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Calculation Cover Sheet

Complete only applicable items.

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Attachment	# Pages	Attachment	# Pages
I	1	XIII	1
II	1	XIV	1
III	1	XV	1
IV	4	XVI	1
V	6	XVII	1
VI	1	XVIII	6
VII	21		
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IX	12		
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Table of Contents

1. Purpose

The purpose of this calculation is to evaluate the thermal difference between backfill only as compared to three different drip shield cases: drip shield over backfill, drip shield under backfill contacting the waste package (WP), and drip shield under backfill with air gap between drip shield and WP.

2. Method

The solution method to be employed is finite element analysis (FEA). The calculation is performed by representing a two-dimensional (2-D) cross section of the WP with backfill and with or without a drip shield using the ANSYS V5.4 code (see Section 4.1 for qualification). The problem is solved between 100 to 600 years after WP repository emplacement using transient FEA.

3. Assumptions

3.1 The WP used in this calculation is a 21-Pressurized Water Reactor (PWR) WP with Absorber Plates that contains twenty-one PWR baseline fuel assemblies. The decay heat for the design basis (20 years old with burnup 60 GWd/MTU) spent nuclear fuel (SNF) assemblies from page 67 of Reference 7.1 is used for this calculation. The design basis SNF heat output as a function of time is from Attachment IX of Reference 7.1 and is tabulated in Attachment VI for this calculation. This assumption is used throughout the calculation.

3.2 The waste package will be emplaced in-drift in a horizontal mode. This assumption is consistent with Controlled Design Assumptions Document (CDA) Key 011 and Key 066, Ref. 7.8. This assumption is used throughout the calculation.

3.3 It is assumed that a cross section at the midsection of the WP will be representative of the hottest portion of the WP. Inherent in this assumption is that axial heat transfer does not significantly affect the solution (i.e., the flow of heat in the radial direction is assumed to dominate the solution). The basis for this assumption is that the metal thermal conductivities and heat generation distributions are such that axial heat transfer is very small or negligible at the midsection. An axial power peaking factor of 1.25 is applied to the PWR SNF heat generation rate. This factor is recommended by the thermal design basis analysis (p. 67, Ref. 7.1) and is assumed to bound the range of axial power peaking factors for PWR SNF. This assumption is used throughout.

3.4 The WP diameter is restricted to be under 2 m for emplacement handling purposes. This limit is consistent with the maximum WP diameter cited in CDA EBDRD 3.7.1.J.1 (Ref. 7.8) This assumption is used throughout.

3.5 It is assumed for this calculation that the waste package will not have filler material placed inside of it. This assumption is consistent with CDA Key 073 (Ref. 7.8). This assumption is used throughout the calculation.

3.6 The WP basket and shell components are assumed to be integrally connected. The basis for this assumption is that the edge of the basket and the inner (corrosion resistant) barrier will be in direct contact. This assumption is used throughout the calculation.

3.7 The backfill and drip shield over the backfill or drip shield under the backfill are assumed to be integrally connected. The basis for this assumption is that the backfill and drip shield will be in direct contact. Thus, only conduction between the backfill and drip shield over the backfill or drip shield under the backfill is considered. This assumption is used throughout the calculation.

3.8 The possibility of emplacement drift backfill will be analyzed in this calculation (CDA Key 046, Ref. 7.8). This assumption is used throughout the calculation.

3.9 The backfill is composed of crushed TSw2 rock (crushed tuff) with effective porosity of 0.48, for which estimates for effective thermal conductivity of 0.58 to 0.74 W/m·K have been reported (p.5-50, Ref. 7.2). The basis of this assumption is from results on a bench-scale experiment to determine the thermal diffusivity of crushed tuff by Sandia National Laboratory (SNL) (Ref. 7.6). To be conservative, a lower bound for thermal conductivity is used. This assumption is used throughout the calculation.

3.10 The emissivity of the TSw2 rock unit is assumed to be 0.85 (p. 22, Ref. 7.3). This value is an historic value that was used in numerous evaluations performed by SNL and can be compared to 0.75 used by Lawrence Livermore National Laboratory (LLNL) (p. 4, Ref. 7.4) and the range of 0.88 to 0.95 given for rocks in a standard heat transfer textbook (Table A.8, p. A27, Ref. 7.16). This assumption is used throughout the calculation.

3.11 The properties of air at atmospheric pressure are assumed to representative of the conditions of air inside the emplacement drift. The basis of this assumption is it is assumed that the emplacement drift is in equilibrium with the atmosphere. This assumption is used throughout the calculation.

3.12 All the material properties are temperature dependent, but some or all the material properties for homogeneous WP internals, Alloy 22, concrete, and backfill have one value listed for a specific property at room temperature. These single property values have no impact on the accuracy of the calculation because these property values do not change drastically enough to affect the accuracy for the temperature range of this calculation. This assumption is used

throughout the calculation.

3.13 The drip shield above backfill used in the finite element representation is "V"-shaped in contrast to the rounded shape given in Attachment II. This provides a simpler geometry mesh and is assumed to have negligible effect on the results. This assumption is used throughout the calculation.

4. Use of Computer Software

4.1 Software Approved for QA Work

The FEA computer code used for this calculation is ANSYS Version (V) 5.4, which is identified as Computer Software Configuration Item (CSCI) 30040 V5.4 and was obtained from Software Configuration Management in accordance with QAP-SI-0 and QAP-SI-3. ANSYS V5.4 (CSCI 30040 V5.4) will hereafter be referred to as 'ANSYS.' ANSYS is a commercially available finite element thermal and mechanical analysis code and is appropriate for the thermal analysis of waste packages, waste package emplacements, and waste package environments as utilized in this calculation.

The analyses using the ANSYS software were executed on a Hewlett-Packard Series 9000 workstation. The software qualification of the ANSYS software, including problems of the type analyzed in this report, is summarized in the Software Qualification Report for ANSYS Version 5.4 (Ref. 7.14). The ANSYS evaluations performed for this calculation are fully within the range of the validation for the ANSYS code used. Access to and use of the code for the calculation was granted and performed in accordance with the QAP-SI series procedures. Inputs and outputs to the ANSYS software are included as attachments as described in the following calculation.

4.2 Software Routines

The presentation graphics and plots were produced with the following computer codes:

- Pro/ENGINEER, executed on a Hewlett-Packard J2240 workstation
- Visio Technical 5.0, executed on an IBM-compatible personal computer
- Microsoft Paint, executed on an IBM-compatible personal computer

The codes are classified as computational support software. None of the above codes are controlled, nor have they been qualified under the QAP-SI series of Management and Operating Contractor (M&O) procedures. Pro/ENGINEER, Visio Technical 5.0, and Microsoft Paint were simply used to provide schematic geometry layouts. No calculation was performed in Pro/ENGINEER, Visio Technical 5.0, or Microsoft Paint.

5. Calculation

5.1 Material Properties

The waste package with backfill with and without drip shield cross section studied in this calculation, shown in Attachments I, II, III, consists of the homogenized WP internal, inner and outer barriers, backfill with or without drip shield over backfill or drip shield under backfill, and drift. The representations of these designs are entered into this calculation as a 2-D axial cross section for each case.

Table 5.1-1 lists the materials used in this calculation and their UNS (Unified Numbering System) designations.

Table 5.1-1. Materials used and their UNS designations

Material Used	UNS Designation
A 516 Carbon Steel, Grade 70	SA-516 K02700
Alloy 22	SB-575 N06022
Backfill	N/A
Concrete	N/A

N/A – Not Applicable

5.1.1 Waste Package Thermal Properties

The WP is composed of several parts; these parts are composed of different materials. The structure of the WP and name of the different parts of the waste package are shown in Figure 5.1.1-1.

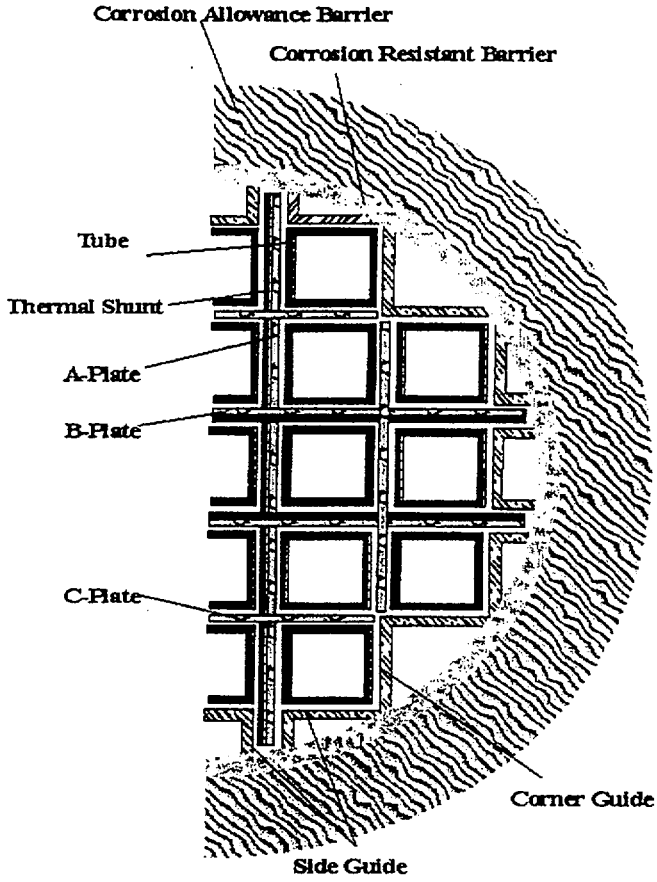


Figure 5.1.1-1. 21-PWR Waste Package Structure

The purpose of this calculation is to determine the thermal difference between backfill and three different drip shield concepts. Therefore, the WP is assumed to be a homogenous heat generating cylinder. This enables the internals of the WP to become a homogeneous material. Table 5.1.1-1 lists the thermal conductivity, density, and specific heat of the homogeneous material (pp. 10, 11, Ref 7.7).

Table 5.1.1-1. Material properties of the homogeneous WP internals

Thermal Conductivity (W/m·K)	Density (kg/m^3)	Specific Heat (J/kg·K)
1.6	3800	Same as A 516

The WP corrosion allowance barrier is composed of A 516 carbon steel, grade 70. Table 5.1.1-2 lists

density and emissivity of A 516 carbon steel, grade 70 (UNS designation SA-516 K02700, hereafter referred to as 'A 516 carbon steel'). The density is taken from page 9 of the *Standard Specification for General Requirements for Steel Plates for Pressure Vessels* (Ref. 7.15). The emissivity (average for smooth oxidized iron) is taken from Table 4.3.2 of Marks' Handbook (p. 4-68, Ref. 7.17).

Table 5.1.1-3 lists the thermal conductivity and specific heat of A 516 carbon steel. Values for thermal conductivity and thermal diffusivity were taken from Table TCD, Section II of the 1995 *American Society of Mechanical Engineers* (ASME) *Boiler and Pressure Vessel Code* (p. 600, Ref. 7.18) and are converted here to conductivity and specific heat in SI units. The conversion of thermal diffusivity (defined in Equation 5-1) to specific heat requires the density listed in Table 5.1.1-2.

$$SpecificHeat(Btu/lb\cdot{}^{\circ}F) = \frac{ThermalConductivity(Btu/hr\cdot ft\cdot{}^{\circ}F)}{Density(lb/ft^3) \times ThermalDiffusivity(ft^2/hr)} \qquad \text{(Equation 5-1)}$$

Table 5.1.1-2. Density and emissivity of A 516 carbon steel

	Density (kg/m^3)	Emissivity
A 516 Carbon Steel	7850	0.80

Table 5.1.1-3. Thermal conductivity and specific heat of A 516 carbon steel

Temperature (°F)	Temperature (°C)	Thermal Conductivity (Btu/hr-ft-F)	Thermal Diffusivity (ft^2/hr)	Thermal Conductivity (W/m-K)	Specific Heat (J/kg-K)
70	21.11	23.6	0.454	40.84	444.12
100	37.78	23.9	0.443	41.36	460.92
150	65.56	24.2	0.433	41.88	477.49
200	93.33	24.4	0.422	42.23	493.98
250	121.11	24.4	0.414	42.23	503.53
300	148.89	24.4	0.406	42.23	513.45
350	176.67	24.3	0.396	42.06	524.26
400	204.44	24.2	0.386	41.88	535.63
450	232.22	23.9	0.375	41.36	544.50
500	260.00	23.7	0.364	41.02	556.26
550	287.78	23.4	0.355	40.50	563.15
600	315.56	23.1	0.346	39.98	570.39
650	343.33	22.7	0.333	39.29	582.39
700	371.11	22.4	0.320	38.77	598.04
750	398.89	22.0	0.308	38.08	610.25
800	426.67	21.7	0.298	37.56	622.12

(°F)	(°C)	Thermal Conductivity (Btu/hr-ft-F)	Thermal Diffusivity (ft^2/hr)	Thermal Conductivity (W/m-K)	Specific Heat (J/kg-K)
850	454.44	21.2	0.286	36.69	633.29
900	482.22	20.9	0.274	36.17	651.67
950	510.00	20.5	0.262	35.48	668.48
1000	537.78	20.0	0.248	34.61	688.99
1050	565.56	19.6	0.237	33.92	706.55
1100	593.33	19.2	0.228	33.23	719.45
1150	621.11	18.7	0.213	32.36	750.06
1200	648.89	18.2	0.197	31.50	789.29
1250	676.67	17.5	0.179	30.29	835.25
1300	704.44	16.7	0.155	28.90	920.49
1350	732.22	15.8	0.119	27.35	1134.00
1400	760.00	15.3	0.077	26.48	1698.00
1450	787.78	15.1	0.154	26.13	837.70
1500	815.56	15.1	0.169	26.13	736.35

The WP corrosion resistant barrier is composed of Alloy 22. Tables 5.1.1-4 and 5.1.1-5 list the emissivity, density, thermal conductivity, and specific heat of Alloy 22 (UNS designation SB-575 N06022). The emissivity of Alloy 22 is taken from CRC Handbook of Chemistry and Physics for nickel-chromium alloy (p. 10-297, Ref. 7.20). The density, thermal conductivity, and specific heat were taken from the manufacturer's catalog for Alloy 22 (p. 13, Ref. 7.21).

Table 5.1.1-4. Density and emissivity of Alloy 22

	Emissivity	Density (kg/m^3)
Alloy 22	0.87	8690

Table 5.1.1-5. Thermal conductivity and specific heat of Alloy 22

Temperature (°C)	Thermal Conductivity (W/m-K)	Temperature (°C)	Specific Heat (J/kg-K)
48	10.1	52	414
100	11.1	100	423
200	13.4	200	444
300	15.5	300	460
400	17.5	400	476
500	19.5	500	485

Temperature (°C)	Thermal Conductivity (W/m·K)	Temperature (°C)	Specific Heat (J/kg·K)
600	21.3	600	514

5.1.2 Backfill Thermal Properties

The properties for backfill are given in Table 5.1.2-1. Table 4-4 of the Bench-Scale Experimental Determination of the Thermal Diffusivity of Crushed Tuff (p. 4-13, Ref. 7.6) states the density and specific heat for backfill. The porosity of backfill is supplied by the Abstract of the Bench-Scale Experimental Determination of the Thermal Diffusivity of Crushed Tuff (Ref. 7.6). The thermal conductivity of backfill is from Assumption 3.11 and emissivity is from Assumption 3.12.

Table 5.1.2-1. Properties of backfill

	Density (kg/m^3)	Porosity	Thermal Conductivity (W/m·K)	Specific Heat (J/kg·K)	Emissivity
Backfill	2600	0.48	0.58	500	0.85

5.1.3 Over Backfill Drip Shield and Under Backfill Drip Shield

The material used to fabricate the over backfill drip shield and under backfill drip shield is Alloy 22. This is the same material as the corrosion resistant barrier material. Therefore, the density and emissivity are given in Table 5.1.1-4 and the thermal conductivity and specific heat are stated in Table 5.1.1-5.

