAT=   2  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.90000        2300.0      0.90000

PROPERTY TABLE KXX    MAT=   3  NUM. POINTS=  8
      TEMPERATURE      DATA          TEMPERATURE      DATA
      -50.000     0.11400E-01  0.00000E+00 0.13000E-01
       32.000     0.14000E-01   100.00     0.15400E-01
       200.00     0.17400E-01   300.00     0.19300E-01
       500.00     0.23100E-01   700.00     0.26800E-01

PROPERTY TABLE DENS   MAT=   3  NUM. POINTS=  8
      TEMPERATURE      DATA          TEMPERATURE      DATA
      -50.000     0.94000E-01  0.00000E+00 0.86000E-01
       32.000     0.81000E-01   100.00     0.71000E-01
       200.00     0.60000E-01   300.00     0.52000E-01
       500.00     0.41200E-01   700.00     0.37300E-01

PROPERTY TABLE C      MAT=   3  NUM. POINTS=  8
      TEMPERATURE      DATA          TEMPERATURE      DATA
      -50.000     0.23850      0.00000E+00 0.23900
       32.000     0.24000       100.00     0.24000
       200.00     0.24100       300.00     0.24300
       500.00     0.24700       700.00     0.25300

PROPERTY TABLE EMIS   MAT=   3  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.85000        2300.0      0.85000
```

Note:
Materials
6 to 9
are not used
(see elements input data)
BAC 1/9/90

Table 5 (continued)

```
PROPERTY TABLE KXX    MAT=    4  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00  2.3800        2300.0        2.3800

PROPERTY TABLE C      MAT=    4  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.71500E-01   2300.0      0.71500E-01

PROPERTY TABLE DENS   MAT=    4  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00  176.80        2300.0        176.80

PROPERTY TABLE KXX    MAT=    5  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.10000        2300.0      0.10000

PROPERTY TABLE C      MAT=    5  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00  1.2400        2300.0        1.2400

PROPERTY TABLE DENS   MAT=    5  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.65000E-02   2300.0      0.65000E-02

PROPERTY TABLE EMIS   MAT=    6  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.85000        2300.0      0.85000

PROPERTY TABLE EMIS   MAT=    7  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.85000        2300.0      0.85000

PROPERTY TABLE EMIS   MAT=    8  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.85000        2300.0      0.85000

PROPERTY TABLE KXX    MAT=    9  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00  10.000        2300.0        10.000

PROPERTY TABLE C      MAT=    9  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.11000        2300.0      0.11000

PROPERTY TABLE DENS   MAT=    9  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00  488.00        2300.0        488.00

PROPERTY TABLE DENS   MAT=   10  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00  106.00        2300.0        106.00

PROPERTY TABLE KXX    MAT=   10  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.30000        2300.0      0.30000

PROPERTY TABLE C      MAT=   10  NUM. POINTS=  2
      TEMPERATURE      DATA          TEMPERATURE      DATA
    0.00000E+00 0.22000        2300.0      0.22000
```

Table 6. Radiation Properties

	Temp. (°F)	ϵ (Total Normal)	α (Solar)	
Concrete:				
	50→100	0.85*→0.95	-[2.4/pg.2.9] (low spec. includes brick & masonry)	
	100	0.94*	-[2.5/pg.48] (rough concrete)	
	100	0.93	-[2.1/pg.237] (red brick)	
Steel:				
	(thermal)	0.94→0.98	-[2.1/pg.236] (rough plate)	
	100	0.80*	-[2.5/pg.46] (sheet, strong, rough oxide)	
	500	0.79*	-[2.5/pg.46] (oxidized at 1100°F)	
	130→500	0.78→0.82*	-[2.8/pg.4-73] (Smooth oxidized)	

Used in the Analysis

Material	ϵ	
Steel:		
all surfaces:	0.80	[2.5, 2.8]
Concrete:		
outer surfaces:	0.90	[2.1]

See Table 4 for input of these results.

Table 7

Calculations of the area for radiation links

AREA CALCULATIONS FOR RADIATION EL-S FOR VCC-24 THERMAL ANALYS

RO	5.5	OUT.RAD	KOEFF.	0.239937	OUTSIDE
RI	2.583	IN.RAD	KOEFF.	0.112683	GAP
TH	0.1745	ANGLE	KOEFF.	0.08725	TOP

Z (FT)	SIDE REAL SET #	AREA	GAP REAL SET #	AREA
0	97	0.439805		
1.833	98	0.479875		
2	99	0.050146		
2.042	100	0.024953	127	0.016451
2.104	101	0.095015	128	0.044622
2.438	102	0.718852	129	0.337599
5.1	103	0.960229	130	0.450958
6.44	104	0.95975	131	0.450733
9.1	105	1.279106	132	0.600715
11.771	106	1.280786	133	0.601503
14.438	107	1.049006	134	0.492651
16.143	108	0.659348	135	0.427182
17.186	109	0.379341		
17.724	110	0.129086		
17.786				

R (FT)	COVER REAL SET	AREA	CONCRETE REAL SET	AREA
0	148	0.060590		
1.25	166	0.161480		
2.52	149	0.173930		
3.083	111	0.048944		
3.083			168	0.240180
4.27			151	0.664824

Calculations for the fuel heat generation input

Total heat generation rate

$$Q = 24\ kWt \cdot 3412\ \frac{Btu/hr}{kWt} = 81,888\ \frac{Btu}{hr}$$

Average per unit of volume

$$q_{av} = \frac{Q}{V} = \frac{81,888}{30.5^2 \pi \cdot 144}\ 1728\ \frac{in^3}{ft^3} = 336.2\ Btu/hr\text{-}ft^3$$

Element #s	Z_{av} (in)	K (Fig. 3)	$q = q_{av} K$
37	16	0.97	326.1
44	40	1.2	403.4
51	64	1.17	393.3
58	96	1.10	369.8
65	128	0.77	258.9

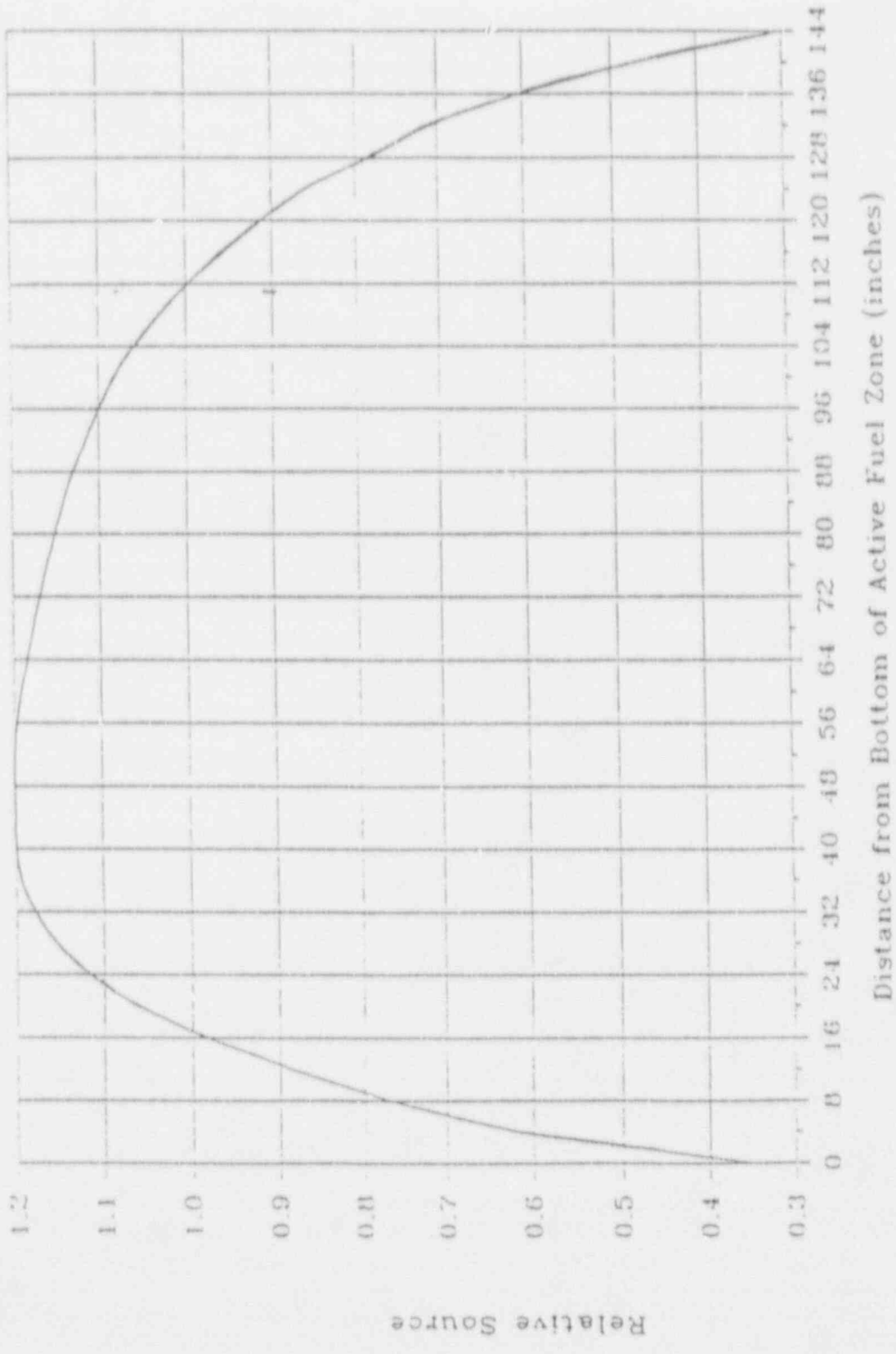


FIGURE 3

AXIAL HEAT SOURCE DISTRIBUTION

Table 8. 100't input: heat load, el. convections constant temperatures

LIST ELEM HEAT GENERATIONS FOR ALL SELECTED ELEMENTS

ELEMENT	HEAT GENERATIONS
37	326.100000
44	403.400000
51	393.300000
58	369.800000
65	258.900000
92	1966.00000
93	1966.00000
94	1966.00000
95	1966.00000
96	1966.00000
153	2950.00000
154	2950.00000
155	2950.00000
156	2950.00000
157	2950.00000
158	2950.00000
159	2950.00000
160	2950.00000
161	2950.00000
162	2950.00000
163	2950.00000
164	2950.00000
165	2950.00000
171	5900.00000
172	5900.00000
173	5900.00000

LIST ELEMENT CONVECTIONS FOR ALL SELECTED ELEMENTS

ELEM	FACE	VALUE(S)		FACE NODES			
17	3	2.00000000	100.000000	43	36	52	59
24	3	2.00000000	100.000000	59	52	68	75
31	3	2.00000000	100.000000	75	68	84	91
38	3	2.00000000	112.600000	91	84	100	107
45	3	2.00000000	130.440000	107	100	116	123
52	3	2.00000000	148.630000	123	116	132	139
59	3	2.00000000	171.490000	139	132	148	155
66	3	2.00000000	189.160000	155	148	164	171
73	3	2.00000000	192.240000	171	164	180	187
80	3	2.00000000	192.240000	187	180	479	486
19	5	2.00000000	100.000000	37	44	60	53
26	5	2.00000000	100.000000	53	60	76	69
33	5	2.00000000	100.000000	69	76	92	85
40	5	2.00000000	112.600000	85	92	108	101
47	5	2.00000000	130.440000	101	108	124	117
54	5	2.00000000	148.630000	117	124	140	133
61	5	2.00000000	171.490000	133	140	156	149
68	5	2.00000000	189.160000	149	156	172	165
75	5	2.00000000	192.240000	165	172	188	181
82	5	2.00000000	192.240000	181	188	204	197

ELEM	FACE	VALUE(S)		FACE NODES			
171	6	2.00000000	100.000000	215	214	221	222
172	6	2.00000000	100.000000	450	215	222	451
164	3	2.00000000	100.000000	191	184	200	207
96	6	2.00000000	100.000000	230	229	236	237
95	6	2.00000000	100.000000	229	228	235	236

Table 8 (cont-d)

94	6	2.00000000	100.000000	228	227	234	235
93	6	2.00000000	100.000000	227	226	233	234
92	6	2.00000000	100.000000	226	225	233	233
153	3	2.00000000	100.000000	15	8	24	31
154	3	2.00000000	100.000000	31	24	40	47
155	3	2.00000000	100.000000	47	40	56	63
156	3	2.00000000	100.000000	63	56	72	79
157	3	2.00000000	100.000000	79	72	88	95
158	3	2.00000000	100.000000	95	88	104	111
159	3	2.00000000	100.000000	111	104	120	127
160	3	2.00000000	100.000000	127	120	136	143
161	3	2.00000000	100.000000	143	136	152	159
162	3	2.00000000	100.000000	159	152	168	175
163	3	2.00000000	100.000000	175	168	184	191
165	3	2.00000000	100.000000	207	200	216	223

ELEM	FACE	VALUE(S)		FACE NODES			
173	3	2.00000000	100.000000	475	471	216	223
173	6	2.00000000	100.000000	216	450	451	223
179	3	2.00000000	192.240000	489	483	196	203
176	3	2.00000000	192.240000	486	479	483	489

LIST TEMPERATURES FOR ALL SELECTED NODES

NODE	LABEL	TEMPR	
144	TEMP	100.000000	0.000000000E+00
241	TEMP	100.000000	0.000000000E+00

Table 9. 100°F case results

PRINT NODAL TEMPERATURES

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
1	182.16874
2	177.71433
3	165.47065
4	165.04810
5	162.15530
6	159.73023
7	146.45632
8	130.77442
9	177.71434
10	165.47045
11	165.04792
12	162.15529
13	159.73029
14	146.45630

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
15	130.77441
17	198.53584
18	192.89140
19	182.63158
20	181.20944
21	173.99238
22	172.00646
23	147.25617
24	130.91962
25	192.89138
26	182.63198
27	181.20980
28	173.99240
29	172.00632

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
30	147.25620
31	130.91963
33	199.04618
34	192.85817
35	183.27238
36	182.54488
37	172.66971
38	171.23148
39	147.46399

Table 9 (cont-d)

40	131.04083
41	192.85805
42	183.27357
43	182.54633
44	172.66943

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
45	171.23102
46	147.46409
47	131.04086
49	204.15185
50	195.06845
51	186.03987
52	184.32904
53	171.31263
54	170.91317
55	147.52603
56	131.06907
57	195.06939
58	186.04764
59	184.33018

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
60	171.31240
61	170.91243
62	147.52619
63	131.06910
65	204.59834
66	194.99286
67	186.55570
68	187.15079
69	169.86023
70	170.11262
71	147.68578
72	131.08671
73	194.99320
74	186.56865

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