5.1.4 Emplacement Drift Thermal Properties

Table 5.1.4-1 lists the thermal conductivity, density, and specific heat of air as the environmental gas in the emplacement drift (see Assumption 3.13). Values for the thermal conductivity, density, and specific heat of air were taken from Table A.4, Appendix A of a standard heat transfer text (p. A15, Ref. 7.16).

Table 5.1.4-1. Thermal conductivity, specific heat, and density of air

Temperature		Thermal Conductivity (W/m·K)	Specific Heat (J/kg·K)	Density (kg/m^3)
(K)	(°C)			
260	-13.15	0.023	1006.2	1.3480
280	6.85	0.025	1006.6	1.2547
300	26.85	0.026	1007.0	1.614
350	76.85	0.030	1009.0	0.9950

(K)	(°C)	Thermal Conductivity (W/m·K)	Specific Heat (J/kg·K)	Density (kg/m³)
400	126.85	0.034	1014.0	0.8711
450	176.85	0.037	1021.0	0.7740
500	226.85	0.041	1030.0	0.6964
550	276.85	0.044	1040.0	0.6329
600	326.85	0.047	1051.0	0.5804
650	376.85	0.050	1063.0	0.5356
700	426.85	0.052	1075.0	0.4975
750	476.85	0.055	1087.0	0.4643
800	526.85	0.057	1099.0	0.4354
900	626.85	0.062	1121.0	0.3868
1000	726.85	0.067	1141.0	0.3482

Table 5.1.4-2 lists the thermal properties of typical stone mix concrete to be used as the drift invert and liner. These values were taken from Table A.3 and A.8 of a standard heat transfer textbook (pp. A13 and A26, Ref. 7.16) for a temperature of 300 K. To be conservative, a lower bound for emissivity is used.

Table 5.1.4-2. Properties of concrete

	Density (kg/m³)	Thermal Conductivity (W/m·K)	Specific Heat (J/kg·K)	Emissivity
Concrete	2300	1.4	880	0.88

5.2 Geometry

5.2.1 Waste Package Geometry

The 21-PWR waste package geometry is composed of the corrosion allowance material barrier, corrosion resistance material barrier, and basket as shown in Attachment I.

5.2.2 Drip Shield Under Backfill Geometry

The drip shield under backfill, shown in Attachment III, will be "U"-shaped to fit over the length of the individual waste packages and will either rest on and drape over the WP or will be separated by a 20 millimeter gap between the WP and drip shield to a point just above the invert. The drip shield will be closed at each end to protect the ends of the waste package. The end closure of the drip shield will be notched at the bottom to clear the top surface of the backfill.

5.2.3 Drip Shield Over Backfill Geometry

The drip shield over backfill, shown in Attachment II, will be shaped to fit atop the in-place backfill and to conform to the angle of repose of the backfill. The drip shield over backfill will be placed continuously, in sections, to cover the placed length of waste packages within the drifts. Each section of drip shield will have a groove rolled into each end of the shield to provide interlock between sections and to intercept water that may flow along the length of the drip shield.

5.2.4 Emplacement Drift Geometry

The basic emplacement drift geometry is shown in Figure 4.1 on page 8 of Reference 7.11. The emplacement drift has a 200 mm thick concrete liner.

5.3 Boundary Conditions

The surface temperature history of the outer diameter emplacement drift (rock interface) used in this calculation is given in Attachment XVIII. The outer diameter surface temperature history between 100 to 600 years was obtained from Appendix A of the Engineered Barrier System Performance Requirements Systems Study Report (pp. A-2 and A-9, Ref. 7.2) that performed a three-dimensional finite element analysis of several cases with backfill at different thermal conductivities. The case that supplies the temperature results is for backfill placed at 100 years from the middle length of the WP with a thermal conductivity of 0.6 W/m·K (p. A-9, Ref. 7.2). The points that represent the outer diameter emplacement drift are designated as "A", "B", and "M"(p. A-2, Ref. 7.2).

5.4 Finite Element Representation Development

The finite element representations used in this calculation are shown in Attachments XIII, XIV, XVI, and XVII. Attachment XIII shows a two-dimensional (2-D) symmetrical view of a 21-PWR WP in an emplacement drift with backfill covering the WP in a finite element representation. The finite element representation from Attachment XIV shows a 2-D symmetrical view of a 21-PWR WP in an emplacement drift with backfill covering the WP with a drip shield above the backfill. Attachment XVI shows a 2-D symmetrical view of a 21-PWR WP in an emplacement drift with a drip shield (under backfill) contacting the WP, and with backfill covering the drip shield. Attachment XVII shows a 2-D symmetrical view of a 21-PWR WP in an emplacement drift with a 20 mm air gap between WP and drip shield (under backfill), and with backfill covering the drip shield.

The development of the ANSYS representations is composed of two input files. The first ANSYS input file developed the finite element representation of the 21-PWR WP with material properties for each component of the WP (Attachments VII and VIII). The second input file for each case reads this input file and then develops the emplacement drift, backfill, and required drip shield for finite element representation with the proper material properties (Attachments IX, X, XI, and XII). The

second input files supply boundary conditions and heat inputs for each case. The combination of these two input files forms the generic ANSYS input file. The generic ANSYS input file has the following basic layout:

1) Comment header used to define problem represented, additional files read by the input deck, and what information is contained in the data files used in the input deck.
2) Definition of representation parameters and dimensions that are used repeatedly. This includes all material properties, reading of boundary condition files, reading of heat generation files, etc. The ANSYS input decks make use of defined variables, which are then used to perform simple calculations concerning units conversions and geometric positions. These variables were entered into the ANSYS input decks along with the units conversion to meters, assigned a variable name, and the variable name was then used throughout the remainder of the input deck to determine the geometry of the waste package basket and shell. Also, the file defining SNF heat loads uses units of years, which are converted to seconds for this calculation. The variables are clearly identified and defined via comments included in the ANSYS input deck.
3) Definition of element types, which will be used to perform the solution.
4) Definition of the representation geometry and mesh structure. The approach used is to define all components by first defining the basic key points, then lines, then areas, and finally the mesh.
5) Definition of all radiation surfaces and creation of a radiation mesh matrix. ANSYS is used to generate all of the required view factors between radiation elements.
6) Application of the volumetric heat generation and boundary conditions to the appropriate geometry components. For transient calculations, the loads and boundary conditions are applied at each time step.
7) Selected positions in the SNF, basket, and WP wall have temperatures for each time step of the transient echoed to the output file for subsequent examination.

Each ANSYS input deck is provided as part of the ANSYS output files in Ref. 7.22. The material input file is provided as Attachment IV. The development of an ANSYS representation involves the following specific steps:

1) Identify the geometry to be represented
2) Identify the material properties that will be required
3) Identify the assumptions used to represent the real geometry and materials
4) Identify the body loads (structural or thermal loads produced within the materials)
5) Identify the boundary conditions/surface loads
6) Specify the problem as steady-state or transient; if transient, specify the time frame to be considered
7) Execute the representation generated to obtain solutions for the given conditions
8) Display the results

A summary of the ANSYS results is provided in Section 6. Notice that selected data is requested in the input file and echoed into the output file.

6. Results

The results provided in this section were derived from the ANSYS executions. These representations are presented in the ANSYS output files listed in Section 8.

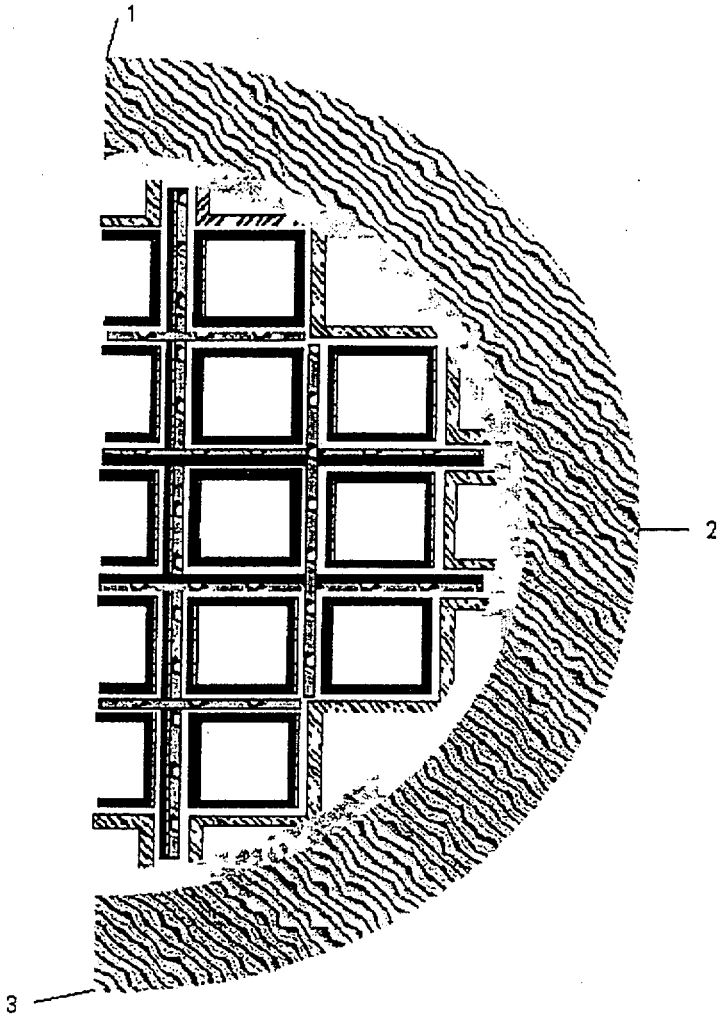
Existing (unqualified) data were used in the development of the results presented in this section. Therefore, the use of any data from this calculation for input into documents supporting procurement, fabrication, or construction is required to be identified and tracked as to be verified (TBV) in accordance with appropriate procedures.

The results of this calculation are expressed as difference of temperature between the WP and backfill case compared to each drip shield case. This is shown in equation 6-1 below:

$$\Delta T\,(°C) = T_{\text{Backfill Case}}(°C) - T_{\text{Drip Shield Case}}(°C) \qquad \text{(Equation 6-1)}$$

The reason for using the difference of temperature for this calculation is that the differences between temperatures between a 2-D thermal analysis and a 3-D (three-dimensional) thermal analysis (accurate representation of absolute temperatures) are greatly magnified when backfill is introduced to the emplacement drift, as described on page 29 of Reference 7.5. Since the calculation is to find how different drip shield concepts thermally affect a WP with backfill in an emplacement drift, then the difference of temperature is appropriate to report these results. Absolute temperature reported in Section 6.1 are therefore not intended to accurately represent the emplaced WP.

This section will first report the temperature results of the four cases, then the difference of temperature between the backfill case compared to each drip shield case. Each result will report the temperature of three points of the WP. These nodes are located at the top outer surface of the WP, middle outer surface of the WP, and the bottom outer surface of the WP as shown in Figure 6-1.



Node No.	Node Name	Node Location
1	o01o180	Top Outer Surface of WP
2	o01o090	Middle Outer Surface of WP
3	o01o000	Bottom Outer Surface of WP

Figure 6-1. Node locations for the 2-D waste package

6.1 Temperature Results

Table 6.1-1 lists the temperature results of the WP with backfill from 100 years to 600 years.

Table 6.1-1. Temperature results of the WP with backfill from 100 years to 600 years

Time (yrs)	o01o180 (°C)	o01o090 (°C)	o01o000 (°C)
100	526	527	522
110	508	510	506
120	487	488	484
130	465	466	462
140	442	443	440
150	420	421	418
160	408	409	406
170	396	397	395
180	384	386	383
190	372	373	371
200	360	361	359
300	302	303	301
400	271	272	270
500	250	251	250
600	235	235	234

Table 6.1-2 lists the temperature results of the WP with backfill and drip shield above backfill from 100 years to 600 years.

Table 6.1-2. Temperature results of the WP with backfill and drip shield above backfill from 100 years to 600 years

Time (yrs)	o01o180 (°C)	o01o090 (°C)	o01o000 (°C)
100	482	489	488
110	467	474	473
120	448	454	454
130	428	434	434
140	408	413	413
150	389	393	393
160	378	383	383
170	368	372	372
180	357	361	361
190	346	350	350
200	335	339	339
300	284	286	286
400	256	258	258
500	237	239	239
600	223	225	225

Table 6.1-3 lists the temperature results of the WP with backfill and drip shield under backfill with contact between WP and drip shield from 100 years to 600 years.

Table 6.1-3. Temperature results of the WP with backfill and drip shield under backfill with contact between WP and drip shield from 100 years to 600 years

Time (yrs)	o01o180 (°C)	o01o090 (°C)	o01o000 (°C)
100	400	394	379
110	391	385	371
120	377	371	358
130	362	357	345
140	347	343	331
150	332	328	318
160	325	321	311
170	316	312	303
180	308	305	296
190	300	297	288
200	291	288	280
300	252	249	243
400	230	228	223
500	216	214	210
600	204	203	199

Table 6.1-4 lists the temperature results of the WP with backfill and drip shield under backfill with 20 mm air gap between WP and drip shield from 100 years to 600 years.

Table 6.1-4. Temperature results of the WP with backfill and drip shield under backfill with 20 mm air gap between WP and drip shield from 100 years to 600 years

Time (yrs)	o01o180 (°C)	o01o090 (°C)	o01o000 (°C)
100	364	359	353
110	357	353	347
120	345	341	336
130	333	329	324
140	320	316	312
150	307	304	300
160	301	297	293
170	294	290	286
180	287	284	280
190	279	277	273
200	272	269	265
300	238	235	233
400	219	217	215
500	206	204	202
600	196	195	193

6.2 Difference of Temperature Results

Table 6.2-1 lists the difference of temperature results of the WP with backfill to the WP with backfill and drip shield above backfill from 100 years to 600 years.

Table 6.2-1. Difference of temperature results of the WP with backfill to WP with backfill and drip shield above backfill from 100 years to 600 years

Time (yrs)	ΔT o01o180 (°C)	ΔT o01o090 (°C)	ΔT o01o000 (°C)
100	44	38	34
110	41	36	33
120	39	34	30
130	37	32	28
140	34	30	27
150	31	28	25
160	30	26	23
170	28	25	23
180	27	25	22
190	26	23	21
200	25	22	20
300	18	17	15
400	15	14	12
500	13	12	11
600	12	10	9

Table 6.2-2 lists the difference of temperature results of the WP with backfill to the WP with backfill and drip shield under backfill, with contact between WP and drip shield, from 100 years to 600 years.

Table 6.2-2. Difference of temperature results of the WP with backfill to WP with backfill and drip shield under backfill, with contact between WP and drip shield, from 100 years to 600 years

Time (yrs)	ΔT o01o180 (°C)	ΔT o01o090 (°C)	ΔT o01o000 (°C)
100	126	133	143
110	117	125	135
120	110	117	126
130	103	109	117
140	95	100	109
150	88	93	100
160	83	88	95
170	80	85	92
180	76	81	87
190	72	76	83
200	69	73	79
300	50	54	58

Time (yrs)	ΔT o01o180 (°C)	ΔT o01o090 (°C)	ΔT o01o000 (°C)
400	41	44	47
500	34	37	40
600	31	32	35

Table 6.2-3 lists the difference of temperature results of the WP with backfill to the WP with backfill and drip shield under backfill, with 20 mm air gap between WP and drip shield, from 100 years to 600 years.