75	187.12195
76	169.86051
77	170.11093
78	147.68618
79	131.08667
81	523.42089

Table 9 (cont-d)

83	218.22739
84	217.44926
85	165.86507
86	166.03314
87	148.41442
88	131.36316
90	217.29020
91	216.61962

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
92	165.84905
93	166.02450
94	148.41643
95	131.36280
97	619.53448
99	263.62115
100	262.45445
101	180.24396
102	180.12339
103	154.67518
104	132.23873
106	262.45392
107	261.41656
108	180.20753

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
109	180.10266
110	154.67996
111	132.23814
113	661.72298
115	286.46328
116	285.20087
117	196.36908
118	196.13070
119	160.58761
120	133.60763
122	285.14642
123	284.03820
124	196.32774
125	196.10737

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
126	160.59299
127	133.60691
129	674.56863

Table 9 (cont-d)

131	299.63533
132	298.76342
133	214.33642
134	214.10933
135	169.56122
136	134.90811
138	298.43643
139	297.68849
140	214.29861
141	214.08791
142	169.56616

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
143	134.90743
144	100.00000
145	594.04955
147	295.89763
148	293.79432
149	220.31420
150	220.00735
151	171.57642
152	135.18528
154	294.64791
155	292.72736
156	220.27215
157	219.98358
158	171.58190

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
159	135.18459
161	518.32186
163	249.08715
164	247.09277
165	202.93520
166	202.71385
167	163.64598
168	134.01317
170	248.21996
171	246.37774
172	202.91481
173	202.70241
174	163.64862
175	134.01280

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP

Table 9 (cont-d)

177	180.82720
178	180.59026
179	183.19840
180	184.14632
181	181.69997
182	181.51032
183	154.38834
184	132.42271
185	180.57744
186	183.30964
187	184.21183
188	181.70838
189	181.51479
190	154.38732

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
191	132.42278
193	167.61615
194	168.87494
195	169.59054
196	168.75264
197	167.56475
198	167.76925
199	147.21297
200	133.30189
201	168.87386
202	169.58774
203	168.75259
204	167.56355
205	167.76884

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
206	147.21306
207	133.30189
209	150.33806
210	151.90375
211	162.05159
212	162.84864
213	163.06755
214	161.07926
215	134.59074
216	144.64261
217	151.76396
218	162.08528
219	162.86664
220	163.06750

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1

Table 9 (cont-d).

TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
221	161.07910
222	134.59075
223	144.64261
225	150.03328
226	151.72117
227	161.63302
228	162.56635
229	162.81542
230	160.85517
233	151.58075
234	161.67051
235	162.58468
236	162.81529
237	160.85507

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
241	100.00000
242	131.80090
243	131.80090
258	131.97001
259	131.97002
274	132.09061
275	132.09065
290	132.12256
291	132.12259
306	132.14528
307	132.14526
322	132.40229
323	132.40188
338	133.37925

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
339	133.37854
354	134.79307
355	134.79222
370	136.20816
371	136.20735
386	136.50720
387	136.50637
402	135.23552
403	135.23509
418	133.55379
419	133.55390
434	134.30554
435	134.30552
450	146.97284

Table 9 (cont-d)

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
451	146.97284
468	161.75596
469	137.15488
470	147.96284
471	146.00117
472	161.75578
473	137.15490
474	147.96284
475	146.00117
476	179.75208
477	181.29332
478	180.05273
479	179.40354
480	168.73866

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
481	168.42979
482	172.30162
483	173.15321
484	181.29782
485	180.02077
486	179.39110
487	168.43037
488	172.30134
489	173.14871

MAXIMUMS
NODE 129
VALUE 674.56863

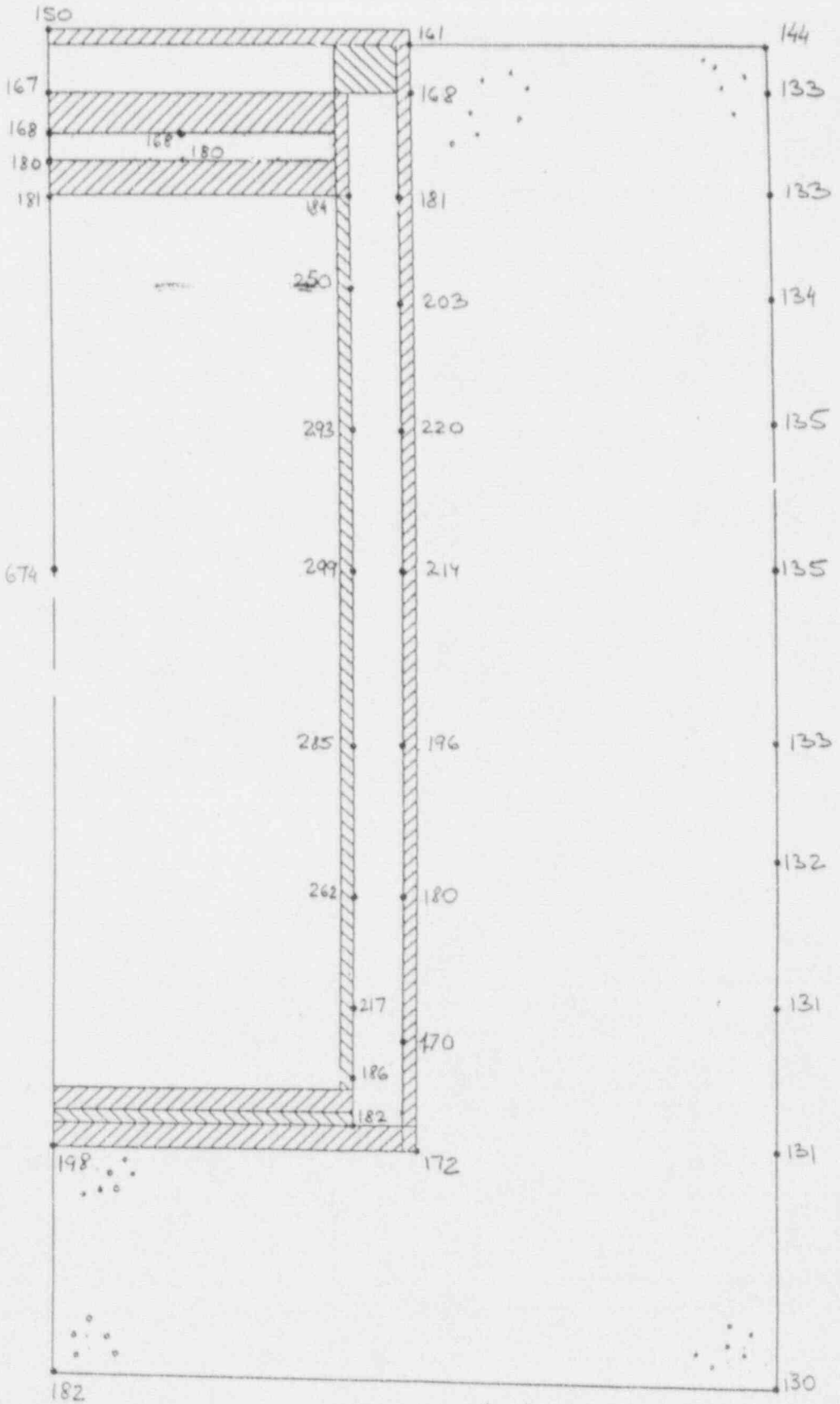


FIGURE 4

VCC TEMPERATURE DISTRIBUTION

100°F, full solar load

Table 10. -40 F input: heat load, el convections constant temperatures

LIST ELEM HEAT GENERATIONS FOR ALL SELECTED ELEMENTS

ELEMENT	HEAT GENERATIONS
37	326.100000
44	403.400000
51	393.300000
58	369.800000
65	258.900000

LIST ELEMENT CONVECTIONS FOR ALL SELECTED ELEMENTS

ELEM	FACE	VALUE(S)		FACE NODES			
17	3	2.00000000	-40.0000000	43	36	52	59
24	3	2.00000000	-40.0000000	59	52	68	75
31	3	2.00000000	-40.0000000	75	68	84	91
38	3	2.00000000	-30.4300000	91	84	100	107
45	3	2.00000000	-16.9000000	107	100	116	123
52	3	2.00000000	-3.10000000	123	116	132	139
59	3	2.00000000	14.2500000	139	132	148	155
66	3	2.00000000	27.6700000	155	148	164	171
73	3	2.00000000	30.0000000	171	164	180	187
80	3	2.00000000	30.0000000	187	180	479	486
19	5	2.00000000	-40.0000000	37	44	60	53
26	5	2.00000000	-40.0000000	53	60	76	69
33	5	2.00000000	-40.0000000	69	76	92	85
40	5	2.00000000	-30.4300000	85	92	108	101
47	5	2.00000000	-16.9000000	101	108	124	117
54	5	2.00000000	-3.10000000	117	124	140	133
61	5	2.00000000	14.2500000	133	140	156	149
68	5	2.00000000	27.6700000	149	156	172	165
75	5	2.00000000	30.0000000	165	172	188	181
82	5	2.00000000	30.0000000	181	188	204	197

ELEM	FACE	VALUE(S)		FACE NODES			
171	6	2.00000000	-40.0000000	215	214	221	222
172	6	2.00000000	-40.0000000	450	215	222	451
164	3	2.00000000	-40.0000000	191	184	200	207
96	6	2.00000000	-40.0000000	230	229	236	237
95	6	2.00000000	-40.0000000	229	228	235	236
94	6	2.00000000	-40.0000000	228	227	234	235
93	6	2.00000000	-40.0000000	227	226	233	234
92	6	2.00000000	-40.0000000	226	225	233	233
153	3	2.00000000	-40.0000000	15	8	24	31
154	3	2.00000000	-40.0000000	31	24	40	47
155	3	2.00000000	-40.0000000	47	40	56	63
156	3	2.00000000	-40.0000000	63	56	72	79
157	3	2.00000000	-40.0000000	79	72	88	95
158	3	2.00000000	-40.0000000	95	88	104	111
159	3	2.00000000	-40.0000000	111	104	120	127
160	3	2.00000000	-40.0000000	127	120	136	143
161	3	2.00000000	-40.0000000	143	136	152	159
162	3	2.00000000	-40.0000000	159	152	168	175
163	3	2.00000000	-40.0000000	175	168	184	191
165	3	2.00000000	-40.0000000	207	200	216	223

ELEM	FACE	VALUE(S)		FACE NODES			
173	3	2.00000000	-40.0000000	475	471	216	223
173	6	2.00000000	-40.0000000	216	450	451	223
179	3	2.00000000	30.0000000	489	483	196	203
176	3	2.00000000	30.0000000	486	479	483	489

Table 10 (cont-d)

LIST TEMPERATURES FOR ALL SELECTED NODES

NODE	LABEL	TEMPR	
144	TEMP	-40.0000000	0.000000000E+00
241	TEMP	-40.0000000	0.000000000E+00

Table 11. -40°F case results.