Table 6.2-3. Difference of temperature results of the WP with backfill to WP with backfill and drip shield under backfill with, 20 mm air gap between WP and drip shield from, 100 years to 600 years

Time (yrs)	ΔT o01o180 (°C)	ΔT o01o090 (°C)	ΔT o01o000 (°C)
100	162	168	169
110	151	157	159
120	142	147	148
130	132	137	138
140	122	127	128
150	113	117	118
160	107	112	113
170	102	107	109
180	97	102	103
190	93	96	98
200	88	92	94
300	64	68	68
400	52	55	55
500	44	47	48
600	39	40	41

7. References

7.1 CRWMS M&O (Civilian Radioactive Waste Management System Management & Operating Contractor) 1997. *Preliminary Design Basis for WP Thermal Analysis.* BBAA00000-01717-0200-00019 REV 00. Las Vegas, NV: M&O. MOL.19980127.0719

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7.10 Not used.

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7.13 Not used.

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7.18 American Society of Mechanical Engineers (ASME) 1995. *1995 ASME Boiler and Pressure Vessel Code, Section II.* New York, NY: ASME. TIC 241170

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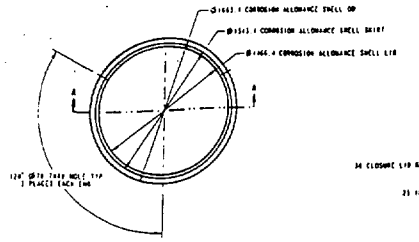
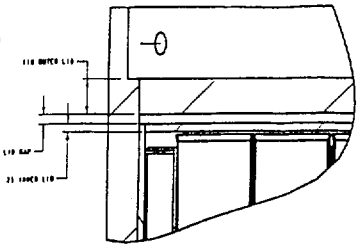
7.22 CRWMS M&O 1998. *ANSYS Output Files for Thermal Calculation of the Waste Package with Drip Shield.* BB0000000-01717-0210-00002 REV. 00, electronic media. Las Vegas, NV: M&O. MOL.19990222.0284

8. Attachments

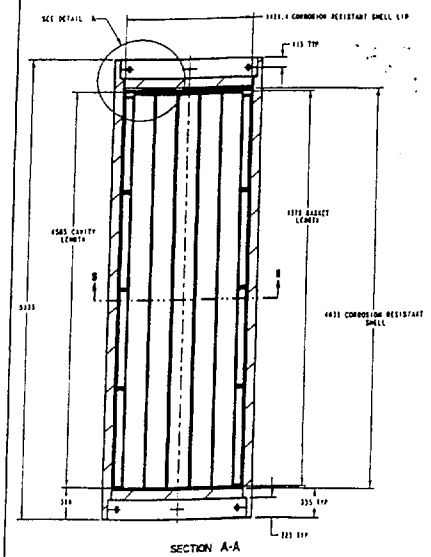
Table 8-1. Attachments

Attachment Number	Description	Filename	Size
I	21-PWR Absorber Plates UCF Waste Package Assembly	SK-0081.dwg	1 page
II	Drip Shield Over Backfill	SK-0076a.dwg	1 page
III	Drip Shield Under Backfill	SK-0075.dwg	1 page
IV	Material Properties File for ANSYS	prop03r.dat	4 pages
V	SNF Conductivity File for ANSYS	pwr14dk.parm	6 pages
VI	SNF Heat Load File for ANSYS	pwr850f.dat	1 page
VII	21-PWR WP Input File for Backfill Case and Drip Shield Under Backfill Cases for ANSYS	drshlow.inp	21 pages
VIII	21-PWR WP Input File for Drip Shield Above Backfill Cases for ANSYS	drshtop.inp	21 pages
IX	Backfill Case Input File for ANSYS	nodrsh.inp	12 pages
X	Drip Shield Above Backfill Case Input File for ANSYS	abvdrsh.inp	14 pages
XI	Drip Shield Under Backfill with Contact Between WP and Drip Shield Case Input File for ANSYS	drshcon.inp	12 pages
XII	Drip Shield Under Backfill with Air Gap Between WP and Drip Shield Case Input File for ANSYS	dslwag.inp	15 pages
XIII	Representation Mesh Geometry Plot, Backfill Case	meshfull.grph	1 page
XIV	Representation Mesh Geometry Plot, Drip Shield Above Backfill Case	meshfull.grph	1 page
XV	File Listing for Ref. 7.22, ANSYS Output Tape	attachment.doc	1 page
XVI	Representation Mesh Geometry Plots, Drip Shield Under Backfill with Contact Between WP and Drip Shield	meshfull.grph	1 page
XVII	Representation Mesh Geometry Plots, Drip Shield Under Backfill with Air Gap Between WP and Drip Shield	meshfull.grph	1 page
XVIII	Emplacement Drift Boundary Conditions	f04d51c1.parm	6 pages

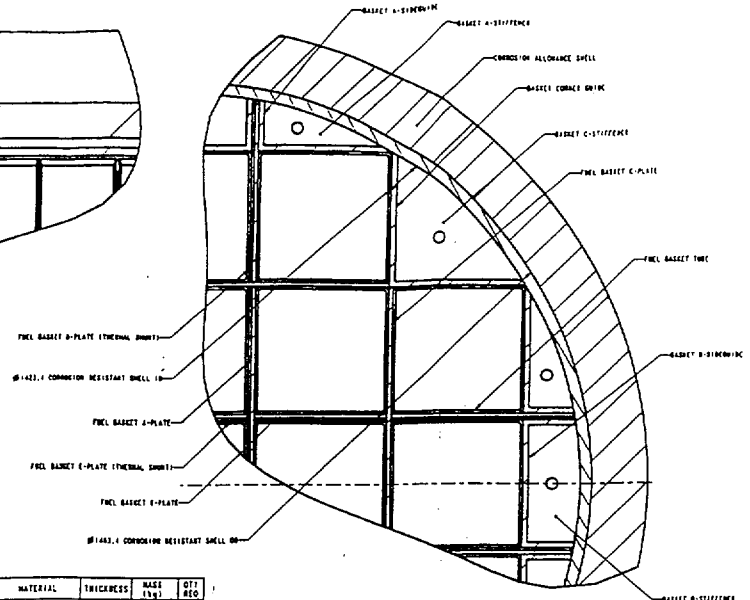




DETAIL A



SECTION A-A



SECTION B-B

COMPONENT NAME	MATERIAL	THICKNESS	MASS (kg)	QTY REQ
BASKET A-SIDEPLATE	SA-516 GR270	16	27	32
BASKET A-STIFFENER	SA-516 GR270	10	1	64
BASKET B-SIDEPLATE	SA-516 GR270	10	36	16
BASKET B-STIFFENER	SA-516 GR270	10	1	32
BASKET C-STIFFENER	SA-516 GR270	10	2	32
BASKET CORNER BRACE	SA-516 GR270	10	42	16
CORROSION ALLOWANCE SHELL	SA-516 GR70	101	10075	1
CORROSION ALLOWANCE SHELL LID	SA-516 GR70	110	1458	2
CORROSION RESISTANT SHELL	SB-575 N06022	24	3434	1
CORROSION RESISTANT SHELL LID	SB-575 N06022	25	317	2
FUEL BASKET A-PLATE	HEATBOND A 878	7	83	6
FUEL BASKET B-PLATE	HEATBOND A 878	7	83	8
FUEL BASKET C-PLATE	HEATBOND A 878	7	44	16
FUEL BASKET D-PLATE	SB-209 A96061 T6	5	21	8
FUEL BASKET E-PLATE	SB-209 A96061 T6	5	31	6
FUEL BASKET TUBE	SA-516 GR70	5	114	21

DO NOT SCALE FROM SKETCH

UNITS: mm

"FOR INFORMATION ONLY"

21-PWR ABSORBER PLATES
UCF WASTE PACKAGE ASSEMBLY

SKETCH NUMBER:	SK-0081.Rev00
SKETCHED BY:	GENE CORNELL GRC 7/28/98 SME 7/28/98 DCL 7/28/98
DATE:	5/27/98
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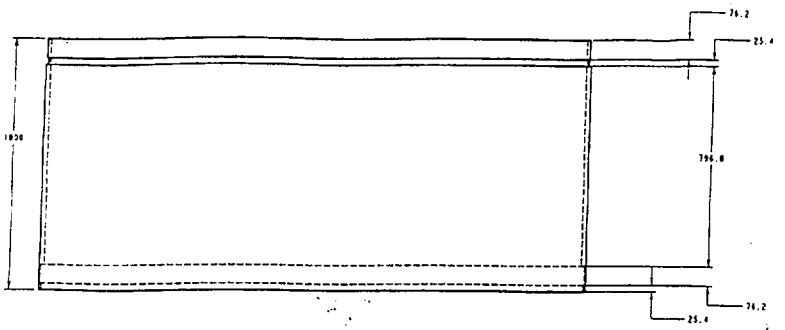

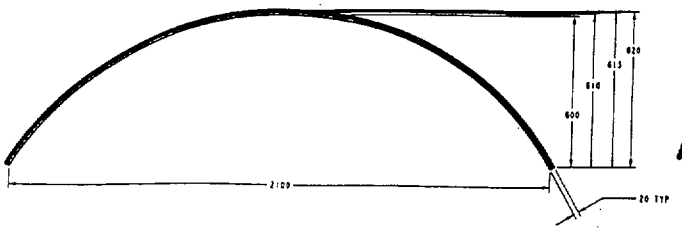

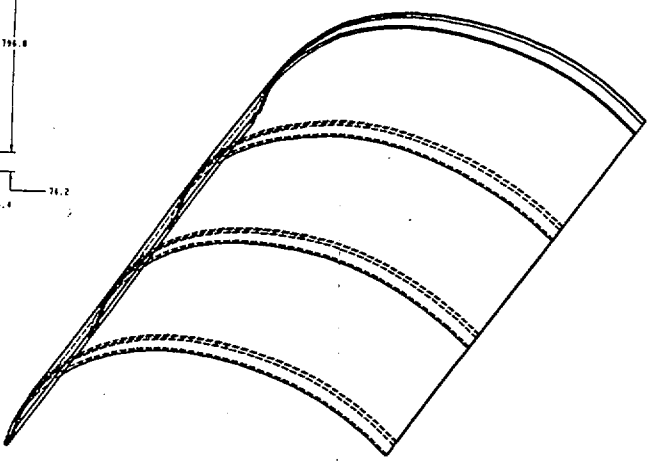

COMPONENT NAME	MATERIAL	THICKNESS	MASS (kg)	QTY REQ
DRIP SHIELD OVER BACKFILL	SB-575 N06022	20	401	1

DO NOT SCALE FROM SKETCH

"FOR INFORMATION ONLY"

DRIP SHIELD OVER BACKFILL

SKETCH NUMBER: SK-0076 REV 00

SKETCHED BY: MICHAEL PLYASKI 12 1/7/99 SMB 01/03/99 TWB 1.8.99

DATE: 01-07-99

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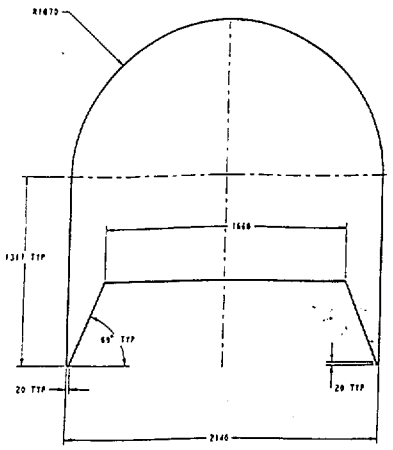

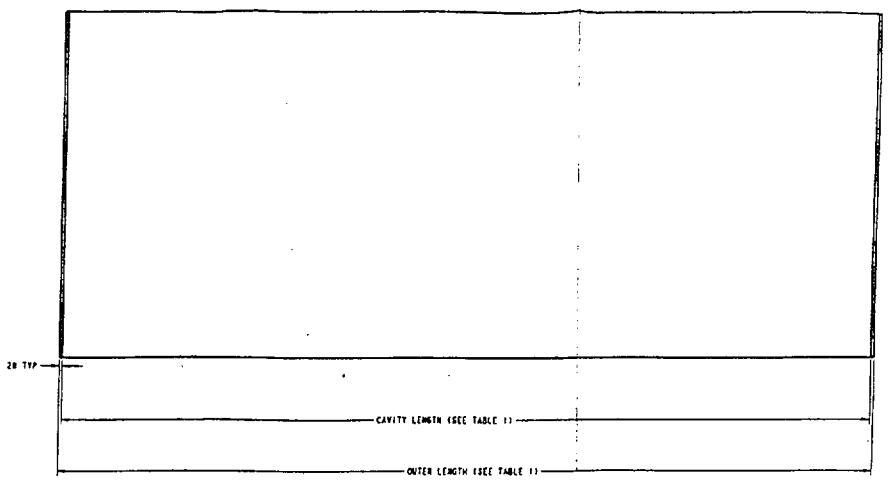

TABLE 1

DRIP SHIELD NAME	CAVITY LENGTH	OUTER LENGTH
DRIP SHIELD UNDER BACKFILL - SHORT	3943	3983
DRIP SHIELD UNDER BACKFILL - STANDARD	5486	5528
DRIP SHIELD UNDER BACKFILL - LONG	6314	6358

TABLE 2

COMPONENT NAME	MATERIAL	THICKNESS	MASS (kg)	QTY REQ
DRIP SHIELD UNDER BACKFILL - SHORT - SHELL	SB-575 N06022	20	4087	1
DRIP SHIELD UNDER BACKFILL - STANDARD - SHELL	SB-575 N06022	20	5669	1
DRIP SHIELD UNDER BACKFILL - LONG - SHELL	SB-575 N06022	20	6549	1
DRIP SHIELD UNDER BACKFILL - END PLATE	SB-575 N06022	20	618	2

DO NOT SCALE FROM SKETCH

UNITS: mm

"FOR INFORMATION ONLY"

DRIP SHIELD
UNDER BACKFILL

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ORIGINATOR:	MICHAEL PLINSKI 12/15/98 SMS 01/04/99
DATE:	12-01-98 TWD 01/04/99
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/COM,   **      Revision by Harold M. Wade on 7-20-98                   **
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/COM,   **         -update on Zircaloy density (6560 kg/m^3)-           **
/COM,   **         -addition of new materials                           **
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/COM,   3       A516 Mild Steel         Outer Container (allowance)
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/COM,   5       Zircaloy 4              SNF Cladding
/COM,   6       Oxidation Layer         Stably Oxidized Zircaloy Surface
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/COM,   10      Argon                   Alternate Fill Gas
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/COM,   12      Copper                  Alternate Thermal Conductor
/COM,   13      Aluminum-Boron          Aluminum Boron Criticality Matl
/COM,   14      SNF                     RESERVED FOR SNF PROPERTIES
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*SET,MEDTMP  (     4,   4, 1),  168.5890608333
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*SET,MEDTMP  (     6,   4, 1),  263.4134209685
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*SET,MEDTMP  (     8,   4, 1),  359.8968764506
*SET,MEDTMP  (     9,   4, 1),  408.5783718535
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*SET,OGRAD   , 0.1421130000000E-01
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*SET,PKASSY  (     3,   1, 1),  111.7147290695
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*SET,PKCLAD  (     9,   4, 1),  417.1567437069
*DIM,PKDIFF  ,TABLE,      9,      4,      1
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*SET,PKDIFF  (     4,   3, 1),-0.3700607278500E-01
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*SET,RODNO   ,  176.0000000000
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*SET,SGY     (     3,   1, 1),  2430125.937360
*SET,SGY     (     4,   1, 1),  825661195.5607
*SET,SUMK    ,  5.654980038328
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*SET,TMP     ,  1.426029534294
*SET,VOLU    , 0.1734432034050
/GO
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```
/COM, ********************************************************************
/COM, ** History of SNF Assembly Heat Generation Rates                   **
/COM, ** Output of PHIA, SCSI: B00000000-01717-1200-3000X Rev.00D        **
/COM, **                                                                 **
/COM, **    Executable File Name:   PHIA00D.EXE                          **
/COM, **    Output File Name:       pwr850f.dat                          **
/COM, **    Execution Date:         08/12/97                             **
/COM, **    Start Age (years):      19.7615 (RHBIII)                     **
/COM, **    Decay Period (years):   900000                               **
/COM, **    Default average enrichment for the burnup specified          **
/COM, **    Enrichment (percent):   4.73                                 **
/COM, **    Burnup (MWd/MTU):       60000                                **
/COM, **    Assembly Type:          PWR                                  **
/COM, **    SNF U Mass (MTU/assy):  0.464                                **
/COM, **                                                                 **
/COM, ** ASSY(#,1) is the SNF assembly heat in Watts.                    **
/COM, ** ASSY(#,0) is the time post emplacement in years.                **
/COM, ********************************************************************
*SET,ASSY,
*DIM,ASSY,TABLE,135,1,
ASSY( 1,1)=   850.00,   849.84,   849.69,   849.54,   849.38,   849.23,
ASSY( 7,1)=   849.07,   848.92,   848.76,   848.61,   848.46,   847.69,
ASSY(13,1)=   846.92,   846.10,   845.07,   844.04,   843.01,   841.99,
ASSY(19,1)=   840.98,   839.96,   838.96,   837.95,   836.95,   835.95,
ASSY(25,1)=   834.96,   833.96,   832.98,   831.99,   831.01,   821.66,
ASSY(31,1)=   812.85,   804.28,   795.93,   787.70,   779.59,   771.71,
ASSY(37,1)=   764.06,   756.53,   749.11,   741.68,   734.26,   727.08,
ASSY(43,1)=   720.13,   713.29,   706.57,   700.21,   694.18,   631.90,
ASSY(49,1)=   578.22,   531.03,   490.23,   452.29,   419.48,   390.19,
ASSY(55,1)=   363.97,   340.43,   319.34,   300.32,   283.20,   267.73,
ASSY(61,1)=   254.49,   241.40,   229.92,   219.45,   209.92,   149.44,
ASSY(67,1)=   119.13,   101.20,    89.32,    80.21,    73.18,    67.65,
ASSY(73,1)=    62.94,    58.80,    55.25,    52.16,    49.40,    46.87,
ASSY(79,1)=    44.62,    42.60,    40.78,    39.12,    37.57,    26.89,
ASSY(85,1)=    21.86,    19.11,    17.55,    16.54,    15.73,    15.14,
ASSY(91,1)=    14.63,    14.01,    13.47,    12.98,    12.55,    12.10,
ASSY(97,1)=    11.69,    11.32,    10.98,    10.67,    10.37,     7.44,
ASSY(103,1)=    5.88,     4.57,     3.72,     3.12,     2.68,     2.35,
ASSY(109,1)=    2.08,     1.85,     1.65,     1.49,     1.36,     1.25,
ASSY(115,1)=    1.15,     1.06,    0.989,    0.924,    0.866,    0.518,
ASSY(121,1)=   0.360,    0.271,    0.215,    0.177,    0.150,    0.129,
ASSY(127,1)=   0.113,    0.100,    0.089,    0.081,    0.074,    0.067,
ASSY(133,1)=   0.062,    0.058,    0.054,
ASSY( 1,0)= 0.000001,     0.01,     0.02,     0.03,     0.04,     0.05,
ASSY( 7,0)=     0.06,     0.07,     0.08,     0.09,     0.10,     0.15,
ASSY(13,0)=     0.20,     0.25,     0.30,     0.35,     0.40,     0.45,
ASSY(19,0)=     0.50,     0.55,     0.60,     0.65,     0.70,     0.75,
ASSY(25,0)=     0.80,     0.85,     0.90,     0.95,     1.00,     1.50,
ASSY(31,0)=     2.00,     2.50,     3.00,     3.50,     4.00,     4.50,
ASSY(37,0)=     5.00,     5.50,     6.00,     6.50,     7.00,     7.50,
ASSY(43,0)=     8.00,     8.50,     9.00,     9.50,    10.00,    15.00,
ASSY(49,0)=    20.00,    25.00,    30.00,    35.00,    40.00,    45.00,
ASSY(55,0)=    50.00,    55.00,    60.00,    65.00,    70.00,    75.00,
ASSY(61,0)=    80.00,    85.00,    90.00,    95.00,   100.00,   150.00,
ASSY(67,0)=   200.00,   250.00,   300.00,   350.00,   400.00,   450.00,
ASSY(73,0)=   500.00,   550.00,   600.00,   650.00,   700.00,   750.00,
ASSY(79,0)=   800.00,   850.00,   900.00,   950.00,  1000.00,  1500.00,
ASSY(85,0)=  2000.00,  2500.00,  3000.00,  3500.00,  4000.00,  4500.00,
ASSY(91,0)=  5000.00,  5500.00,  6000.00,  6500.00,  7000.00,  7500.00,
ASSY(97,0)=  8000.00,  8500.00,  9000.00,  9500.00, 10000.00, 15000.00,
ASSY(103,0)= 20000.00, 25000.00, 30000.00, 35000.00, 40000.00, 45000.00,
ASSY(109,0)= 50000.00, 55000.00, 60000.00, 65000.00, 70000.00, 75000.00,
ASSY(115,0)= 80000.00, 85000.00, 90000.00, 95000.00, 100000.00, 150000.00,
ASSY(121,0)= 200000.00, 250000.00, 300000.00, 350000.00, 400000.00, 450000.00,
ASSY(127,0)= 500000.00, 550000.00, 600000.00, 650000.00, 700000.00, 750000.00,
ASSY(133,0)= 800000.00, 850000.00, 900000.00,
ASSY( 0,1)=1.0
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/COM,   ANSYS REVISION  5.4                                    07/01/98
/COM,   2-D Thermal Model of 21 PWR WP with No Drip Shield   M. Plinski
/COM,   and No Backfill
/COM,   ****************************************************************
/COM,   *                                                              *
/COM,   *                                                              *
/COM,   * File name: drshlow.inp                                       *
/COM,   *       21 PWR UCF: tube=236.4 mm, tube_thck=5 mm              *
/COM,   *       guide=10 mm, shunt=5 mm, A/B/C ss-boron plate=7 mm     *
/COM,   *       Helium Fill Gas                                        *
/COM,   *                                                              *
/COM,   * Material Property file: prop03r.dat                         *
/COM,   *                                                              *
/COM,   * SNF Conductivity file:  pwr14dk.parm                        *
/COM,   *       15x15 Mark-B4 PWR SNF Assembly                         *
/COM,   *                                                              *
/COM,   * SNF Heat Loads file:    pwr850f.dat                          *
/COM,   *       SNF Type: 20 years old, 60000 MWd/MTU                  *
/COM,   *                                                              *
/COM,   * Surface Temp. file:    f04d51c1.parm                        *
/COM,   *       83 MTU/acre (20.5 kgU/m^2) AML (High Thermal Loading)  *
/COM,   *       5.0 m Diameter Drift with Concrete Invert              *
/COM,   *       Drift spacing = 22.5 m                                 *
/COM,   *       Mutiple WPs                                            *
/COM,   *                                                              *
/COM,   ****************************************************************
/COM,   Increase the number of database pages from 16 (256) to 32 Mb
/COM,/CONFIG,nvpag,512,
/COM,   Work space must also be increased (-m 64)
/COM,   ****************************************************************
/TITLE, 21 PWR UCF/Waste Package with 10 yr old, 48 GWD/MTU SNF
/UNITS,SI,
/COM,   ****************************************************************
/COM,           Read in average effective conductivities from SNF model
PARRES,CHANGE,pwr14dk,parm,
/COM,           Read in surface temps. from repository model
PARRES,CHANGE,f04d51c1,parm,
/COM,   ****************************************************************
/COM,
/COM,           Define Required Constants:
PI=3.141592654
/COM,
/COM,           Define UCF/waste package parameters
/COM,           (UCF dimensions converted from inches/cm/mm to meters were required)
/COM,                   DCRAD = disposal container outer radius (m)
/COM,                   DCIRD = disposal container inner radius (m)
/COM,                   OWALL = outer barrier thickness (m)
/COM,                   IWALL = inner barrier thickness (m)
/COM,
/COM,                   CELL  = tube cell opening (m)
/COM,                   HCELL = 1/2 of tube cell opening (m)
/COM,                   QCELL = 1/4 of basket cell opening (m)
/COM,                   SWALL = carbon steel tube thickness (m)
/COM,                   TWALL = ss-boron nuetronic plate thickness (m)
/COM,                   PWALL = Aluminum thermal conducting plate thickness (m)
/COM,                   GWALL = basket guide thickness (m)
/COM,                   CORGAP= gaps between corner guide and tube
/COM,                   PLTGAP= gaps between plates and tubes
/COM,                   ACTVL = active fuel length
/COM,                   PEAKF = assembly heat axial peaking factor
/COM,
CELL=226.4/1000.0
SWALL=5.0/1000.0
TWALL=7.0/1000.0
GWALL=10.0/1000.0
PWALL=5.0/1000.0
CORGAP=2.0/1000.0
PLTGAP=2.0/1000.0
OWALL=100.0/1000.0
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IWALL=20.0/1000.0
/COM,
ACTVL=141.8*2.54/100.0
PEAKF=1.25
/COM,
TUBE=CELL+2*SWALL
DCIX=(1.5*TUBE)+(TWALL+PWALL+2*PLTGAP)
DCIY=(2.5*TUBE)+(TWALL+PWALL+2*PLTGAP)+(TWALL+2*PLTGAP)
DCIRD=SQRT(DCIX**2+DCIY**2)
DCRAD=DCIRD+IWALL+OWALL
HCELL=CELL/2.0
QCELL=HCELL/2.0
SCELL=HCELL+SWALL
/COM,
/COM,           Define calculated parameters
/COM,                   ASSY = assembly heat production (W)  f(yrs)
/COM,                   FUEL = volumetric heat production (W/m3) f(yrs)
/COM,                   FVOLU = assy_volume=cell_width^2*active_length
/COM,
/COM,                   PITCH = basket cell outer width (m)
/COM,                   QCELL = 1/4 of basket cell opening (m)
/COM,                   SCELL = 1/2 of basket cell opening+SS wall(m)
/COM,                   ACELL = 1/2 of basket cell opening+SS+AL (m)   (NOT USED)
/COM,
/COM,                   GX## = x coord. of basket guide or thermal shunt/shell contact
/COM,                   GX## = y coord. of basket guide or thermal shunt/shell contact
/COM,
/COM,                   MI45 = x coord. MIRAD at 45 deg.               (NOT USED)
/COM,                   MO45 = x coord. MIRAD+MWALL at 45 deg.         (NOT USED)
/COM,                   DI45 = x coord. DCRAD-OWALL-IWALL at 45 deg.
/COM,                   DM45 = x coord. DCRAD-OWALL at 45 deg.
/COM,                   DO45 = x coord. DCRAD at 45 deg.
*SET,ASSY,
*DIM,ASSY, TABLE,135,1,
*DIM,FUEL, TABLE,135,1
FVOLU=4*HCELL*HCELL*ACTVL
WPVOLU=DCIRD*DCIRD*PI*ACTVL
/COM,
/COM,
GX22=(TUBE/2)+(TWALL+PWALL+2*PLTGAP)/2-(GWALL/2)
GY22=SQRT(DCIRD*DCIRD-GX22*GX22)
GX23=(TUBE/2)+(TWALL+PWALL+2*PLTGAP)/2+(GWALL/2)
GY23=SQRT(DCIRD*DCIRD-GX23*GX23)
GY24=(2.5*TUBE)+(TWALL+PWALL+2*PLTGAP)+(TWALL+2*PLTGAP)+CORGAP+GWALL
GX24=SQRT(DCIRD*DCIRD-GY24*GY24)
GY25=(2.5*TUBE)+(TWALL+PWALL+2*PLTGAP)+(TWALL+2*PLTGAP)+CORGAP
GX25=SQRT(DCIRD*DCIRD-GY25*GY25)
GY26=(2.5*TUBE)+(TWALL+PWALL+2*PLTGAP)+(TWALL+2*PLTGAP)
GX26=SQRT(DCIRD*DCIRD-GY26*GY26)
GX27=(1.5*TUBE)+(TWALL+PWALL+2*PLTGAP)+CORGAP
GY27=SQRT(DCIRD*DCIRD-GX27*GX27)
GX28=(1.5*TUBE)+(TWALL+PWALL+2*PLTGAP)+CORGAP+GWALL
GY28=SQRT(DCIRD*DCIRD-GX28*GX28)
/COM,
/COM,
DI45=DCIRD/SQRT(2.0)
DM45=(DCRAD-OWALL)/SQRT(2.0)
DO45=DCRAD/SQRT(2.0)
/COM,
/COM,           Define Transient Time parameters based upon the following:
/COM,                   Note: 1 year = 3.15576e7 seconds
/COM,                   TM_START = start time (sec)
/COM,                   TMI* = time increment for solution (sec)
/COM,                   TME* = start and stop for time do-loops (sec)
/COM,                   TMTMAX = time of maximum cladding temperature
/COM,
TM_START=(1E-6)*(3.15576E7)
TMI0=0.1*3.15576E7
TMI1=1.0*3.15576E7
TMI10=10.0*3.15576E7
```

```
TMI100=100.0*3.15576E7
TMI1000=1000.0*3.15576E7
TME10=10.0*3.15576E7+TM_START
TME90=90.0*3.15576E7+TM_START
TME100=100.0*3.15576E7+TM_START
TME500=500.0*3.15576E7+TM_START
/COM,
/COM,   ***************************************************************
/COM,           Define different element types
/PREP7
ETYPE
ET,  1,55,
ET,  7,32,
ET, 18,50,1,
/COM,   ***************************************************************
/COM,           File props04.dat descibes material properties
/COM,           and thier reference numbers
MPREAD,prop03r,dat,
/COM,           Read in single assembly heat loads
/COM,           Calculate the volumetric heat generation
/COM,           (Assembly time is in years, FUEL is in seconds)
/INPUT,pwr850f,dat
*VFACT,3.15576E7,
*MFUN,FUEL(1,0),COPY,ASSY(1,0),
*VFACT,(PEAKF*21/WPVOLU),
*VFUN,FUEL(1),COPY,ASSY(1),
FUEL(0,1)=1.0
/COM,
/COM,   ***************************************************************
/COM,           Define new material 14 for SNF effective conductivity
/COM,           Density:        DENS    (kg/m^3)
/COM,           Conductivity:   KXX     (W/m/K)
/COM,           Specific Heat:  C       (J/kg/K)
MPTEMP
MPTEMP,   1, .00000E+00,
MPDATA,DENS,14, 1, 773.4/(FVOLU),
MPDATA,   C,14, 1, .27400E+03,
/COM,           Store average effective conductivities
IINC=1
TBSKT=25.0
MPTEMP
MPTEMP,IINC,TBSKT,
IINC=IINC+1
*DO,TBSKT,50.0,400.0,50.0,
     MPTEMP,IINC,TBSKT,
     IINC=IINC+1
*ENDDO
IINC=1
TBSKT=25.0
MPDATA,KXX,14,IINC,KEFFMD(TBSKT),
IINC=IINC+1
*DO,TBSKT,50.0,400.0,50.0,
     MPDATA,KXX,14,IINC,KEFFMD(TBSKT),
     IINC=IINC+1
*ENDDO