```
PRINT NODAL TEMPERATURES

        ***** POST1 NODAL TEMPERATURE LISTING *****

 LOAD STEP     1  ITERATION=    12  SECTION=  1
 TIME=   0.00000E+00     LOAD CASE=  1

   NODE       TEMP
     1     33.533683
     2     27.679710
     3     11.071659
     4     10.504022
     5     6.6237431
     6     3.3601016
     7    -14.330956
     8    -34.771347
     9     27.679719
    10     11.071471
    11     10.503848
    12     6.6237051
    13     3.3601316
    14    -14.330963

        ***** POST1 NODAL TEMPERATURE LISTING *****

 LOAD STEP     1  ITERATION=    12  SECTION=  1
 TIME=   0.00000E+00     LOAD CASE=  1

  NODE       TEMP
    15    -34.771347
    17     52.162855
    18     46.563684
    19     35.580424
    20     33.721875
    21     24.100089
    22     21.373545
    23    -13.748895
    24    -34.675911
    25     46.563665
    26     35.580813
    27     33.722235
    28     24.100169
    29     21.373483

        ***** POST1 NODAL TEMPERATURE LISTING *****

 LOAD STEP     1  ITERATION=    12  SECTION=  1
 TIME=   0.00000E+00     LOAD CASE=  1

   NODE       TEMP
    30    -13.748880
    31    -34.675909
    33     52.773953
    34     46.452450
    35     36.498346
    36     35.599017
    37     22.350446
    38     20.364315
    39    -13.629886
```

Table II (cont-d)

40	-34.605238
41	46.452328
42	36.499511
43	35.600429
44	22.350266

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
45	20.364116
46	-13.629843
47	-34.605236
49	58.143364
50	48.643285
51	40.397257
52	38.175111
53	20.580019
54	19.906165
55	-13.584940
56	-34.597324
57	48.644248
58	40.404856
59	38.176224

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
60	20.579888
61	19.905825
62	-13.584064
63	-34.597328
65	58.680441
66	48.490696
67	41.127132
68	42.004918
69	18.646966
70	18.771818
71	-13.427623
72	-34.582033
73	48.491113
74	41.139778

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
75	41.976746
76	18.647081
77	18.771044
78	-13.427442
79	-34.582050
81	389.98694

Table II (cont-d)

83	80.938851
84	80.167468
85	12.325451
86	12.516352
87	-12.760716
88	-34.463879
90	79.995669
91	79.328414

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
92	12.318197
93	12.512417
94	-12.759775
95	-34.463992
97	488.09014
99	136.23725
100	135.09126
101	16.586784
102	16.440706
103	-10.852514
104	-34.053508
106	135.06094
107	134.03891
108	16.565330

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
109	16.428525
110	-10.849617
111	-34.053716
113	531.85129
115	158.29074
116	157.03640
117	27.957774
118	27.753140
119	-6.9788395
120	-33.190137
122	156.96318
123	155.85593
124	27.933551
125	27.739465

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
126	-6.9755850
127	-33.190393
129	541.72950

Table II (cont.-d)

131	167.35460
132	166.48797
133	41.472702
134	41.261815
135	-0.42085331
136	-32.225631
138	166.14608
139	165.39970
140	41.450903
141	41.249459
142	-0.41791234

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
143	-32.225875
144	-40.000000
145	453.95454
147	157.49291
148	155.39846
149	45.670079
150	45.400465
151	0.96479890
152	-32.047802
154	156.23072
155	154.30411
156	45.645881
157	45.386797
158	0.96805030

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
159	-32.048041
161	374.84165
163	99.433413
164	97.422542
165	31.867767
166	31.673337
167	-5.5297055
168	-33.135850
170	98.554809
171	96.681261
172	31.858006
173	31.667848
174	-5.5283981
175	-33.135965

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP

Table II (cont-d)

177	18.333624
178	17.889132
179	20.851603
180	21.827559
181	15.122193
182	14.883781
183	-14.814881
184	-35.075976
185	17.876027
186	20.964989
187	21.901875
188	15.126352
189	14.885989
190	-14.815406

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
191	-35.075957
193	5.2625610
194	6.4057056
195	4.6542508
196	3.6050905
197	1.5619095
198	1.6916456
199	-25.128221
200	-37.226700
201	6.4056984
202	4.6542022
203	3.6055774
204	1.5610859
205	1.6913328

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
206	-25.128146
207	-37.226698
209	-25.670124
210	-20.957904
211	-4.8531961
212	-3.9470250
213	-3.2631743
214	-4.7600140
215	-35.156889
216	-38.312257
217	-20.957910
218	-4.8531705
219	-3.9472052
220	-3.2629584

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1

Table II (cont-d)

TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
221	-4.7600090
222	-35.156890
223	-38.312259
225	-25.797257
226	-20.968914
227	-5.1304573
228	-4.2328740
229	-3.5549042
230	-4.7273821
233	-20.968913
234	-5.1304497
235	-4.2329688
236	-3.5547593
237	-4.7273265

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
241	-40.000000
242	-32.909301
243	-32.909303
258	-32.726555
259	-32.726549
274	-32.637178
275	-32.637159
290	-32.615661
291	-32.615646
306	-32.617541
307	-32.617551
322	-32.539972
323	-32.540166
338	-31.865543

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
339	-31.866044
354	-30.818180
355	-30.818756
370	-29.341385
371	-29.341908
386	-29.069019
387	-29.069586
402	-30.656262
403	-30.656503
418	-33.319135
419	-33.319039
434	-36.406730
435	-36.406752
450	-37.708380

Table II (cont-d)

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
451	-37.708378
468	-4.3324949
469	-34.723640
470	-37.621620
471	-38.350655
472	-4.3324997
473	-34.723638
474	-37.621619
475	-38.350657
476	17.095090
477	18.771756
478	17.142237
479	16.421827
480	6.6610498

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
481	5.5169261
482	8.1155686
483	9.1091545
484	18.776331
485	17.109852
486	16.406617
487	5.5170510
488	8.1147435
489	9.1050972

MAXIMUMS

NODE	129
VALUE	541.72950

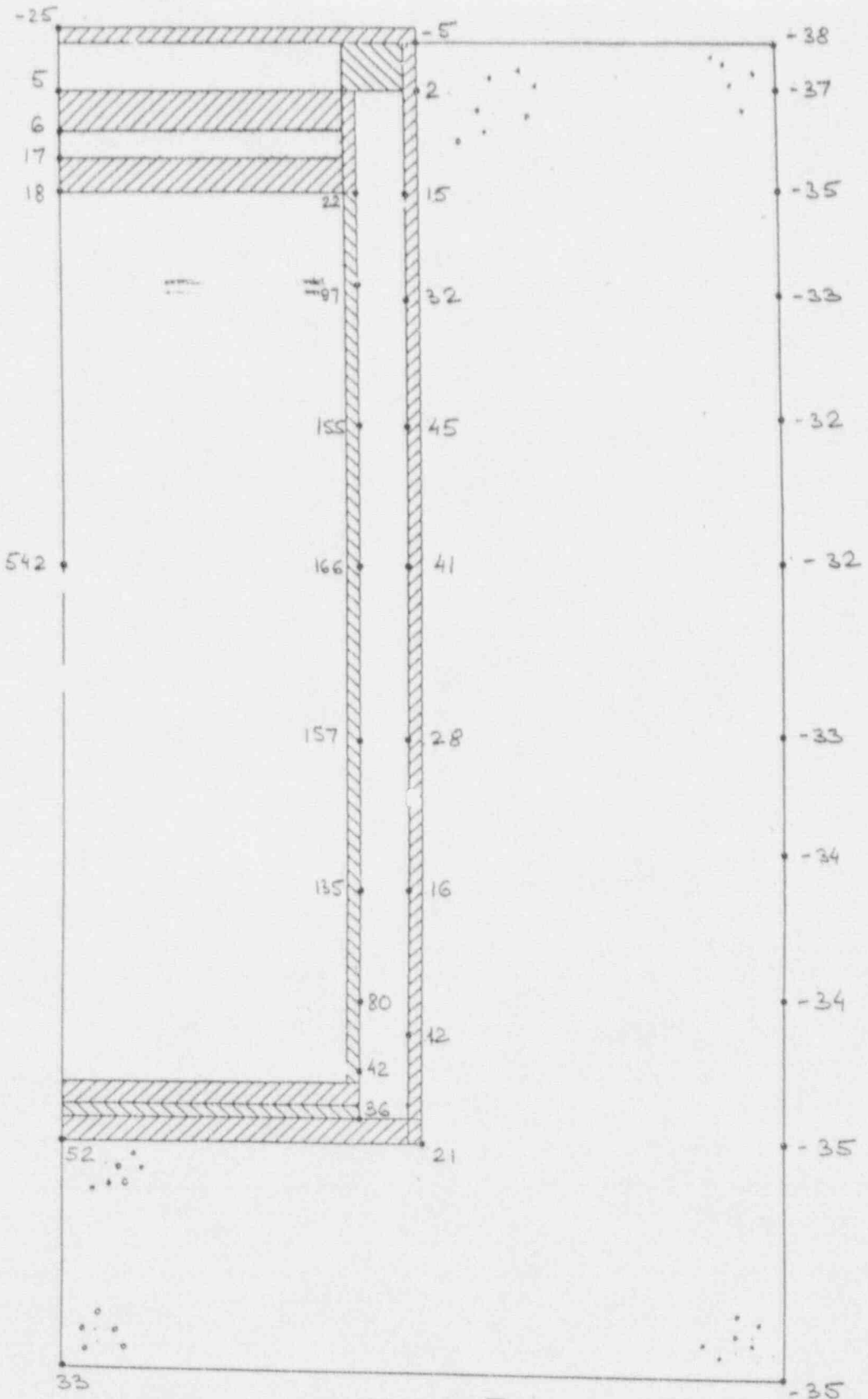


FIGURE 5

VCC TEMPERATURE DISTRIBUTION

-40°F, no solar load

Table 12. 75°F input: heat load, el convections, constant temperatures

LIST ELEM HEAT GENERATIONS FOR ALL SELECTED ELEMENTS

ELEMENT	HEAT GENERATIONS
37	326.100000
44	403.400000
51	393.300000
58	369.800000
65	258.900000

LIST ELEMENT CONVECTIONS FOR ALL SELECTED ELEMENTS

ELEM	FACE	VALUE(S)		FACE NODES			
17	3	2.00000000	75.0000000	43	36	52	59
24	3	2.00000000	75.0000000	59	52	68	75
31	3	2.00000000	75.0000000	75	68	84	91
38	3	2.00000000	86.9000000	91	84	100	107
45	3	2.00000000	104.300000	107	100	116	123
52	3	2.00000000	121.900000	123	116	132	139
59	3	2.00000000	144.000000	139	132	148	155
66	3	2.00000000	161.000000	155	148	164	171
73	3	2.00000000	164.000000	171	164	180	187
80	3	2.00000000	164.000000	187	180	479	486
19	5	2.00000000	75.0000000	37	44	60	53
26	5	2.00000000	75.0000000	53	60	76	69
33	5	2.00000000	75.0000000	69	76	92	85
40	5	2.00000000	86.9000000	85	92	108	101
47	5	2.00000000	104.300000	101	108	124	117
54	5	2.00000000	121.900000	117	124	140	133
61	5	2.00000000	144.000000	133	140	156	149
68	5	2.00000000	161.000000	149	156	172	165
75	5	2.00000000	164.000000	165	172	188	181
82	5	2.00000000	164.000000	181	188	204	197

ELEM	FACE	VALUE(S)		FACE NODES			
171	6	2.00000000	75.0000000	215	214	221	222
172	6	2.00000000	75.0000000	450	215	222	451
164	3	2.00000000	75.0000000	191	184	200	207
96	6	2.00000000	75.0000000	230	229	236	237
95	6	2.00000000	75.0000000	229	228	235	236
94	6	2.00000000	75.0000000	228	227	234	235
93	6	2.00000000	75.0000000	227	226	233	234
92	6	2.00000000	75.0000000	226	225	233	233
153	3	2.00000000	75.0000000	15	8	24	31
154	3	2.00000000	75.0000000	31	24	40	47
155	3	2.00000000	75.0000000	47	40	56	63
156	3	2.00000000	75.0000000	63	56	72	79
157	3	2.00000000	75.0000000	79	72	88	95
158	3	2.00000000	75.0000000	95	88	104	111
159	3	2.00000000	75.0000000	111	104	120	127
160	3	2.00000000	75.0000000	127	120	136	143
161	3	2.00000000	75.0000000	143	136	152	159
162	3	2.00000000	75.0000000	159	152	168	175
163	3	2.00000000	75.0000000	175	168	184	191
165	3	2.00000000	75.0000000	207	200	216	223

ELEM	FACE	VALUE(S)		FACE NODES			
173	3	2.00000000	75.0000000	475	471	216	223
173	6	2.00000000	75.0000000	216	450	451	223
179	3	2.00000000	164.000000	489	483	196	203
176	3	2.00000000	164.000000	486	479	483	489

Table 12 (cont-d)