/COM,   ***************************************************************
/COM,           Construct geometry for Disposal Container
/COM,
/COM,
K,1,0.0,0.0,0.0,
K,2,DM45,-DM45,0.0,
K,3,DM45,DM45,0.0,
/COM,
/COM,      Define disposal container outer radius and material interface
/COM,
K, 4,              0.0,       (0.0-DCRAD),0.0,
K, 5,            DCRAD,             0.0,0.0,
K, 6,              0.0,           DCRAD,0.0,
K, 7,              0.0,     (OWALL-DCRAD),0.0,
```

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K, 8,      (DCRAD-OWALL),                0.0,0.0,
K, 9,                0.0,      (DCRAD-OWALL),0.0,
L,7,4,
L,6,9,
L,8,5,
LARC,5,4,1,              DCRAD,
LARC,6,5,1,              DCRAD,
LARC,7,2,1,      (DCRAD-OWALL),
LARC,2,8,1,      (DCRAD-OWALL),
LARC,8,3,1,      (DCRAD-OWALL),
LARC,3,9,1,      (DCRAD-OWALL),
AL, 1, 4, 3, 7, 6,
AL, 3, 5, 2, 9, 8,
/COM,  ***************************************************************
/COM,           Define UCF shell inner edge and area
/COM,
K,10,  0.0,      DCIRD,0.0,
K,11, GX22,       GY22,0.0,
K,12, GX23,       GY23,0.0,
K,13, GX24,       GY24,0.0,
K,14, GX25,       GY25,0.0,
K,15, GX26,       GY26,0.0,
K,16, GX27,       GY27,0.0,
K,17, GX28,       GY28,0.0,
/COM,
K,18, DI45,       DI45,0.0,
K,19, GY28,       GX28,0.0,
K,20, GY27,       GX27,0.0,
K,21, GY26,       GX26,0.0,
K,22, GY25,       GX25,0.0,
K,23, GY24,       GX24,0.0,
K,24, GY23,       GX23,0.0,
K,25, GY22,       GX22,0.0,
K,26, DCIRD,       0.0,0.0,
L,9,10,
L,26,8,
LARC,11,10,1,DCIRD,
LARC,12,11,1,DCIRD,
LARC,13,12,1,DCIRD,
LARC,14,13,1,DCIRD,
LARC,15,14,1,DCIRD,
LARC,16,15,1,DCIRD,
LARC,17,16,1,DCIRD,
LARC,18,17,1,DCIRD,
LARC,19,18,1,DCIRD,
LARC,20,19,1,DCIRD,
LARC,21,20,1,DCIRD,
LARC,22,21,1,DCIRD,
LARC,23,22,1,DCIRD,
LARC,24,23,1,DCIRD,
LARC,25,24,1,DCIRD,
LARC,26,25,1,DCIRD,
L,3,18
LSEL,S,LINE,,12,19,
LSEL,A,LINE,,9,
LSEL,A,LINE,,10,
LSEL,A,LINE,,28,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,20,27,
LSEL,A,LINE,,11,
LSEL,A,LINE,,8,
LSEL,A,LINE,,28,
AL,ALL,
LSEL,ALL,
/COM,*************************************************************************************************************
/COM,                    Define top side guide and its vicinity
/COM,
K,27,  0.0,  GY24, 0.0,
K,500,GX22-PLTGAP,  GY24, 0.0,
```

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K,28, GX22,  GY24, 0.0,
K,29, GX23,  GY24, 0.0,
K,501,GX23+PLTGAP,  GY24, 0.0,
K,30,  0.0,  GY25, 0.0,
K,31, TUBE/2,  GY25, 0.0,
K,32, TUBE/2+PLTGAP,  GY25, 0.0,
K,33, TUBE/2+PLTGAP+PWALL,  GY25, 0.0,
K,34, TUBE/2+PLTGAP+PWALL+TWALL,  GY25, 0.0,
K,35, TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP,  GY25, 0.0,
L,10,27,
L,27,500,
L,500,28,
L,28,11,
L,12,29,
L,29,501,
L,501,13,
L,28,29,
L,27,30,
L,31,30,
L,500,31,
L,32,31,
L,33,32,
L,34,33,
L,35,34,
L,35,501,
L,14,35,
L,28,32,
L,29,34,
/COM,
/COM,                   Two cavity areas near the top side guide
/COM,
LSEL,S,LINE,,29,32,
LSEL,A,LINE,,12,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,33,35,
LSEL,A,LINE,,14,
AL,ALL,
LSEL,ALL,
/COM,                   Top side guide
LSEL,S,LINE,,32,33,
LSEL,A,LINE,,36,
LSEL,A,LINE,,13,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,37,39,
LSEL,A,LINE,,30,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,39,40,
LSEL,A,LINE,,46,
LSEL,A,LINE,,31,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,41,42,
LSEL,A,LINE,,46,
LSEL,A,LINE,,47,
LSEL,A,LINE,,36,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,43,44,
LSEL,A,LINE,,34,
LSEL,A,LINE,,47,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,44,45,
LSEL,A,LINE,,15,
LSEL,A,LINE,,35,
AL,ALL,
LSEL,ALL,
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/COM,
/COM,          Define the gap between top side guide and tubes
/COM,
K,36, 0.0,  GY26, 0.0,
K,37, TUBE/2,  GY26, 0.0,
K,38, TUBE/2+PLTGAP,  GY26, 0.0,
K,39, TUBE/2+PLTGAP+PWALL,  GY26, 0.0,
K,40, TUBE/2+PLTGAP+PWALL+TWALL,  GY26, 0.0,
K,41, TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP,  GY26, 0.0,
L,30,36,
L,36,37,
L,37,31,
L,37,38,
L,38,32,
L,38,39,
L,39,33,
L,39,40,
L,40,34,
L,40,41,
L,41,35,
L,41,15,
LSEL,S,LINE,,48,50,
LSEL,A,LINE,,38,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,50,52,
LSEL,A,LINE,,40,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,52,54,
LSEL,A,LINE,,41,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,54,56,
LSEL,A,LINE,,42,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,56,58,
LSEL,A,LINE,,43,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,58,59,
LSEL,A,LINE,,16,
LSEL,A,LINE,,45,
AL,ALL,
LSEL,ALL,
/COM,*************************************************************************************************************
/COM,                Define top row of tubes and plates
/COM,
K,42,   0.0,                                                    GY26-SWALL,       0.0,
K,43,   TUBE/2-SWALL,                                           GY26-SWALL,       0.0,
K,44,   0.0,                                                    GY26-TUBE+SWALL,  0.0,
K,45,   TUBE/2-SWALL,                                           GY26-TUBE+SWALL,  0.0,
K,46,   0.0,                                                    GY26-TUBE,        0.0,
K,47,   TUBE/2,                                                 GY26-TUBE,        0.0,
K,48,   TUBE/2+PLTGAP,                                          GY26-TUBE,        0.0,
K,49,   TUBE/2+PLTGAP+PWALL,                                    GY26-TUBE,        0.0,
K,50,   TUBE/2+PLTGAP+PWALL+TWALL,                              GY26-TUBE,        0.0,
K,51,   TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP,                       GY26-TUBE,        0.0,
K,52,   1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP-SWALL,               GY26-TUBE+SWALL,  0.0,
K,53,   1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP,                     GY26-TUBE,        0.0,
K,54,   1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP-SWALL,               GY26-SWALL,       0.0,
K,55,   TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP+SWALL,                 GY26-SWALL,       0.0,
K,56,   TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP+SWALL,                 GY26-TUBE+SWALL,  0.0,
L,36,42,
L,42,43,
L,43,37,
L,42,44,
L,44,45,
L,45,43,
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L,44,46,
L,47,46,
L,47,45,
L,37,47,
/COM,                           Half tube
AL,60,61,62,49,
AL,61,63,64,65,
AL,66,67,68,64,
AL,68,69,62,65,
/COM,                           Plates
L,48,47
L,48,38,
L,49,48,
L,49,39,
L,50,49,
L,40,50,
L,51,50,
L,51,41,
L,41,40,
AL,51,69,70,71,
AL,53,71,72,73,
AL,55,73,74,75,
AL,57,75,76,77,
/COM,                           Whole tube
L,41,55,
L,55,56,
L,51,56,
L,56,52,
L,53,51,
L,52,53,
L,52,54,
L,15,53,
L,15,54,
L,55,54,
AL,80,82,83,81,
AL,84,83,85,86,
AL,87,86,59,78,
AL,78,77,80,79,
AL,87,79,81,84,
/COM,*************************************************************************************************
/COM,                   Define corner guide
/COM,
K,57,GX27,GY26-TUBE,0.0,
K,58,GX27,GY26-TUBE-PLTGAP,0.0,
K,59,GX27,GX27,0.0,
K,60,GX28,GX28,0.0,
L,59,58,
L,58,57,
L,57,16,
L,20,59,
L,17,60,
L,60,19,
L,57,60,
AL,94,90,92,18,
AL,89,88,91,21,93,94,
AL,20,19,92,93,
/COM,*************************************************************************************************
/COM,                   Set element shapes and sizes for tubes
/COM,                           14x14 mesh in fuel with 2
/COM,                           divisions per tube layer
/COM,
ESHAPE,2,
ESIZE,,1,
/COM,
/COM,                           Full tube
/COM,
LSEL,S,LINE,,81,
LSEL,A,LINE,,82,
LSEL,A,LINE,,84,
LSEL,A,LINE,,85,
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LSEL,A,LINE,,87,
LSEL,A,LINE,,59,
LSEL,A,LINE,,77,
LSEL,A,LINE,,79,
LESIZE,ALL,,, 14,
LSEL,ALL,
LSEL,S,LINE,,78,
LSEL,A,LINE,,80,
LSEL,A,LINE,,83,
LSEL,A,LINE,,86,
LESIZE,ALL,,, 2,
LSEL,ALL,
/COM,                          Half tube
LSEL,S,LINE,,49,
LSEL,A,LINE,,61,
LSEL,A,LINE,,64,
LSEL,A,LINE,,67,
LESIZE,ALL,,, 7,
LSEL,ALL,
LSEL,S,LINE,,63,
LSEL,A,LINE,,65,
LSEL,A,LINE,,69,
LESIZE,ALL,,, 14,
LSEL,ALL,
LSEL,S,LINE,,60,
LSEL,A,LINE,,66,
LSEL,A,LINE,,68,
LSEL,A,LINE,,62,
LESIZE,ALL,,, 2,
LSEL,ALL,
/COM,
/COM,                            Mesh areas
/COM,                       first fuel, then tubes
MAT,14,
TYPE,1,
AMESH,31,
AMESH,20,
MAT, 3,
TYPE,1,
AMESH,27,30,1,
AMESH,21,22,1,
AMESH,19,
/COM,                            Copy tube mesh
/COM,
/COM,
AGEN,2,19,22,1,0.0,-(TUBE+2*PLTGAP+TWALL),0.0,0,0,
AGEN,2,27,31,1,0.0,-(TUBE+2*PLTGAP+TWALL),0.0,0,0,
AGEN,2,27,31,1,(TUBE+2*PLTGAP+TWALL),-(TUBE+2*PLTGAP+TWALL),0.0,0,0,
/COM,
/COM,*************************************************************************************************
/COM,                    Gaps between the tubes (row 1/2)
/COM,
K,85,   0.0,              GY26-TUBE-PLTGAP,                  0.0,
K,86,   TUBE/2,           GY26-TUBE-PLTGAP,                  0.0,
K,87,   0.0,              GY26-TUBE-PLTGAP-TWALL,            0.0,
K,88,   TUBE/2,           GY26-TUBE-PLTGAP-TWALL,            0.0,
K,89,   TUBE/2+PLTGAP,    GY26-TUBE-PLTGAP,                  0.0,
K,90,   TUBE/2+PLTGAP,    GY26-TUBE-PLTGAP-TWALL,            0.0,
K,91,   TUBE/2+PLTGAP+PWALL,    GY26-TUBE-PLTGAP,            0.0,
K,92,   TUBE/2+PLTGAP+PWALL,    GY26-TUBE-PLTGAP-TWALL,      0.0,
K,93,   TUBE/2+PLTGAP+PWALL+TWALL,    GY26-TUBE-PLTGAP,      0.0,
K,94,   TUBE/2+PLTGAP+PWALL+TWALL,    GY26-TUBE-PLTGAP-TWALL,      0.0,
K,95,   TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP,    GY26-TUBE-PLTGAP,      0.0,
K,96,   TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP,    GY26-TUBE-PLTGAP-TWALL,      0.0,
K,97,   1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP,    GY26-TUBE-PLTGAP,      0.0,
K,98,   1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP,    GY26-TUBE-PLTGAP-TWALL,      0.0,
K,99,   TUBE/2+PLTGAP,    GY26-TUBE-PLTGAP-TWALL-PLTGAP,      0.0,
K,100,  TUBE/2+PLTGAP+PWALL,    GY26-TUBE-PLTGAP-TWALL-PLTGAP,      0.0,
K,101,  TUBE/2+PLTGAP+PWALL+TWALL,    GY26-TUBE-PLTGAP-TWALL-PLTGAP,      0.0,
K,102,  1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP+PLTGAP,    GY26-TUBE-PLTGAP-TWALL-PLTGAP,      0.0,
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K,103,  1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP+PLTGAP+TWALL,   GY26-TUBE-PLTGAP-TWALL-PLTGAP,        0.0,
L,46,85,
L,85,86,
L,86,47,
L,86,89,
L,89,48,
L,89,91,
L,91,49,
L,91,93,
L,50,93,
L,93,95,
L,95,51,
L,95,97,
L,97,53,
L,97,58,
L,57,53,
L,85,87,
L,88,87,
L,88,86,
L,90,88,
L,90,89,
L,92,90,
L,92,91,
L,94,92,
L,93,94,
L,96,94,
L,96,95,
L,98,96,
L,97,98,
L,98,59,
L,87,61,
L,64,88,
L,64,99,
L,99,90,
L,99,100,
L,100,92,
L,100,101,
L,94,101,
L,101,76,
L,76,96,
L,74,98,
L,74,102,
L,102,103,
L,84,103,
L,102,59,
AL,67,130,131,132
AL,131,145,146,147,
AL,146,159,98,160
AL,70,132,133,134
AL,133,147,148,149
AL,147,148,149,133
AL,148,160,161,162,
AL,72,134,135,136
AL,135,149,150,151
AL,150,162,163,164
AL,74,136,137,138
AL,137,151,152,153
AL,152,164,165,166
AL,139,153,154,155
AL,76,138,139,140
AL,154,166,167,168
AL,140,141,82,142
AL,144,142,143,89
AL,155,156,157,141
AL,143,157,158,88
AL,168,156,114,169
AL,158,169,170,173
AL,17,85,144,90
KSEL,S, , ,      82
KSEL,A, , ,      21
```