LIST TEMPERATURES FOR ALL SELECTED NODES

NODE	LABEL	TEMPR	
144	TEMP	75.0000000	0.000000000E+00
241	TEMP	75.0000000	0.000000000E+00

Table 13. 75°F case results

PRINT NODAL TEMPERATURES

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
1	150.22445
2	144.69042
3	128.58333
4	127.91042
5	123.43108
6	120.06291
7	102.04475
8	80.485679
9	144.69043
10	128.58314
11	127.91024
12	123.43106
13	120.06296
14	102.04474

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITEPATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
15	80.485679
17	168.27738
18	162.70519
19	152.44001
20	150.89722
21	142.95160
22	140.53941
23	103.92405
24	80.708138
25	162.70517
26	152.44041
27	150.89758
28	142.95163
29	140.53929

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
30	103.92408
31	80.708141
33	168.82362
34	162.64958
35	153.18270
36	152.40762
37	141.56458
38	139.98518
39	104.30502

Table 13 (cont-d)

40	80.857185
41	162.64945
42	153.18388
43	152.40906
44	141.56432

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
45	139.98479
46	104.30510
47	80.857189
49	174.01969
50	164.87624
51	156.34160
52	154.46252
53	140.16711
54	139.67072
55	104.41419
56	80.883284
57	164.87718
58	156.34933
59	154.46364

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
60	140.16690
61	139.67007
62	104.41433
63	80.883276
65	174.49720
66	164.77460
67	156.93110
68	157.62979
69	138.67567
70	138.85505
71	104.64583
72	80.924160
73	164.77496
74	156.94397

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
75	157.60110
76	138.67591
77	138.85357
78	104.64618
79	80.924129
81	497.36086

Table 13 (cont-d)

83	191.29033
84	190.51634
85	134.49749
86	134.61738
87	105.69151
88	81.282587
90	190.35171
91	189.68445

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
92	134.48357
93	134.60986
94	105.69330
95	81.282394
97	594.33788
99	239.33766
100	238.17454
101	148.12269
102	147.95064
103	112.05091
104	82.199705
106	238.16851
107	237.13360
108	148.08944

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
109	147.93172
110	112.05541
111	82.199387
113	637.05926
115	262.23500
116	260.97515
117	163.77507
118	163.49211
119	117.76841
120	83.565986
122	260.91587
123	259.80870
124	163.73737
125	163.47083

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
126	117.77347
127	83.565597
129	649.58785

Table 13 (cont-d)

131	274.77805
132	273.90641
133	181.25244
134	180.97890
135	126.47481
136	84.836556
138	273.57710
139	272.82863
140	181.21805
141	180.95940
142	126.47945

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
143	84.836181
144	75.000000
145	567.51845
147	269.94825
148	267.85019
149	186.76935
150	186.41647
151	128.25812
152	85.045619
154	268.69593
155	266.77750
156	186.73102
157	186.39481
158	128.26327

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
159	85.045247
161	490.80204
163	220.23333
164	218.20511
165	168.33019
166	168.05915
167	119.29032
168	83.569224
170	219.36356
171	217.48421
172	168.31220
173	168.04905
174	119.29272
175	83.569026

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP

Table 13 (cont-d)

177	141.86375
178	141.49328
179	145.52929
180	146.57612
181	143.42178
182	143.10317
183	106.15149
184	80.975730
185	141.48039
186	145.64104
187	146.64365
188	143.42925
189	143.10713
190	106.15055

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00C00E+00 LOAD CASE= 1

NODE	TEMP
191	80.975762
193	124.03437
194	125.95841
195	126.24062
196	125.01510
197	123.24616
198	123.49923
199	92.448921
200	78.250311
201	125.95841
202	126.24056
203	125.01563
204	123.24469
205	123.49868

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
206	92.449055
207	78.250314
209	93.597749
210	98.775536
211	114.62946
212	115.77222
213	116.43282
214	114.31725
215	79.754489
216	76.983694
217	98.775532
218	114.62948
219	115.77200
220	116.43319

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1

Table 13 (cont-d)

TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
221	114.31725
222	79.754488
223	76.983689
225	93.418856
226	98.714263
227	114.26506
228	115.42266
229	116.09042
230	114.31052
233	98.714265
234	114.26506
235	115.42256
236	116.09068
237	114.31061

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
241	75.000000
242	82.463095
243	32.463091
258	82.902881
259	82.902892
274	83.061366
275	83.061403
290	83.102474
291	83.102506
306	83.139817
307	83.139801
322	83.443116
323	83.442755
338	85.001221

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
339	85.000448
354	86.650224
355	86.649331
370	88.614429
371	88.613608
386	88.944003
387	88.943107
402	86.769389
403	86.768952
418	83.162440
419	83.162611
434	79.218561
435	79.218521
450	77.725280

Table 13 (cont-d)

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
451	77.725284
468	114.92797
469	80.287651
470	77.822997
471	76.941713
472	114.92796
473	80.287655
474	77.822999
475	76.941709
476	140.34589
477	142.55255
478	141.13164
479	140.35473
480	125.72479

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
481	125.17334
482	130.26066
483	131.48985
484	142.55707
485	141.09958
486	140.34160
487	125.17345
488	130.25992
489	131.48568

MAXIMUM
NODE 129
VALUE 649.58785

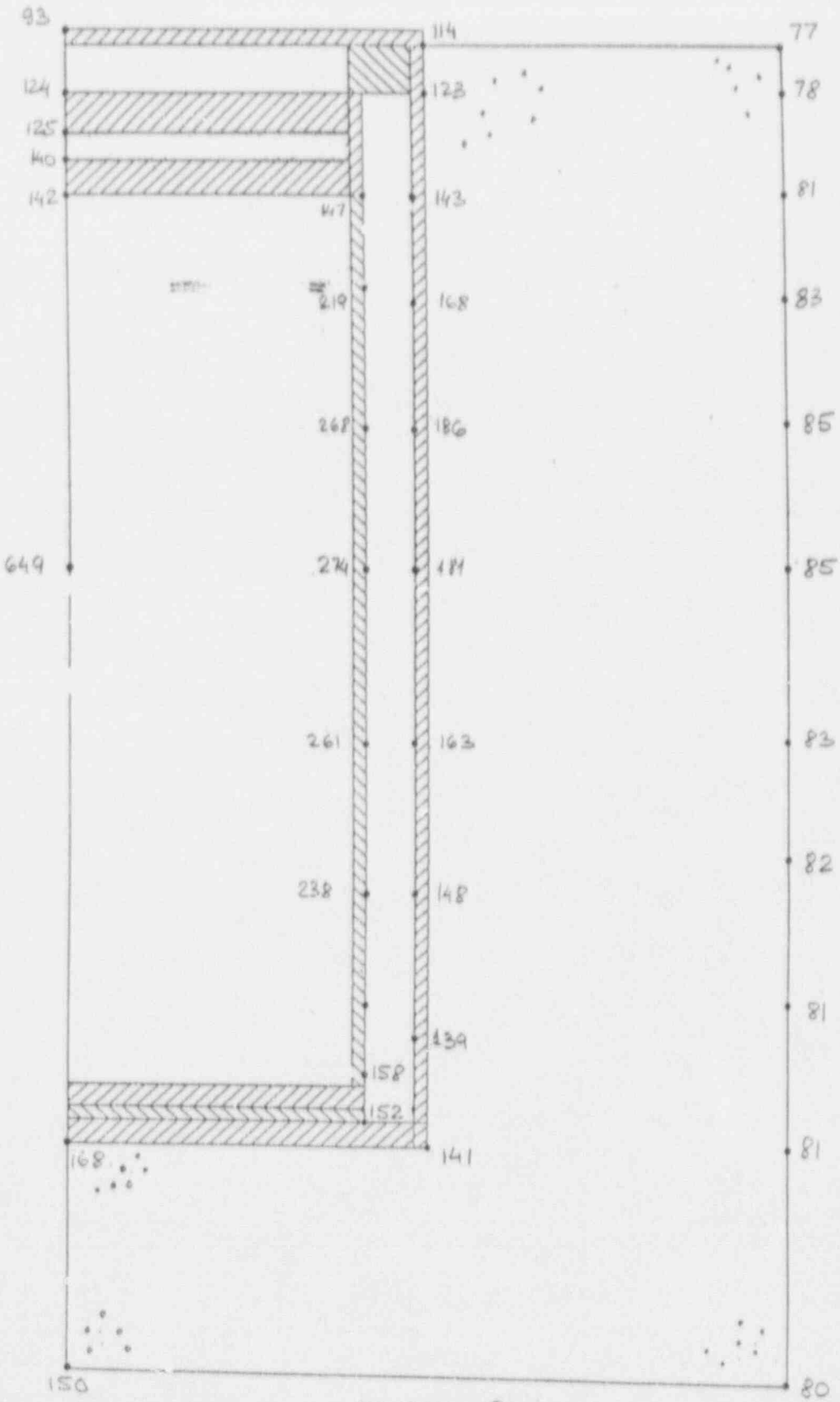


FIGURE 6

VCC TEMPERATURE DISTRIBUTION

75°F, no solar load

Table 14. Plugged inlets input: heat generations, element convections ambient temperatures.

LIST ELEM HEAT GENERATIONS FOR ALL SELECTED ELEMENTS

ELEMENT	HEAT GENERATIONS
37	326.100000
44	403.400000
51	393.300000
58	369.800000
65	258.900000

LIST ELEMENT CONVECTIONS FOR ALL SELECTED ELEMENTS

ELEM	FACE	VALUE(S)		FACE NODES			
17	3	2.00000000	151.500000	4[illegible]	36	52	59
24	3	2.00000000	151.500000	5[illegible]	52	68	75
31	3	2.00000000	151.500000	75	68	84	91
38	3	2.00000000	151.500000	91	84	100	107
45	3	2.00000000	151.500000	107	100	116	123
52	3	2.00000000	151.500000	123	116	132	139
59	3	2.00000000	151.500000	139	132	148	155
66	3	2.00000000	151.500000	155	148	164	171
73	3	2.00000000	151.500000	17[illegible]	164	180	187
80	3	2.00000000	151.500000	187	180	479	486
19	5	2.00000000	151.500000	37	44	60	53
26	5	2.00000000	151.500000	53	60	76	69
33	5	2.00000000	151.500000	69	76	92	85
40	5	2.00000000	151.500000	85	92	108	101
47	5	2.00000000	151.500000	101	108	124	117
54	5	2.00000000	151.500000	117	124	140	133
61	5	2.00000000	151.500000	133	140	156	149
68	5	2.00000000	151.500000	149	156	172	165
75	5	2.00000000	151.500000	165	172	188	181
82	5	2.00000000	151.500000	181	188	204	197

ELEM	FACE	VALUE(S)		FACE NODES			
171	6	2.00000000	75.0000000	215	214	221	222
172	6	2.00000000	75.0000000	450	215	222	451
164	3	2.00000000	75.0000000	191	184	200	207
96	6	2.00000000	75.0000000	230	229	236	237
95	6	2.00000000	75.0000000	229	228	235	236
94	6	2.00000000	75.0000000	228	227	234	235
93	6	2.00000000	75.0000000	227	226	233	234
92	6	2.00000000	75.0000000	226	225	233	233
153	3	2.00000000	75.0000000	15	8	24	31
154	3	2.00000000	75.0000000	31	24	40	47
155	3	2.00000000	75.0000000	47	40	56	63
156	3	2.00000000	75.0000000	63	56	72	79
157	3	2.00000000	75.0000000	79	72	88	95
158	3	2.00000000	75.0000000	95	88	104	111
159	3	2.00000000	75.0000000	111	104	120	127
160	3	2.00000000	75.0000000	127	120	136	143
161	3	2.00000000	75.0000000	143	136	152	159
162	3	2.00000000	75.0000000	159	152	168	175
163	3	2.00000000	75.0000000	175	168	184	191
165	3	2.00000000	75.0000000	207	200	216	223

ELEM	FACE	VALUE(S)		FACE NODES			
173	3	2.00000000	75.0000000	475	471	216	223
173	6	2.00000000	75.0000000	216	450	451	223
179	3	2.00000000	151.500000	489	483	196	203
176	3	2.00000000	151.500000	486	479	483	489

Table 14 (cont-d)

LIST TEMPERATURES FOR ALL SELECTED NODES

NODE	LABEL	TEMPR	
144	TEMP	75.0000000	0.000000000E+00
241	TEMP	75.0000000	0.000000000E+00

Table 15. Plugged vents results

PRINT NODAL TEMPERATURES

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
1	198.71533
2	191.05607
3	166.67519
4	165.33711
5	156.71445
6	151.12165
7	122.28637
8	84.748980
9	191.05608
10	166.67500
11	165.33693
12	156.71445
13	151.12172
14	122.28635

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