```
NUMMRG,KP, ,
KSEL,ALL
AL,173,171,172,126,22,91
/COM,
/COM,*********************************************************************************************
/COM,        Plates between tubes (column 2/3)
/COM,
K,104,1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP+PLTGAP,GX26-TUBE,0.0,
K,105,1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP+PLTGAP+TWALL,GX26-TUBE,0.0,
L,104,72,
L,105,104,
L,77,105,
L,104,102,
L,103,105,
AL,112,177,170,174,
AL,175,178,177,171
AL,172,178,129,176
/COM,
/COM,                    Mesh plates between tubes (1/2 column)
/COM,
LSEL,S,LINE,,53,
LSEL,A,LINE,,55,
LSEL,A,LINE,,72,
LSEL,A,LINE,,74,
LESIZE,ALL,,, 2,
LSEL,ALL,
LSEL,S,LINE,,71,75,2,
LESIZE,ALL,,, 14,
LSEL,ALL,
MAT,7,
TYPE,1,
AMESH,23,
AMESH,26,
MAT,18,
TYPE,1,
AMESH,24,
MAT,19,
TYPE,1,
AMESH,25,
AGEN,2,23,26,1,0.0,-(TUBE+PLTGAP+TWALL+PLTGAP),0.0,0,0,
/COM,
/COM,                    Mesh plates between tubes (2/3 column)
/COM,
LSEL,S,LINE,,177,
LSEL,A,LINE,,178,
LESIZE,ALL,,, 14,
LSEL,ALL,
LSEL,S,LINE,,171,
LSEL,S,LINE,,175,
LESIZE,ALL,,, 2,
LSEL,ALL,
MAT,7,
TYPE,1,
AMESH,72,
AMESH,74,
MAT,19,
TYPE,1,
AMESH,73,
/COM,
/COM,                    Copy tubes and plates (all rows)
/COM,
AGEN,2,19,31,1,0.0,-(4*TUBE+2*(2*PLTGAP+TWALL)+2*(2*PLTGAP+PWALL+TWALL)),0,0,
AGEN,2,35,48,1,0.0,-(TUBE+2*PLTGAP+PWALL+TWALL),0,0,
AGEN,2,72,78,1,0.0,-(TUBE+2*PLTGAP+PWALL+TWALL),0,0,
AGEN,2,35,48,1,0.0,-(2*TUBE+2*(2*PLTGAP+PWALL+TWALL)),0,0,
AGEN,2,72,78,1,0.0,-(2*TUBE+2*(2*PLTGAP+PWALL+TWALL)),0,0,
/COM,
/COM,                    Mesh plates between tubes ( 1/2 row)
/COM,
LSEL,S,LINE,,145,
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LSEL,A,LINE,,147,
LSEL,A,LINE,,149,
LSEL,A,LINE,,151,
LSEL,A,LINE,,153,
LSEL,A,LINE,,155,
LSEL,A,LINE,,157,
LSEL,A,LINE,,135,
LSEL,A,LINE,,150,
LSEL,A,LINE,,137,
LSEL,A,LINE,,152,
LESIZE,ALL,,, 2,
LSEL,ALL,
LSEL,S,LINE,,146,
LSEL,A,LINE,,131,
LESIZE,ALL,,, 7,
LSEL,ALL,
LSEL,S,LINE,,156,
LSEL,A,LINE,,141,
LESIZE,ALL,,, 14,
LSEL,ALL,
MAT,7,
TYPE,1,
AMESH,49,
AMESH,51,
AMESH,52,
AMESH,54,
AMESH,62,
AMESH,63,
AMESH,64,
AMESH,68,
AMESH,65,
AMESH,67,
AMESH,69,
MAT,19,
TYPE,1,
AMESH,50,
AMESH,53,
AMESH,56,
AMESH,59,
AMESH,61,
AMESH,66,
AMESH,58,
AMESH,60,
MAT,18,
TYPE,1,
AMESH,55,
AMESH,57,
/COM,                    Copy tubes and plates (all rows)
/COM,
AGEN,2,49,69,1,0.0,-(3*TUBE+(2*PLTGAP+TWALL)+2*(2*PLTGAP+PWALL+TWALL)),0,0,
NUMMRG,all, ,
/COM,                    Plates between the tubes (2/3 row)
/COM,
K,253,    0.0,                          TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,254,    0.0,                          TUBE/2+PLTGAP+PWALL,            0.0,
K,255, TUBE/2,                          TUBE/2+PLTGAP+PWALL,            0.0,
K,256, TUBE/2,                          TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,257,    0.0,                          TUBE/2+PLTGAP,                  0.0,
K,258, TUBE/2,                          TUBE/2+PLTGAP,                  0.0,
K,259, TUBE/2+PLTGAP,                   TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,260, TUBE/2+PLTGAP,                   TUBE/2+PLTGAP+PWALL,            0.0,
K,261, TUBE/2+PLTGAP,                   TUBE/2+PLTGAP,                  0.0,
K,262, TUBE/2+PLTGAP+PWALL,             TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,263, TUBE/2+PLTGAP+PWALL,             TUBE/2+PLTGAP+PWALL,            0.0,
K,264, TUBE/2+PLTGAP+PWALL,             TUBE/2+PLTGAP,                  0.0,
K,265, TUBE/2+PLTGAP+PWALL+TWALL,       TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,266, TUBE/2+PLTGAP+PWALL+TWALL,       TUBE/2+PLTGAP+PWALL,            0.0,
K,267, TUBE/2+PLTGAP+PWALL+TWALL,       TUBE/2+PLTGAP,                  0.0,
K,268, TUBE/2+2*PLTGAP+PWALL+TWALL,     TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,269, TUBE/2+2*PLTGAP+PWALL+TWALL,     TUBE/2+PLTGAP+PWALL,            0.0,
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K,270, TUBE/2+2*PLTGAP+PWALL+TWALL,     TUBE/2+PLTGAP,                  0.0,
K,271, 1.5*TUBE+2*PLTGAP+PWALL+TWALL,   TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,272, 1.5*TUBE+3*PLTGAP+PWALL+TWALL,   TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,273, 1.5*TUBE+3*PLTGAP+PWALL+2*TWALL, TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,274, 1.5*TUBE+4*PLTGAP+PWALL+2*TWALL, TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,275, 1.5*TUBE+2*PLTGAP+PWALL+TWALL,   TUBE/2+PLTGAP+PWALL,            0.0,
K,276, 1.5*TUBE+3*PLTGAP+PWALL+TWALL,   TUBE/2+PLTGAP+PWALL,            0.0,
K,277, 1.5*TUBE+3*PLTGAP+PWALL+2*TWALL, TUBE/2+PLTGAP+PWALL,            0.0,
K,278, 1.5*TUBE+4*PLTGAP+PWALL+2*TWALL, TUBE/2+PLTGAP+PWALL,            0.0,
K,279, 1.5*TUBE+2*PLTGAP+PWALL+TWALL,   TUBE/2+PLTGAP,          0.0,
K,280, 1.5*TUBE+3*PLTGAP+PWALL+TWALL,   TUBE/2+PLTGAP,                  0.0,
K,281, 1.5*TUBE+3*PLTGAP+PWALL+2*TWALL, TUBE/2+PLTGAP,          0.0,
K,282, 1.5*TUBE+4*PLTGAP+PWALL+2*TWALL, TUBE/2+PLTGAP,          0.0,
K,283, GY26,                            TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,284, GY26,                            TUBE/2+PLTGAP+PWALL,            0.0,
K,285, GY26,                            TUBE/2+PLTGAP+PWALL,            0.0,
/COM,
L,67,253,
L,253,256,
L,256,68
L,253,254,
L,254,255,
L,255,256,
L,254,257,
L,258,257,
L,258,255,
L,257,137,
L,140,258,
/COM,
L,256,259,
L,259,107,
L,255,260,
L,260,259,
L,261,258,
L,261,260,
L,170,261,
/COM,
L,259,262,
L,262,110
L,260,263,
L,263,262,
L,261,264,
L,264,263,
L,173,264,
/COM,
L,262,265,
L,112,265,
L,263,266,
L,266,265,
L,264,267,
L,267,266
L,267,175,
/COM,
L,265,268,
L,268,69,
L,266,269,
L,269,268,
L,270,267,
L,270,269,
L,152,270,
/COM,
L,268,271,
L,271,72,
L,269,275,
L,271,275,
L,279,270,
L,275,279,
L,150,279,
L,271,272,
L,272,104,
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L,275,276,
L,276,272,
L,280,279,
L,280,276,
L,164,280,
/COM,
L,272,273,
L,105,273,
L,276,277,
L,277,273,
L,280,281,
L,281,277,
L,281,166,
/COM,
L,273,274,
L,274,77,
L,277,278,
L,278,274,
L,282,281,
L,282,278,
L,160,282,
/COM,
AL,103,179,182,183
AL,182,186,189,190,
AL,189,261,270,274,
AL,270,282,229,319,
AL,181,183,328,332,
AL,328,190,340,342,
AL,340,274,350,352,
AL,350,319,271,357,
AL,185,332,359,364,
AL,359,342,366,371,
AL,366,352,376,378,
AL,376,357,275,380,
AL,188,364,383,391,
AL,383,371,394,395,
AL,394,378,396,397,
AL,396,380,278,398,
AL,191,391,399,400,
AL,399,395,401,402,
AL,401,397,403,404,
AL,403,398,281,405,
AL,109,400,406,407,
AL,406,402,408,409,
AL,408,404,410,411,
AL,410,405,245,412,
AL,174,407,413,414,
AL,413,409,415,416,
AL,415,411,417,418,
AL,417,412,264,419,
AL,175,414,420,421,
AL,420,416,422,423,
AL,422,418,424,425,
AL,424,419,266,426,
AL,176,421,427,428,
AL,427,423,429,430,
AL,429,425,431,432,
AL,431,426,268,433,
LSEL,S,LINE,,182,
LSEL,A,LINE,,189,
LSEL,A,LINE,,269,
LESIZE,ALL,,, 7,
LSEL,ALL,
LSEL,S,LINE,,406,
LSEL,A,LINE,,408,
LSEL,A,LINE,,410,
LESIZE,ALL,,, 14,
LSEL,ALL,
LSEL,S,LINE,,186,
LSEL,A,LINE,,261,
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LSEL,A,LINE,,190,
LSEL,A,LINE,,274,
LSEL,A,LINE,,342,
LSEL,A,LINE,,352,
LSEL,A,LINE,,371,
LSEL,A,LINE,,378,
LSEL,A,LINE,,395,
LSEL,A,LINE,,397,
LSEL,A,LINE,,402,
LSEL,A,LINE,,404,
LSEL,A,LINE,,359,
LSEL,A,LINE,,383,
LSEL,A,LINE,,366,
LSEL,A,LINE,,394,
LSEL,A,LINE,,376,
LSEL,A,LINE,,396,
LSEL,A,LINE,,409,
LSEL,A,LINE,,411,
LSEL,A,LINE,,416,
LSEL,A,LINE,,418,
LSEL,A,LINE,,423,
LSEL,A,LINE,,425,
LSEL,A,LINE,,430,
LSEL,A,LINE,,432,
LESIZE,ALL,,, 2,
LSEL,ALL,
MAT,7,
TYPE,1,
AMESH,155,
AMESH,158,
AMESH,159,
AMESH,162,
AMESH,171,
AMESH,174,
AMESH,175,
AMESH,178,
AMESH,179,
AMESH,182,
AMESH,187,
AMESH,190,
MAT,19,
TYPE,1,
AMESH,167,169,1,
AMESH,170,
AMESH,183,186,1,
AMESH,156,
AMESH,176,
AMESH,160,
AMESH,172,
AMESH,180,
AMESH,188,
MAT,18,
TYPE,1,
AMESH,157,
AMESH,161,
AMESH,163,
AMESH,165,
AMESH,166,
AMESH,164,
AMESH,173,
AMESH,177,
AMESH,181,
AMESH,189,
/COM,                                   Copy plates (all 2/3 row)
/COM,
AGEN,2,175,178,1,TUBE+2*PLTGAP+TWALL,0.0,0.0,
NUMMRG,all, ,
/COM,
/COM,
K,286,    0.0,                          -(TUBE/2+PLTGAP),              0.0,
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K,287,    0.0,                          -(TUBE/2+PLTGAP+PWALL),          0.0,
K,288,    0.0,                          -(TUBE/2+PLTGAP+TWALL+PWALL),    0.0,
K,289, TUBE/2,                          -(TUBE/2+PLTGAP),                0.0,
K,290, TUBE/2,                          -(TUBE/2+PLTGAP+PWALL),          0.0,
K,291, TUBE/2,                          -(TUBE/2+PLTGAP+TWALL+PWALL),    0.0,
K,292, TUBE/2+PLTGAP,                   -(TUBE/2+PLTGAP),                0.0,
K,293, TUBE/2+PLTGAP,                   -(TUBE/2+PLTGAP+PWALL),          0.0,
K,294, TUBE/2+PLTGAP,                   -(TUBE/2+PLTGAP+TWALL+PWALL),    0.0,
K,295, TUBE/2+PLTGAP+PWALL,             -(TUBE/2+PLTGAP),                0.0,
K,296, TUBE/2+PLTGAP+PWALL,             -(TUBE/2+PLTGAP+PWALL),          0.0,
K,297, TUBE/2+PLTGAP+PWALL,             -(TUBE/2+PLTGAP+TWALL+PWALL),    0.0,
K,298, TUBE/2+PLTGAP+PWALL+TWALL,       -(TUBE/2+PLTGAP),                0.0,
K,299, TUBE/2+PLTGAP+PWALL+TWALL,       -(TUBE/2+PLTGAP+PWALL),          0.0,
K,300, TUBE/2+PLTGAP+PWALL+TWALL,       -(TUBE/2+PLTGAP+TWALL+PWALL),    0.0,
K,301, TUBE/2+2*PLTGAP+PWALL+TWALL,     -(TUBE/2+PLTGAP),                0.0,
K,302, TUBE/2+2*PLTGAP+PWALL+TWALL,     -(TUBE/2+PLTGAP+PWALL),          0.0,
K,303, TUBE/2+2*PLTGAP+PWALL+TWALL,     -(TUBE/2+PLTGAP+TWALL+PWALL),    0.0,
K,304, 1.5*TUBE+2*PLTGAP+PWALL+TWALL,   -(TUBE/2+PLTGAP),                0.0,
K,305, 1.5*TUBE+2*PLTGAP+PWALL+TWALL,   -(TUBE/2+PLTGAP+PWALL),          0.0,
K,306, 1.5*TUBE+2*PLTGAP+PWALL+TWALL,   -(TUBE/2+PLTGAP+TWALL+PWALL),    0.0,
K,307, 1.5*TUBE+3*PLTGAP+PWALL+TWALL,   -(TUBE/2+PLTGAP),                0.0,
K,308, 1.5*TUBE+3*PLTGAP+PWALL+TWALL,   -(TUBE/2+PLTGAP+PWALL),          0.0,
K,309, 1.5*TUBE+3*PLTGAP+PWALL+TWALL,   -(TUBE/2+PLTGAP+TWALL+PWALL),    0.0,
K,310, 1.5*TUBE+3*PLTGAP+PWALL+2*TWALL, -(TUBE/2+PLTGAP),                0.0,
K,311, 1.5*TUBE+3*PLTGAP+PWALL+2*TWALL, -(TUBE/2+PLTGAP+PWALL),          0.0,
K,312, 1.5*TUBE+3*PLTGAP+PWALL+2*TWALL, -(TUBE/2+PLTGAP+TWALL+PWALL),    0.0,
K,313, 1.5*TUBE+4*PLTGAP+PWALL+2*TWALL, -(TUBE/2+PLTGAP),                0.0,
K,314, 1.5*TUBE+4*PLTGAP+PWALL+2*TWALL, -(TUBE/2+PLTGAP+PWALL),          0.0,
K,315, 1.5*TUBE+4*PLTGAP+PWALL+2*TWALL,-(TUBE/2+PLTGAP+TWALL+PWALL),     0.0,
K,316, GY26,                            -(TUBE/2+PLTGAP),                0.0,
K,317, GY26,                            -(TUBE/2+PLTGAP+PWALL),          0.0,
K,318, GY26,                            -(TUBE/2+PLTGAP+TWALL+PWALL),    0.0,
L,143,286,
L,286,289,
L,144,289,
L,286,287,
L,287,290,
L,289,290,
L,287,288,
L,291,288,
L,290,291,
L,288,179,
L,182,291,
L,289,292,
L,290,293,
L,293,292,
L,294,291,
L,294,293,
L,212,294,
L,292,171,
L,290,293,
L,293,292,
L,291,294,
L,294,293,
L,212,294,
L,292,295,
L,295,174,
L,293,296,
L,296,295,
L,297,294,
L,297,296,
L,215,297,
L,298,295,
L,176,298,
L,296,299,
L,299,298,
L,297,300,
L,300,299,
L,300,217,
L,298,301,
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L,301,145,
L,299,302,
L,302,301,
L,303,300,
L,303,302,
L,194,303,
L,301,304,
L,304,148,
L,302,305,
L,304,305,
L,306,303,
L,305,306,
L,192,306,
L,304,307,
L,307,163,
L,305,308,
L,308,307,
L,309,306,
L,309,308,
L,206,309,
L,307,310,
L,165,310,
L,308,311,
L,311,310,
L,309,312,
L,312,311,
L,312,208,
L,310,313,
L,313,153,
L,311,314,
L,314,313,
L,315,312,
L,315,314,
L,202,315,
AL,234,434,435,440,
AL,435,443,444,445,
AL,444,447,448,449,
AL,287,451,448,450,
AL,440,452,458,273,
AL,452,445,453,454,
AL,453,449,455,456,
AL,455,451,329,457,
AL,458,459,460,277,
AL,459,454,461,462,
AL,461,456,463,464,
AL,463,457,333,465,
AL,460,466,467,280,
AL,466,462,468,469,
AL,468,464,470,471,
AL,470,465,336,472,
AL,467,473,474,283,
AL,473,469,475,476,
AL,475,471,477,478,
AL,477,472,339,479,
AL,240,480,474,481,
AL,480,476,482,483,
AL,482,484,478,485,
AL,484,303,479,486,
AL,481,487,488,262,
AL,487,483,489,490,
AL,489,485,491,492,
AL,491,486,322,493,
AL,265,488,494,495,
AL,494,490,496,497,
AL,496,492,498,499,
AL,498,493,324,500,
AL,269,495,501,502,
AL,501,497,503,504,
AL,503,499,505,506,
AL,505,500,326,507,
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LSEL,S,LINE,,435,
LSEL,A,LINE,,444,
LSEL,A,LINE,,448,
LESIZE,ALL,,,7,
LSEL,S,LINE,,443,
LSEL,A,LINE,,447,
LSEL,A,LINE,,446,
LSEL,A,LINE,,454,
LSEL,A,LINE,,449,
LSEL,A,LINE,,456,
LSEL,A,LINE,,459,
LSEL,A,LINE,,461,
LSEL,A,LINE,,463,
LSEL,A,LINE,,462,
LSEL,A,LINE,,464,
LSEL,A,LINE,,466,
LSEL,A,LINE,,468,
LSEL,A,LINE,,470,
LSEL,A,LINE,,469,
LSEL,A,LINE,,471,
LSEL,A,LINE,,476,
LSEL,A,LINE,,478,
LESIZE,ALL,,,2,
LSEL,ALL,
LSEL,S,LINE,,480,
LSEL,A,LINE,,482,
LSEL,A,LINE,,484,
LESIZE,ALL,,,14,
LSEL,ALL,
LSEL,S,LINE,,483,
LSEL,A,LINE,,485,
LSEL,A,LINE,,485,
LSEL,A,LINE,,490,
LSEL,A,LINE,,492,
LSEL,A,LINE,,497,
LSEL,A,LINE,,499,
LSEL,A,LINE,,504,
LSEL,A,LINE,,506,
LESIZE,ALL,,,2,
LSEL,ALL,
MAT,7,
TYPE,1,
AMESH,195,
AMESH,198,
AMESH,199,
AMESH,202,
AMESH,211,
AMESH,214,
AMESH,215,
AMESH,218,
AMESH,219,
AMESH,222,
AMESH,227,
AMESH,230,
MAT,18,
TYPE,1,
AMESH,196,
AMESH,200,
AMESH,204,
AMESH,212,
AMESH,216,
AMESH,220,
AMESH,203,
AMESH,205,
AMESH,206,
AMESH,228,
MAT,19,
TYPE,1,
AMESH,197,
AMESH,201,
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AMESH,208,
AMESH,209,
AMESH,213,
AMESH,217,
AMESH,221,
AMESH,207,
AMESH,210,
AMESH,223,
AMESH,224,
AMESH,225,
AMESH,226,
AMESH,229,
AGEN,2,215,218,1,TUBE+2*PLTGAP+TWALL,0.0,0.0,
NUMMRG,all, ,
/COM,*************************************************************************************************
/COM,                    Side side guide
/COM,
K,319,GY25,TUBE/2+2*PLTGAP+TWALL+PWALL, 0.0,
K,320,GY25,TUBE/2+PLTGAP+TWALL+PWALL,   0.0,
K,321,GY25,TUBE/2+PLTGAP+PWALL,         0.0,
K,322,GY25,TUBE/2+PLTGAP,               0.0,
K,323,GY25,TUBE/2,                      0.0,
K,324,GY25,0.0,                         0.0,
K,325,GY24,GX23+PLTGAP,                 0.0,
K,326,GY24,GX23,                        0.0,
K,327,GY24,GX22,                        0.0,
K,328,GY24,GX22-PLTGAP,                 0.0,
K,329,GY24,0.0,                         0.0,
L,319,22,
L,320,319,
L,321,320,
L,322,321,
L,323,322,
L,324,323,
L,324,329,
L,23,325,
L,325,326,
L,326,327,
L,327,328,
L,328,329,
L,329,26,
L,80,319,
L,109,320,
L,111,321,
L,114,322,
L,158,323,
L,326,24,
L,25,327,
L,322,327,
L,323,328,
L,320,326,
L,319,325,
AL,23,124,508,528
AL,528,437,529,509,
AL,529,438,530,514,
AL,530,441,531,517,
AL,531,446,532,518,
AL,24,508,522,538,
AL,538,509,537,523
AL,537,514,517,535,524,
AL,535,518,536,525,
AL,536,521,519,526,
AL,25,522,523,533,
AL,533,524,534,26,
AL,534,525,526,527,27,
/COM,
LSEL,S,LINE,,38,
LSEL,A,LINE,,30,
LSEL,A,LINE,,12,
LESIZE,ALL,,,7,
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LSEL,ALL,
LSEL,S,LINE,,29,
LSEL,A,LINE,,32,
LSEL,A,LINE,,33,
LESIZE,ALL,,,7,
LSEL,ALL,
LSEL,S,LINE,,37,
LSEL,A,LINE,,39,
LSEL,A,LINE,,46,
LSEL,A,LINE,,47,
LSEL,A,LINE,,44,
LSEL,A,LINE,,15,
LSEL,A,LINE,,13,
LSEL,A,LINE,,36,
LESIZE,ALL,,,2,
LSEL,ALL,
LSEL,S,LINE,,35,
LSEL,A,LINE,,45,
LESIZE,ALL,,,14,
LSEL,ALL,
LSEL,S,LINE,,14,
LESIZE,ALL,,,15,
LSEL,ALL,
/COM,
ESHAPE,0,
MAT,7,
TYPE,1,
AMESH,13,18,1,
AMESH,5,6,1,
MAT,3,
TYPE,1,
AMESH,7,12,1,
/COM,*************************************************************************************************
/COM,                          Mesh top corner guide
/COM,
LSEL,S,LINE,,90,
LSEL,A,LINE,,92,
LSEL,A,LINE,,93,
LESIZE,ALL,,,14,
LSEL,ALL,
LSEL,S,LINE,,91,
LESIZE,ALL,,,16,
LSEL,ALL,
LSEL,S,LINE,,18,
LSEL,A,LINE,,94,
LSEL,A,LINE,,88,
LSEL,A,LINE,,21,
LESIZE,ALL,,,2,
LSEL,ALL,
LSEL,S,LINE,,19,
LSEL,A,LINE,,20,
LESIZE,ALL,,,12,
LSEL,ALL,
MAT,7,
TYPE,1
AMESH,70,
AMESH,71,
AMESH,34,
MAT,3,
TYPE,1
AMESH,32,
AMESH,33,
/COM,
/COM,                          Mesh side side guide
/COM,
LSEL,S,LINE,,508,
LSEL,A,LINE,,522,
LSEL,A,LINE,,25,
LESIZE,ALL,,,14,
LSEL,ALL,
```

```
LSEL,S,LINE,,24,
LSEL,A,LINE,,538,
LSEL,A,LINE,,537,
LSEL,A,LINE,,535,
LSEL,A,LINE,,536,
LSEL,A,LINE,,521,
LSEL,A,LINE,,524,
LSEL,A,LINE,,26,
LESIZE,ALL,,,2,
LSEL,ALL,
LSEL,S,LINE,,520,
LSEL,A,LINE,,526,
LSEL,A,LINE,,27,
LSEL,A,LINE,,533,
LSEL,A,LINE,,534,
LSEL,A,LINE,,527,
LSEL,A,LINE,,519,
LESIZE,ALL,,,7,
LSEL,ALL,
MAT,7,
TYPE,1
AMESH,235,239,1,
AMESH,245,
AMESH,247,
MAT,3,
TYPE,1
AMESH,240,244,1
AMESH,246,
/COM,
/COM,                          Mesh upper 1/4 inner barrier
/COM,
ESHAPE,0,
LSEL,S,LINE,,9,
LSEL,A,LINE,,8,
LESIZE,ALL,,,40,
LSEL,ALL,
LSEL,S,LINE,,10,
LSEL,A,LINE,,28,
LSEL,A,LINE,,11,
LESIZE,ALL,,,2,
LSEL,ALL,
MAT,15,
TYPE,1
AMESH,3,4,1
NUMMRG,all, ,
/COM,
/COM,                  Copy bottom 1/2 corner guides and inner barrier
/COM,
LOCAL,11,1,0.0,0.0,0.0,
AGEN,2,5,12,1,0.0,-90,0.0,
AGEN,2,14,18,1,0.0,-90,0.0,
AGEN,2,32,34,1,0.0,-90,0.0,
AGEN,2,65,69,2,0.0,-90,0.0,
AGEN,2,70,71,1,0.0,-90,0.0,
AGEN,2,235,247,1,0.0,-90,0.0,
AGEN,2,3,4,1,0.0,-90,0.0,
NUMMRG,all, ,
CSYS,0,
AL,519,551,255,532,563,
MAT,7,
TYPE,1,
AMESH,266,
L,121,365,
AL,200,540,636,623,
MAT,7,
TYPE,1,
AMESH,284,
/COM,
/COM,                          Mesh outer barrier
/COM,
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LSEL,S,LINE,,4,
LSEL,A,LINE,,5,
LESIZE,ALL,,,80,
LSEL,ALL,
LSEL,S,LINE,,1,
LSEL,A,LINE,,2,
LSEL,A,LINE,,3,
LESIZE,ALL,,,7,
LSEL,ALL,
MAT,3,
TYPE,1
AMESH,1,2,1
NUMMRG,all, ,
/com,                   modify an area on the lower corner guide
ACLEAR,     262
ADELE,     262
ACLEAR,     268
ADELE,     268
LDELE,     585
LSTR,     315,     252
FLST,2,8,4
FITEM,2,582
FITEM,2,586
FITEM,2,388
FITEM,2,392
FITEM,2,578
FITEM,2,583
FITEM,2,552
FITEM,2,584
AL,P51X
FLST,2,4,4
FITEM,2,393
FITEM,2,221
FITEM,2,552
FITEM,2,605
AL,P51X
FLST,5,1,4,ORDE,1
FITEM,5,552
CM,_Y,LINE
LSEL, , , ,P51X
!*
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,14,1,
CMDEL,_Y
CMDEL,_Y1
mat,3,
type,1
ASEL,S, , ,     262
amesh,all
ALLSEL,ALL
mat,7,
type,1
ASEL,S, , ,     268
amesh,all
/COM,
/COM,           DEVELOP DRIP SHIELD AND DRIFT
/COM,
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/COM,   ****************************************************************
/COM,   ANSYS REVISION  5.4                                      06/23/98
/COM,   2-D Thermal Model of 21 PWR WP with Above Drip Shield   M. Plinski
/COM,   ****************************************************************
/COM,   *                                                               *
/COM,   *                                                               *
/COM,   * File name: drshtop.inp                                        *
/COM,   *       21 PWR UCF: tube=236.4 mm, tube_thck=5 mm               *
/COM,   *       guide=10 mm, shunt=5 mm, A/B/C ss-boron plate=7 mm      *
/COM,   *       Helium Fill Gas                                         *
/COM,   *                                                               *
/COM,   * Material Property file: prop03r.dat                          *
/COM,   *                                                               *
/COM,   * SNF Conductivity file:  pwr14dk.parm                         *
/COM,   *       15x15 Mark-B4 PWR SNF Assembly                          *
/COM,   *                                                               *
/COM,   * SNF Heat Loads file:    pwr850f.dat                           *
/COM,   *       SNF Type: 20 years old, 60000 MWd/MTU                   *
/COM,   *                                                               *
/COM,   * Surface Temp. file:    f04d51c1.parm                         *
/COM,   *       83 MTU/acre (20.5 kgU/m^2) AML (High Thermal Loading)   *
/COM,   *       5.0 m Diameter Drift with Concrete Invert               *
/COM,   *       Drift spacing = 22.5 m                                  *
/COM,   *       Mutiple WPs                                             *
/COM,   *                                                               *
/COM,   ****************************************************************
/COM,   Increase the number of database pages from 16 (256) to 32 Mb
/COM,/CONFIG,nvpag,512,
/COM,   Work space must also be increased (-m 64)
/COM,   ****************************************************************
/TITLE, 21 PWR UCF/Waste Package with 10 yr old, 48 GWD/MTU SNF
/UNITS,SI,
/COM,   ****************************************************************
/COM,           Read in average effective conductivities from SNF model
PARRES,CHANGE,pwr14dk,parm,
/COM,           Read in surface temps. from repository model
PARRES,CHANGE,f04d51c1,parm,
/COM,   ****************************************************************
/COM,
/COM,           Define Required Constants:
PI=3.141592654
/COM,
/COM,           Define UCF/waste package parameters
/COM,           (UCF dimensions converted from inches/cm/mm to meters were required)
/COM,                   DCRAD = disposal container outer radius (m)
/COM,                   DCIRD = disposal container inner radius (m)
/COM,                   OWALL = outer barrier thickness (m)
/COM,                   IWALL = inner barrier thickness (m)
/COM,
/COM,                   CELL  = tube cell opening (m)
/COM,                   HCELL = 1/2 of tube cell opening (m)
/COM,                   QCELL = 1/4 of basket cell opening (m)
/COM,                   SWALL = carbon steel tube thickness (m)
/COM,                   TWALL = ss-boron nuetronic plate thickness (m)
/COM,                   PWALL = Aluminum thermal conducting plate thickness (m)
/COM,                   GWALL = basket guide thickness (m)
/COM,                   CORGAP= gaps between corner guide and tube
/COM,                   PLTGAP= gaps between plates and tubes
/COM,                   ACTVL = active fuel length
/COM,                   PEAKF = assembly heat axial peaking factor
/COM,
CELL=226.4/1000.0
SWALL=5.0/1000.0
TWALL=7.0/1000.0
GWALL=10.0/1000.0
PWALL=5.0/1000.0
CORGAP=2.0/1000.0
PLTGAP=2.0/1000.0
OWALL=100.0/1000.0
IWALL=20.0/1000.0
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/COM,
ACTVL=141.8*2.54/100.0
PEAKF=1.25
/COM,
TUBE=CELL+2*SWALL
DCIX=(1.5*TUBE)+(TWALL+PWALL+2*PLTGAP)
DCIY=(2.5*TUBE)+(TWALL+PWALL+2*PLTGAP)+(TWALL+2*PLTGAP)
DCIRD=SQRT(DCIX**2+DCIY**2)
DCRAD=DCIRD+IWALL+OWALL
HCELL=CELL/2.0
QCELL=HCELL/2.0
SCELL=HCELL+SWALL
/COM,
/COM,           Define calculated parameters
/COM,                   ASSY = assembly heat production (W)  f(yrs)
/COM,                   FUEL = volumetric heat production (W/m3) f(yrs)
/COM,                   FVOLU = assy_volume=cell_width^2*active_length
/COM,
/COM,                   PITCH = basket cell outer width (m)
/COM,                   QCELL = 1/4 of basket cell opening (m)
/COM,                   SCELL = 1/2 of basket cell opening+SS wall(m)
/COM,                   ACELL = 1/2 of basket cell opening+SS+AL (m)   (NOT USED)
/COM,
/COM,                   GX## = x coord. of basket guide or thermal shunt/shell contact
/COM,                   GX## = y coord. of basket guide or thermal shunt/shell contact
/COM,
/COM,                   MI45 = x coord. MIRAD at 45 deg.               (NOT USED)
/COM,                   MO45 = x coord. MIRAD+MWALL at 45 deg.         (NOT USED)
/COM,                   DI45 = x coord. DCRAD-OWALL-IWALL at 45 deg.
/COM,                   DM45 = x coord. DCRAD-OWALL at 45 deg.
/COM,                   DO45 = x coord. DCRAD at 45 deg.
*SET,ASSY,
*DIM,ASSY, TABLE,135,1,
*DIM,FUEL, TABLE,135,1
FVOLU=4*HCELL*HCELL*ACTVL
WPVOLU=DCIRD*DCIRD*PI*ACTVL
/COM,
/COM,
GX22=(TUBE/2)+(TWALL+PWALL+2*PLTGAP)/2-(GWALL/2)
GY22=SQRT(DCIRD*DCIRD-GX22*GX22)
GX23=(TUBE/2)+(TWALL+PWALL+2*PLTGAP)/2+(GWALL/2)
GY23=SQRT(DCIRD*DCIRD-GX23*GX23)
GY24=(2.5*TUBE)+(TWALL+PWALL+2*PLTGAP)+(TWALL+2*PLTGAP)+CORGAP+GWALL
GX24=SQRT(DCIRD*DCIRD-GY24*GY24)
GY25=(2.5*TUBE)+(TWALL+PWALL+2*PLTGAP)+(TWALL+2*PLTGAP)+CORGAP
GX25=SQRT(DCIRD*DCIRD-GY25*GY25)
GY26=(2.5*TUBE)+(TWALL+PWALL+2*PLTGAP)+(TWALL+2*PLTGAP)
GX26=SQRT(DCIRD*DCIRD-GY26*GY26)
GX27=(1.5*TUBE)+(TWALL+PWALL+2*PLTGAP)+CORGAP
GY27=SQRT(DCIRD*DCIRD-GX27*GX27)
GX28=(1.5*TUBE)+(TWALL+PWALL+2*PLTGAP)+CORGAP+GWALL
GY28=SQRT(DCIRD*DCIRD-GX28*GX28)
/COM,
/COM,
DI45=DCIRD/SQRT(2.0)
DM45=(DCRAD-OWALL)/SQRT(2.0)
DO45=DCRAD/SQRT(2.0)
/COM,
/COM,           Define Transient Time parameters based upon the following:
/COM,                   Note: 1 year = 3.15576e7 seconds
/COM,                   TM_START = start time (sec)
/COM,                   TMI* = time increment for solution (sec)
/COM,                   TME* = start and stop for time do-loops (sec)
/COM,                   TMTMAX = time of maximum cladding temperature
/COM,
TM_START=(1E-6)*(3.15576E7)
TMI0=0.1*3.15576E7
TMI1=1.0*3.15576E7
TMI10=10.0*3.15576E7
TMI100=100.0*3.15576E7
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```
TMI1000=1000.0*3.15576E7
TME10=10.0*3.15576E7+TM_START
TME90=90.0*3.15576E7+TM_START
TME100=100.0*3.15576E7+TM_START
TME500=500.0*3.15576E7+TM_START
/COM,
/COM,   ********************************************************************
/COM,           Define different element types
/PREP7
ETYPE
ET,  1,55,
ET,  7,32,
ET, 18,50,1,
/COM,   ********************************************************************
/COM,           File props04.dat descibes material properties
/COM,           and thier reference numbers
MPREAD,prop03r,dat,
/COM,           Read in single assembly heat loads
/COM,           Calculate the volumetric heat generation
/COM,           (Assembly time is in years, FUEL is in seconds)
/INPUT,pwr850f,dat
*VFACT,3.15576E7,
*MFUN,FUEL(1,0),COPY,ASSY(1,0),
*VFACT,(PEAKF*21/WPVOLU),
*VFUN,FUEL(1),COPY,ASSY(1),
FUEL(0,1)=1.0
/COM,
/COM,   ********************************************************************
/COM,           Define new material 14 for SNF effective conductivity
/COM,           Density:        DENS    (kg/m^3)
/COM,           Conductivity:   KXX     (W/m/K)
/COM,           Specific Heat:  C       (J/kg/K)
MPTEMP
MPTEMP,   1, .00000E+00,
MPDATA,DENS,14, 1, 773.4/(FVOLU),
MPDATA,   C,14, 1, .27400E+03,
/COM,           Store average effective conductivities
IINC=1
TBSKT=25.0
MPTEMP
MPTEMP,IINC,TBSKT,
IINC=IINC+1
*DO,TBSKT,50.0,400.0,50.0,
     MPTEMP,IINC,TBSKT,
     IINC=IINC+1
*ENDDO
IINC=1
TBSKT=25.0
MPDATA,KXX,14,IINC,KEFFMD(TBSKT),
IINC=IINC+1
*DO,TBSKT,50.0,400.0,50.0,
     MPDATA,KXX,14,IINC,KEFFMD(TBSKT),
     IINC=IINC+1
*ENDDO