15	84.748980
17	219.84397
18	214.56736
19	205.14701
20	203.63229
21	195.60958
22	192.51535
23	127.36175
24	85.197381
25	214.56734
26	205.14741
27	203.63266
28	195.60958
29	192.51520

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
30	127.36179
31	85.197386
33	220.40669
34	214.50940
35	205.95737
36	205.20215
37	194.42882
38	192.87578
39	128.24012

40	85.444345
41	214.50927
42	205.95857
43	205.20360
44	194.42852

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
45	192.87525
46	128.24023
47	85.444350
49	225.56705
50	216.76091
51	209.29143
52	207.40498
53	193.30899
54	192.68356
55	128.48184
56	85.487073
57	216.76184
58	209.29923
59	207.40611

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
60	193.30875
61	192.68271
62	128.48203
63	85.487063
65	226.05252
66	216.64835
67	209.90941
68	210.71170
69	192.14124
70	192.09204
71	128.88854
72	85.552775
73	216.64867
74	209.92243

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
75	210.68267
76	192.14159
77	192.09010
78	128.88899
79	85.552734
81	544.95197

83	243.95886
84	243.19153
85	188.99244
86	188.92712
87	130.67357
88	85.949036
90	243.02329
91	242.36441

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
92	188.97406
93	188.91721
94	130.67593
95	85.948793
97	633.46087
99	282.66367
100	281.53098
101	197.37908
102	197.00643
103	134.93804
104	86.590965
106	281.49805
107	280.49573
108	197.33997

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
109	196.98415
110	134.94334
111	86.590587
113	670.03424
115	293.35079
116	292.06813
117	201.02151
118	200.68809
119	136.23271
120	86.920727
122	292.03490
123	290.90684
124	200.97861
125	200.66388

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
126	136.23847
127	86.920288
129	665.57851

131	290.44336
132	289.58057
133	199.86035
134	199.53234
135	135.66140
136	86.692565
138	289.24362
139	288.50477
140	199.82396
141	199.51171
142	135.66631

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
143	86.692167
144	75.000000
145	570.54212
147	271.43642
148	269.30842
149	188.42511
150	188.09634
151	129.64898
152	85.446534
154	270.18416
155	268.23567
156	188.38674
157	188.07466
158	129.65413

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
159	85.446160
161	488.60486
163	212.89187
164	210.84649
165	161.17871
166	160.94783
167	116.45908
168	83.196161
170	212.02124
171	210.12392
172	161.16159
173	160.93821
174	116.46137
175	83.195970

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP

177	134.65454
178	134.29875
179	137.80771
180	138.82908
181	135.93630
182	135.67677
183	103.19213
184	80.480850
185	134.28584
186	137.91960
187	138.89710
188	135.94347
189	135.68057
190	103.19123

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
191	80.480881
193	118.62297
194	120.29727
195	120.40984
196	119.31610
197	117.72963
198	117.95894
199	90.623810
200	77.941624
201	120.29727
202	120.40978
203	119.31662
204	117.72822
205	117.95840

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
206	90.623939
207	77.941627
209	91.394293
210	95.982169
211	110.12239
212	111.13602
213	111.72677
214	109.85965
215	79.245637
216	76.784521
217	95.982164
218	110.12241
219	111.13581
220	111.72713

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1

TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
221	109.85965
222	79.245637
223	76.784516
225	91.236308
226	95.929189
227	109.80057
228	110.82627
229	111.42351
230	109.85479
233	95.929191
234	109.80057
235	110.82617
236	111.42376
237	109.85487

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
241	75.000000
242	88.244295
243	88.244290
258	89.142800
259	89.142814
274	89.373054
275	89.373103
290	89.426513
291	89.426556
306	89.487797
307	89.487776
322	89.909456
323	89.908983
338	91.034124

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
339	91.033214
354	91.393848
355	91.392834
370	91.140101
371	91.139232
386	89.453202
387	89.452305
402	86.191068
403	86.190651
418	82.468946
419	82.469110
434	78.815243
435	78.815206
450	77.448981

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
451	77.448985
468	110.39784
469	79.722687
470	77.537544
471	76.746356
472	110.39782
473	79.722691
474	77.537547
475	76.746352
476	133.28244
477	135.24613
478	133.80387
479	133.05852
480	120.13151

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
481	119.59022
482	123.99611
483	125.08733
484	135.25066
485	133.77178
486	133.04524
487	119.59033
488	123.99536
489	125.08317

MAXIMUMS
NODE 113
VALUE 670.03424

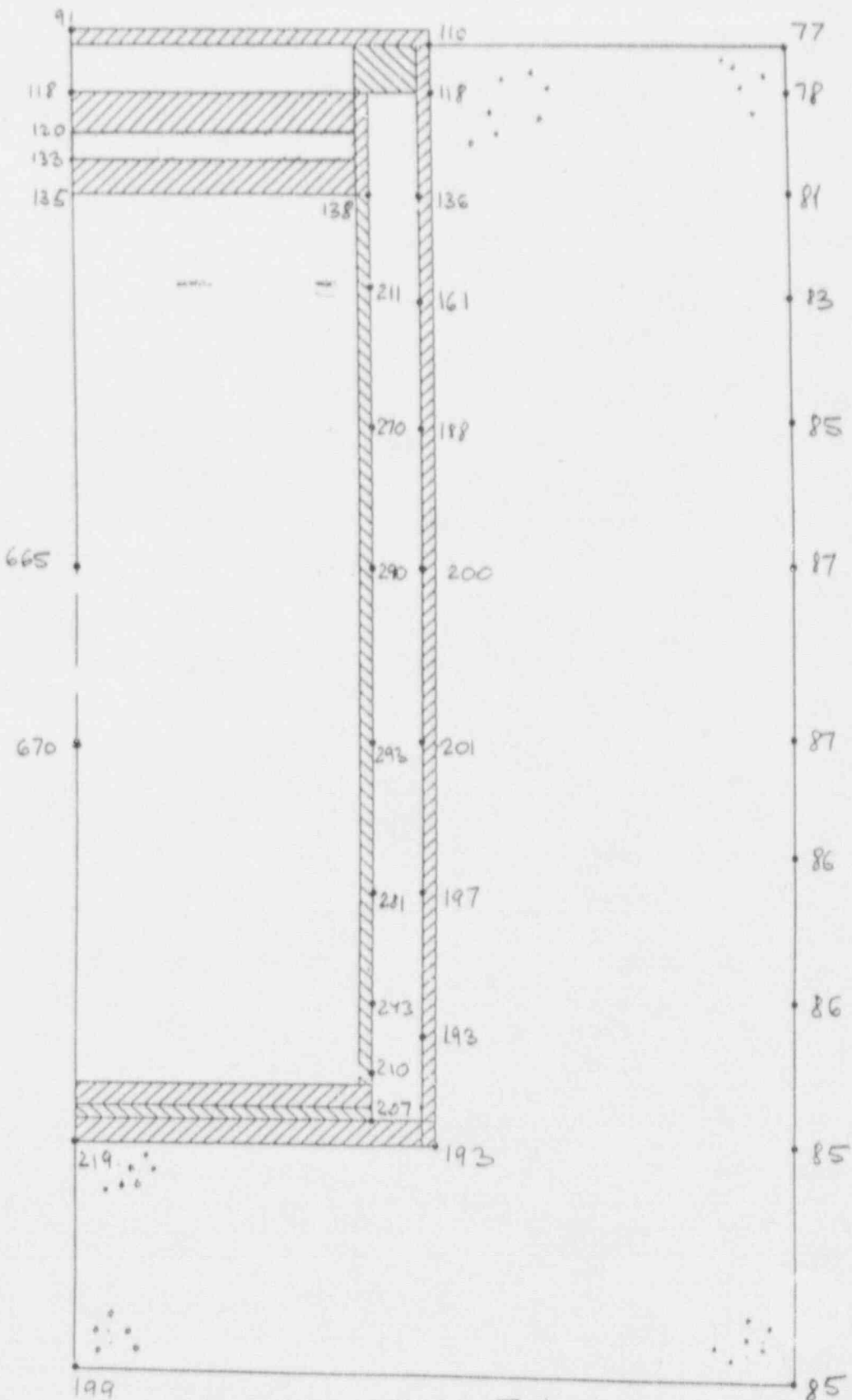


FIGURE 7

VCC TEMPERATURE DISTRIBUTION

Plugged inlets, 75°F ambient

Table 16

Summary of the VCC-24 thermal analysis

Ambient T, °F	Solar	Air outlet	Outer concrete	Inner concrete	MSB shell
75	no	163	85	186	274
-40	no	30	-32	45	166
100	yes	192	135	220	299
75 plugged inlets	no	228	87	201	293

Gradient in the concrete

75	101
-40	77
100	85
Plugged inlets	114 - max (see Appendix B, page 84 for two more cases)

APPENDIX A - COMPUTER PROGRAM DESCRIPTIONS

ANSYS/PC-Thermal

ANSYS/PC-Thermal is a common finite element program implemented on the IBM-PC and compatible microcomputers. The program has capabilities for steady and transient thermal analysis and includes temperature dependent properties. The version used was v4.3 supported by Swanson Analysis Systems, Inc. of Houston, PA.

Appendix B

This Appendix presents two analyses which were not initially included in this calc. package.

B1. 125° F day, full solar load.

The full solar load for this analysis is 260 Btu/hr/ft², top and 130 Btu/hr/ft², side. This results in the following input for the model.

Solar loads for the cask

6240 Btu/hr/ft³ – side, 1/4 in thickness
12480 Btu/hr/ft³ – top, 1/4 in thickness
4160 Btu/hr/ft³ – cover plate, 3/4 in thickness

The annulus air temperatures were taken from Table 1, page 9. ANSYS input/output is attached. Temperature distribution is shown in Figure B1-1. The results are summarized in Table B-2.

LIST ELEM HEAT GENERATIONS FOR ALL SELECTED ELEMENTS

ELEMENT	HEAT GENERATIONS
37	326.100000
44	403.400000
51	393.300000
58	369.800000
65	258.900000
92	4160.00000
93	4160.00000
94	4160.00000
95	4160.00000
96	4160.00000
153	6240.00000
154	6240.00000
155	6240.00000
156	6240.00000
157	6240.00000
158	6240.00000
159	6240.00000
160	6240.00000
161	6240.00000
162	6240.00000
163	6240.00000
164	6240.00000
165	6240.00000
171	12480.0000
172	12480.0000
173	12480.0000

LIST ELEMENT CONVECTIONS FOR ALL SELECTED ELEMENTS

ELEM	FACE	VALUE(S)		FACE NODES			
17	3	2.00000000	125.000000	43	36	52	59
24	3	2.00000000	125.000000	59	52	68	75
31	3	2.00000000	125.000000	75	68	84	91
38	3	2.00000000	138.000000	91	84	100	107
45	3	2.00000000	157.000000	107	100	116	123
52	3	2.00000000	176.000000	123	116	132	139
59	3	2.00000000	200.000000	139	132	148	155
66	3	2.00000000	219.000000	155	148	164	171
73	3	2.00000000	222.000000	171	164	180	187
80	3	2.00000000	222.000000	187	180	479	486
19	5	2.00000000	125.000000	37	44	60	53
26	5	2.00000000	125.000000	53	60	76	69
33	5	2.00000000	125.000000	69	76	92	85
40	5	2.00000000	138.000000	85	92	108	101
47	5	2.00000000	157.000000	101	108	124	117
54	5	2.00000000	176.000000	117	124	140	133
61	5	2.00000000	200.000000	133	140	156	149
68	5	2.00000000	219.000000	149	156	172	165
75	5	2.00000000	222.000000	165	172	188	181
82	5	2.00000000	222.000000	181	188	204	197

ELEM	FACE	VALUE(S)		FACE NODES			
171	6	2.00000000	125.000000	215	214	221	222
172	6	2.00000000	125.000000	450	215	222	451
164	3	2.00000000	125.000000	191	184	200	207
96	6	2.00000000	125.000000	230	229	236	237
95	6	2.00000000	125.000000	229	228	235	236

94	6	2.00000000	125.000000	228	227	234	235
93	6	2.00000000	125.000000	227	226	233	234
92	6	2.00000000	125.000000	226	225	233	233
153	3	2.00000000	125.000000	15	8	24	31
154	3	2.00000000	125.000000	31	24	40	47
155	3	2.00000000	125.000000	47	40	56	63
156	3	2.00000000	125.000000	63	56	72	79
157	3	2.00000000	125.000000	79	72	88	95
158	3	2.00000000	125.000000	95	88	104	111
159	3	2.00000000	125.000000	111	104	120	127
160	3	2.00000000	125.000000	127	120	136	143
161	3	2.00000000	125.000000	143	136	152	159
162	3	2.00000000	125.000000	159	152	168	175
163	3	2.00000000	125.000000	175	168	184	191
165	3	2.00000000	125.000000	207	200	216	223

ELEM	FACE	VALUE(S)		FACE NODES			
173	3	2.00000000	125.000000	475	471	216	223
173	6	2.00000000	125.000000	216	450	451	223
179	3	2.00000000	222.000000	489	483	196	203
176	3	2.00000000	222.000000	486	479	483	489

LIST TEMPERATURES FOR ALL SELECTED NODES

NODE	LABEL		TEMPR
144	TEMP	125.000000	0.000000000E+00
241	TEMP	125.000000	0.000000000E+00

PRINT NODAL TEMPERATURES

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
1	214.58593
2	211.29213
3	203.22707
4	203.08066
5	201.93513
6	200.53878
7	192.43523
8	183.13676
9	211.29214
10	203.22687
11	203.08049
12	201.93512
13	200.53885
14	192.43521

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
15	183.13675
17	229.14704
18	223.42094
19	213.13639
20	211.83301
21	205.34231
22	203.80763
23	192.00653
24	183.18399
25	223.42092
26	213.13679
27	211.83337
28	205.34231
29	203.80748

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
30	192.00656
31	183.18399
33	229.62100
34	223.40994
35	213.67324
36	212.99259
37	204.07542
38	202.77459
39	192.02300

40	183.26390
41	223.40981
42	213.67444
43	212.99405
44	204.07511

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
45	202.77407
46	192.02312
47	183.26394
49	234.63683
50	225.60179
51	216.04372
52	214.50292
53	202.74757
54	202.44643
55	192.03290
56	183.28553
57	225.60272
58	216.05154
59	214.50406

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
60	202.74732
61	202.44558
62	192.03310
63	183.28556
65	235.05195
66	225.55263
67	216.48483
68	216.97466
69	201.32031
70	201.64948
71	192.11639
72	183.29307
73	225.55295
74	216.49786

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
75	216.94565
76	201.32063
77	201.64754
78	192.11684
79	183.29303
81	549.91670

83	245.43658
84	244.65358
85	197.43691
86	197.66103
87	192.51616
88	183.51107
90	244.50094
91	243.82638

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
92	197.41863
93	197.65117
94	192.51844
95	183.51066
97	645.38080
99	288.46030
100	287.28933
101	212.56024
102	212.49842
103	198.62624
104	184.31974
106	287.29514
107	286.25474
108	212.52039

***** POST1 NODAL TEMPERATURE STING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
109	212.47573
110	198.63146
111	184.31910
113	687.18742
115	311.57328
116	310.30901
117	229.43472
118	229.24387
119	204.84139
120	185.71141
122	310.25890
123	309.15047
124	229.38943
125	229.21831

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
126	204.84728
127	185.71064
129	700.77441

131	325.70118
132	324.82853
133	248.23817
134	248.06198
135	214.26317
136	187.06165
138	324.50455
139	323.75674
140	248.19658
141	248.03841
142	214.26861

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.0 `00E+00 LOAD CASE= 1

NODE	TEMP
143	187.06090
144	125.00000
145	622.10385
147	323.42672
148	321.31893
149	255.08060
150	254.82146
151	216.68667
152	187.43193
154	322.17989
155	320.25837
156	255.03440
157	254.79535
158	216.69269

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
159	187.43118
161	547.48253
163	279.70081
164	277.74042
165	238.93204
166	238.76203
167	209.83895
168	186.55981
170	278.83654
171	277.03200
172	238.90893
173	238.74907
174	209.84194
175	186.55940

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP

177	221.18017
178	221.05203
179	222.24849
180	223.09986
181	221.24350
182	221.17929
183	204.21915
184	185.87597
185	221.03927
186	222.35918
187	223.16315
188	221.25294
189	221.18431
190	204.21801

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
191	185.87604
193	212.82169
194	213.31400
195	214.08237
196	213.59711
197	212.89807
198	213.06186
199	202.73492
200	190.50035
201	213.31074
202	214.07696
203	213.59666
204	212.89714
205	213.06160

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
206	202.73498
207	190.50036
209	205.51416
210	204.16629
211	210.35741
212	210.85388
213	210.65099
214	208.66338
215	187.69672
216	215.94781
217	203.87351
218	210.42744
219	210.89153
220	210.65048

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1

TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
221	208.66306
222	187.69674
223	215.94780
225	205.05412
226	203.86221
227	209.84471
228	210.63965
229	210.50224
230	208.17626
233	203.56784
234	209.92261
235	210.67786
236	210.50170
237	208.17598

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
241	125.00000
242	184.96208
243	184.96208
258	185.01675
259	185.01676
274	185.09905
275	185.09909
290	185.12396
291	185.12400
306	185.13648
307	185.13645
322	185.33244
323	185.33198
338	186.23637

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
339	186.23560
354	187.67745
355	187.67653
370	189.14795
371	189.14707
386	189.54553
387	189.54463
402	188.58498
403	188.58449
418	187.87799
419	187.87811
434	192.41850
435	192.41849
450	220.83188

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
451	220.83188
468	209.42258
469	192.66971
470	222.76545
471	218.88835
472	209.42223
473	192.66973
474	222.76544
475	218.88835
476	220.53928
477	221.41472
478	220.31296
479	219.78552
480	213.38593

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
481	213.14922
482	215.56962
483	216.06139
484	221.41920
485	220.28110
486	219.77383
487	213.15071
488	215.56972
489	216.05647

MAXIMUMS
NODE 129
VALUE 700.77441

***** ROUTINE COMPLETED ***** CP= 614.0700 TIME= 15.5409

B2. 75° day, no solar load, ½ inlets blocked

The air flow calculations are shown in Table B-1. ANSYS input/output is attached. Temperature distribution is shown in Figure B2-1. The results are summarized in Table B2.

Table B-2

Case	Solar	Air outlet	Outer concrete	Inner concrete	MSB shell
75°F, ½ inlets blocked	no	173	86	194	279
125°F	yes	222	187	255	325
		T gradient			
75° ½ blocked		108			
125°		68			

8/

1/2 INLETS BLOCKED	D(H)	A	L	F	K	A**2	K/A**2	VEL	Re	%
1. INLET SNOW SKIRT with screens		11.87000			0.77000	140.89690	0.00546	1.18965	0.000E+00	
2. INLET SECTION DOWN OUTSIDE	0.66700	11.87000	3.00000	0.04000	0.17991	140.89690	0.00128	1.18965	4.338E+03	
3. BEND & ENTER. SKID CHANNELS		2.34000			1.38000	5.47560	0.25203	6.03467	0.000E+00	
4. SKID CHANNELS	1.08000	2.34000	5.11833	0.03000	0.14218	5.47560	0.02597	6.03467	3.563E+04	
5. BEND INTO 12 IN SQ TUBE		4.00000			2.16000	16.00000	0.13500	3.53028	0.000E+00	
6. BENDS AT CHANNEL AND INLET ASSY		4.00000			0.38700	16.00000	0.02419	3.53028	0.000E+00	
7. STRAIGHT SECTION	1.00000	4.00000	1.33333	0.02600	0.03467	16.00000	0.00217	3.53028	1.930E+04	
8. INLET ASSEMBLY AND BEND INTO ANN.		4.47200			1.38400	19.99878	0.06920	3.15768	0.000E+00	
9. SUDDEN EXPANSION INTO ANNULUS		5.76000			0.05000	33.17760	0.00151	2.45159	0.000E+00	
10. FLOW UP ANNULUS	0.66600	5.76000	14.16667	0.03300	0.70195	33.17760	0.02116	2.45159	8.927E+03	
11. BEND&CNTRCT INTO 3" by 52" SLIT		4.33333			1.20000	18.77778	0.06391	3.25872	0.000E+00	
12. Z - BEND		4.33333			2.78000	18.77778	0.14805	3.25872	0.000E+00	
13. OUTLET STRAIGHT SECTION	1.89000	4.33333	2.66667	0.02600	0.03668	18.77778	0.00195	3.25872	3.367E+04	
14. DISCHARGE with screens		4.33333			1.14000	18.77778	0.06071	3.25872	0.000E+00	

SUM K/A**2	0.81257
INLET TEMP	75.00000
OUTLET TEMP	172.80000
AVG TEMP	123.90000
DRAFT HEIGHT	15.00000
GUESS DT=	97.80000
HEAT =	81888.00000
CP=	0.24100
M=(HEAT BALENCE)	0.96508
AVG DENSITY	0.06834
DP FLOW=	0.17195
DP STACK=	0.17171
DT CALC	97.80000
M=(DP FLOW)	0.96508
AVG Q/IN	568.66667

X POSITION	f RELATIVE POWER	Q(x) POWER/IN	QX	DT TEMP	AIR TEMPERATURE
0					75.00000
0-16	0.69000000	392.38000	6278.08000	7.52924	82.52924
16-32	1.08000000	614.16000	9826.56000	11.78490	94.31414
32-48	1.20000000	682.40000	10918.40000	13.09433	107.40847
48-64	1.19000000	676.71333	10827.41333	12.98521	120.39369
64-80	1.17000000	665.34000	10645.44000	12.76697	133.16066
80-96	1.12000000	636.90667	10190.50667	12.22138	145.38204
96-112	1.05000000	597.10000	9553.60000	11.45754	156.83958
112-128	0.90000000	511.80000	8188.80000	9.82075	166.66033
128-144	0.60000000	341.20000	5459.20000	6.54717	173.20750

Table B-1

LIST ELEMENT CONVECTIONS FOR ALL SELECTED ELEMENTS

ELEM	FACE	VALUE(S)		FACE NODES			
17	3	2.00000000	75.0000000	43	36	52	59
24	3	2.00000000	75.0000000	59	52	68	75
31	3	2.00000000	75.0000000	75	68	84	91
38	3	2.00000000	88.4000000	91	84	100	107
45	3	2.00000000	107.400000	107	100	116	123
52	3	2.00000000	126.800000	123	116	132	139
59	3	2.00000000	151.100000	139	132	148	155
66	3	2.00000000	169.900000	155	148	164	171
73	3	2.00000000	173.000000	171	164	180	187
80	3	2.00000000	173.000000	187	180	479	486
19	5	2.00000000	75.0000000	37	44	60	53
26	5	2.00000000	75.0000000	53	60	76	69
33	5	2.00000000	75.0000000	69	76	92	85
40	5	2.00000000	88.4000000	85	92	108	101
47	5	2.00000000	107.400000	101	108	124	117
54	5	2.00000000	126.800000	117	124	140	133
61	5	2.00000000	151.100000	133	140	156	149
68	5	2.00000000	169.900000	149	156	172	165
75	5	2.00000000	173.000000	165	172	188	181
82	5	2.00000000	173.000000	181	188	204	197

ELEM	FACE	VALUE(S)		FACE NODES			
171	6	2.00000000	75.0000000	215	214	221	222
172	6	2.00000000	75.0000000	450	215	222	451
164	3	2.00000000	75.0000000	191	184	200	207
96	6	2.00000000	75.0000000	230	229	236	237
95	6	2.00000000	75.0000000	229	228	235	236
94	6	2.00000000	75.0000000	228	227	234	235
93	6	2.00000000	75.0000000	227	226	233	234
92	6	2.00000000	75.0000000	226	225	233	233
153	3	2.00000000	75.0000000	15	8	24	31
154	3	2.00000000	75.0000000	31	24	40	47
155	3	2.00000000	75.0000000	47	40	56	63
156	3	2.00000000	75.0000000	63	56	72	79
157	3	2.00000000	75.0000000	79	72	88	95
158	3	2.00000000	75.0000000	95	88	104	111
159	3	2.00000000	75.0000000	111	104	120	127
160	3	2.00000000	75.0000000	127	120	136	143
161	3	2.00000000	75.0000000	143	136	152	159
162	3	2.00000000	75.0000000	159	152	168	175
163	3	2.00000000	75.0000000	175	168	184	191
165	3	2.00000000	75.0000000	207	200	216	223

ELEM	FACE	VALUE(S)		FACE NODES			
173	3	2.00000000	75.0000000	475	471	216	223
173	6	2.00000000	75.0000000	216	450	451	223
179	3	2.00000000	173.000000	489	483	196	203
176	3	2.00000000	173.000000	486	479	483	489

LIST TEMPERATURES FOR ALL SELECTED NODES

NODE	LABEL	TEMPR	
144	TEMP	75.0000000	0.000000000E+00
241	TEMP	75.0000000	0.000000000E+00

PRINT NODAL TEMPERATURES

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
1	151.38805
2	145.80681
3	129.51836
4	128.82957
5	124.25080
6	120.83086
7	102.54164
8	80.595963
9	145.80682
10	129.51817
11	128.82940
12	124.25079
13	120.83091
14	102.54163

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
15	80.595963
17	169.53030
18	163.95143
19	153.68815
20	152.14812
21	144.21548
22	141.79211
23	104.55561
24	80.833454
25	163.95141
26	153.68854
27	152.14848
28	144.21551
29	141.79200

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
30	104.55564
31	80.833457
33	170.07683
34	163.89674
35	154.43063
36	153.65568
37	142.83480
38	141.26412
39	104.96432

40	80.992536
41	163.89662
42	154.43181
43	153.65712
44	142.83454

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
45	141.26372
46	104.96441
47	80.992540
49	175.28042
50	166.13011
51	157.58916
52	155.70620
53	141.44444
54	140.95640
55	105.08047
56	81.020867
57	166.13106
58	157.59689
59	155.70733

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 2 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
60	141.44423
61	140.95575
62	105.08062
63	81.020859
65	175.75841
66	166.02863
67	158.17892
68	158.87366
69	139.96434
70	140.15394
71	105.32186
72	81.064899
73	166.02899
74	158.19179

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
75	158.84497
76	139.96458
77	140.15246
78	105.32221
79	81.064868
81	499.11717

83	192.64963
84	191.87548
85	135.90186
86	136.01652
87	106.41516
88	81.456830
90	191.71104
91	191.04364

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
92	135.88789
93	136.00897
94	106.41697
95	81.456636
97	596.92299
99	241.49136
100	240.32494
101	150.70363
102	150.53361
103	113.42349
104	82.458238
106	240.32240
107	239.28428
108	150.67008

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
109	150.51452
110	113.42803
111	82.457916
113	640.22802
115	265.53351
116	264.27550
117	167.65503
118	167.35777
119	119.63722
120	83.955983
122	264.21466
123	263.10953
124	167.61688
125	167.33624

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
126	119.64234
127	83.955588
129	654.44080

131	279.64122
132	278.76834
133	186.99958
134	186.71310
135	129.28410
136	85.376920
138	278.44066
139	277.69109
140	186.96452
141	186.69323
142	129.28883

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
143	85.376538
144	75.000000
145	573.72457
147	276.32302
148	274.22826
149	194.06583
150	193.69116
151	131.75255
152	85.704233
154	275.07135
155	273.15701
156	194.02656
157	193.66896
158	131.75783

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
159	85.703852
161	497.49761
163	227.53066
164	225.49572
165	175.81633
166	175.52174
167	122.77114
168	84.218898
170	226.66153
171	224.77627
172	175.79776
173	175.51132
174	122.77362
175	84.218694

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP

177	147.48638
178	147.09672
179	151.54357
180	152.61766
181	149.52973
182	149.17365
183	108.80589
184	81.469206
185	147.08384
186	151.65522
187	152.68474
188	149.53742
189	149.17772
190	108.80492

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
191	81.469239
193	128.21681
194	130.33101
195	130.75651
196	129.43089
197	127.54934
198	127.82587
199	93.972400
200	78.527117
201	130.33101
202	130.75644
203	129.43142
204	127.54783
205	127.82530

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
206	93.972537
207	78.527121
209	95.325658
210	100.96103
211	118.13593
212	119.37897
213	120.09090
214	117.78160
215	80.171185
216	77.155034
217	100.96103
218	118.13595
219	119.37876
220	120.09128

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1

TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
221	117.78160
222	80.171185
223	77.155029
225	95.130341
226	100.89314
227	117.73814
228	118.99830
229	119.71824
230	117.77298
233	100.89314
234	117.73814
235	118.99819
236	119.71850
237	117.77307

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
241	75.000000
242	82.609619
243	82.609616
258	83.079269
259	83.079279
274	83.247368
275	83.247405
290	83.291212
291	83.291244
306	83.333168
307	83.333152
322	83.665276
323	83.664913
338	85.366517

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
339	85.365737
354	87.172950
355	87.172047
370	89.361523
371	89.360686
386	89.858681
387	89.857764
402	87.670764
403	87.670313
418	83.840371
419	83.840547
434	79.578400
435	79.578359
450	77.961296

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
451	77.961300
468	118.44914
469	80.750752
470	78.067408
471	77.109471
472	118.44912
473	80.750756
474	78.067410
475	77.109467
476	145.84772
477	148.24818
478	146.81512
479	146.00632
480	130.04563

***** POST1 NODAL TEMPERATURE LISTING *****

LOAD STEP 1 ITERATION= 12 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

NODE	TEMP
481	129.49069
482	135.10393
483	136.43686
484	148.25270
485	146.78308
486	145.99332
487	129.49080
488	135.10320
489	136.43268

MAXIMUMS

NODE	129
VALUE	654.44080

It can be seen that even for 125°F steady state condition (which will not be achieved in 14 hours) temperature limit for the concrete is not exceeded. The further analysis for fuel temperature is presented in the "MSB thermal-hydraulic analysis" calc. package.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

January 15, 1993

DOCKET NO. 72-1007 (PROJECT M-53)

PUBLIC DISCLOSURE OF PROPRIETARY INFORMATION THAT FORMS THE BASIS OF FINAL RULE TO ADD VSC-24 CASK TO APPROVED LIST (10 CFR 72.214)

PERMISSION HAS BEEN GIVEN TO RELEASE THE ATTACHED DOCUMENTS AS STATED ON FORM AND IN THE LETTER DATED JANUARY 8, 1993. APPROVAL FOR RELEASE SIGNED BY JOHN V. MASSEY ON JANUARY 15, 1993.

Charles J. Haughney

Charles J. Haughney, Chief
Source Containment and
Devices Branch
Division of Industrial and
Medical Nuclear Safety
Office of Nuclear Material Safety
and Safeguards