/COM,   ********************************************************************
/COM,          Construct geometry for Disposal Container
/COM,
/COM,
K,1,0.0,0.0,0.0,
K,2,DM45,-DM45,0.0,
K,3,DM45,DM45,0.0,
/COM,
/COM,      Define disposal container outer radius and material interface
/COM,
K, 4,              0.0,        (0.0-DCRAD),0.0,
K, 5,            DCRAD,              0.0,0.0,
K, 6,              0.0,             DCRAD,0.0,
K, 7,              0.0,      (OWALL-DCRAD),0.0,
K, 8,      (DCRAD-OWALL),              0.0,0.0,
```

```
K, 9,                0.0,      (DCRAD-OWALL),0.0,
L,7,4,
L,6,9,
L,8,5,
LARC,5,4,1,              DCRAD,
LARC,6,5,1,              DCRAD,
LARC,7,2,1,       (DCRAD-OWALL),
LARC,2,8,1,       (DCRAD-OWALL),
LARC,8,3,1,       (DCRAD-OWALL),
LARC,3,9,1,       (DCRAD-OWALL),
AL, 1, 4, 3, 7, 6,
AL, 3, 5, 2, 9, 8,
/COM,  ***************************************************************
/COM,           Define UCF shell inner edge and area
/COM,
K,10,  0.0,      DCIRD,0.0,
K,11, GX22,       GY22,0.0,
K,12, GX23,       GY23,0.0,
K,13, GX24,       GY24,0.0,
K,14, GX25,       GY25,0.0,
K,15, GX26,       GY26,0.0,
K,16, GX27,       GY27,0.0,
K,17, GX28,       GY28,0.0,
/COM,
K,18, DI45,       DI45,0.0,
K,19, GY28,       GX28,0.0,
K,20, GY27,       GX27,0.0,
K,21, GY26,       GX26,0.0,
K,22, GY25,       GX25,0.0,
K,23, GY24,       GX24,0.0,
K,24, GY23,       GX23,0.0,
K,25, GY22,       GX22,0.0,
K,26, DCIRD,       0.0,0.0,
L,9,10,
L,26,8,
LARC,11,10,1,DCIRD,
LARC,12,11,1,DCIRD,
LARC,13,12,1,DCIRD,
LARC,14,13,1,DCIRD,
LARC,15,14,1,DCIRD,
LARC,16,15,1,DCIRD,
LARC,17,16,1,DCIRD,
LARC,18,17,1,DCIRD,
LARC,19,18,1,DCIRD,
LARC,20,19,1,DCIRD,
LARC,21,20,1,DCIRD,
LARC,22,21,1,DCIRD,
LARC,23,22,1,DCIRD,
LARC,24,23,1,DCIRD,
LARC,25,24,1,DCIRD,
LARC,26,25,1,DCIRD,
L,3,18
LSEL,S,LINE,,12,19,
LSEL,A,LINE,,9,
LSEL,A,LINE,,10,
LSEL,A,LINE,,28,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,20,27,
LSEL,A,LINE,,11,
LSEL,A,LINE,,8,
LSEL,A,LINE,,28,
AL,ALL,
LSEL,ALL,
/COM,*************************************************************************************************
/COM,                    Define top side guide and its vicinity
/COM,
K,27,  0.0,  GY24, 0.0,
K,500,GX22-PLTGAP,  GY24, 0.0,
K,28, GX22,  GY24, 0.0,
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K,29, GX23,  GY24, 0.0,
K,501,GX23+PLTGAP,  GY24, 0.0,
K,30,  0.0,  GY25, 0.0,
K,31, TUBE/2,  GY25, 0.0,
K,32, TUBE/2+PLTGAP,  GY25, 0.0,
K,33, TUBE/2+PLTGAP+PWALL,  GY25, 0.0,
K,34, TUBE/2+PLTGAP+PWALL+TWALL,  GY25, 0.0,
K,35, TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP,  GY25, 0.0,
L,10,27,
L,27,500,
L,500,28,
L,28,11,
L,12,29,
L,29,501,
L,501,13,
L,28,29,
L,27,30,
L,31,30,
L,500,31,
L,32,31,
L,33,32,
L,34,33,
L,35,34,
L,35,501,
L,14,35,
L,28,32,
L,29,34,
/COM,
/COM,                   Two cavity areas near the top side guide
/COM,
LSEL,S,LINE,,29,32,
LSEL,A,LINE,,12,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,33,35,
LSEL,A,LINE,,14,
AL,ALL,
LSEL,ALL,
/COM,                   Top side guide
LSEL,S,LINE,,32,33,
LSEL,A,LINE,,36,
LSEL,A,LINE,,13,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,37,39,
LSEL,A,LINE,,30,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,39,40,
LSEL,A,LINE,,46,
LSEL,A,LINE,,31,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,41,42,
LSEL,A,LINE,,46,
LSEL,A,LINE,,47,
LSEL,A,LINE,,36,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,43,44,
LSEL,A,LINE,,34,
LSEL,A,LINE,,47,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,44,45,
LSEL,A,LINE,,15,
LSEL,A,LINE,,35,
AL,ALL,
LSEL,ALL,
/COM,
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/COM,          Define the gap between top side guide and tubes
/COM,
K,36, 0.0,  GY26, 0.0,
K,37, TUBE/2,  GY26, 0.0,
K,38, TUBE/2+PLTGAP,  GY26, 0.0,
K,39, TUBE/2+PLTGAP+PWALL,  GY26, 0.0,
K,40, TUBE/2+PLTGAP+PWALL+TWALL,  GY26, 0.0,
K,41, TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP,  GY26, 0.0,
L,30,36,
L,36,37,
L,37,31,
L,37,38,
L,38,32,
L,38,39,
L,39,33,
L,39,40,
L,40,34,
L,40,41,
L,41,35,
L,41,15,
LSEL,S,LINE,,48,50,
LSEL,A,LINE,,38,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,50,52,
LSEL,A,LINE,,40,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,52,54,
LSEL,A,LINE,,41,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,54,56,
LSEL,A,LINE,,42,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,56,58,
LSEL,A,LINE,,43,
AL,ALL,
LSEL,ALL,
LSEL,S,LINE,,58,59,
LSEL,A,LINE,,16,
LSEL,A,LINE,,45,
AL,ALL,
LSEL,ALL,
/COM,*************************************************************************************************************
/COM,                Define top row of tubes and plates
/COM,
K,42,   0.0,                                                GY26-SWALL,      0.0,
K,43,   TUBE/2-SWALL,                                       GY26-SWALL,      0.0,
K,44,   0.0,                                                GY26-TUBE+SWALL, 0.0,
K,45,   TUBE/2-SWALL,                                       GY26-TUBE+SWALL, 0.0,
K,46,   0.0,                                                GY26-TUBE,       0.0,
K,47,   TUBE/2,                                             GY26-TUBE,       0.0,
K,48,   TUBE/2+PLTGAP,                                      GY26-TUBE,       0.0,
K,49,   TUBE/2+PLTGAP+PWALL,                                GY26-TUBE,       0.0,
K,50,   TUBE/2+PLTGAP+PWALL+TWALL,                          GY26-TUBE,       0.0,
K,51,   TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP,                   GY26-TUBE,       0.0,
K,52,   1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP-SWALL,           GY26-TUBE+SWALL, 0.0,
K,53,   1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP,                 GY26-TUBE,       0.0,
K,54,   1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP-SWALL,           GY26-SWALL,      0.0,
K,55,   TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP+SWALL,             GY26-SWALL,      0.0,
K,56,   TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP+SWALL,             GY26-TUBE+SWALL, 0.0,
L,36,42,
L,42,43,
L,43,37,
L,42,44,
L,44,45,
L,45,43,
L,44,46,
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L,47,46,
L,47,45,
L,37,47,
/COM,                              Half tube
AL,60,61,62,49,
AL,61,63,64,65,
AL,66,67,68,64,
AL,68,69,62,65,
/COM,                              Plates
L,48,47
L,48,38,
L,49,48,
L,49,39,
L,50,49,
L,40,50,
L,51,50,
L,51,41,
L,41,40,
AL,51,69,70,71,
AL,53,71,72,73,
AL,55,73,74,75,
AL,57,75,76,77,
/COM,                              Whole tube
L,41,55,
L,55,56,
L,51,56,
L,56,52,
L,53,51,
L,52,53,
L,52,54,
L,15,53,
L,15,54,
L,55,54,
AL,80,82,83,81,
AL,84,83,85,86,
AL,87,86,59,78,
AL,78,77,80,79,
AL,87,79,81,84,
/COM,*************************************************************************************************
/COM,                    Define corner guide
/COM,
K,57,GX27,GY26-TUBE,0.0,
K,58,GX27,GY26-TUBE-PLTGAP,0.0,
K,59,GX27,GX27,0.0,
K,60,GX28,GX28,0.0,
L,59,58,
L,58,57,
L,57,16,
L,20,59,
L,17,60,
L,60,19,
L,57,60,
AL,94,90,92,18,
AL,89,88,91,21,93,94,
AL,20,19,92,93,
/COM,*************************************************************************************************
/COM,                     Set element shapes and sizes for tubes
/COM,                             14x14 mesh in fuel with 2
/COM,                             divisions per tube layer
/COM,
ESHAPE,2,
ESIZE,,1,
/COM,
/COM,                              Full tube
/COM,
LSEL,S,LINE,,81,
LSEL,A,LINE,,82,
LSEL,A,LINE,,84,
LSEL,A,LINE,,85,
LSEL,A,LINE,,87,
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```
LSEL,A,LINE,,59,
LSEL,A,LINE,,77,
LSEL,A,LINE,,79,
LESIZE,ALL,,, 14,
LSEL,ALL,
LSEL,S,LINE,,78,
LSEL,A,LINE,,80,
LSEL,A,LINE,,83,
LSEL,A,LINE,,86,
LESIZE,ALL,,, 2,
LSEL,ALL,
/COM,                              Half tube
LSEL,S,LINE,,49,
LSEL,A,LINE,,61,
LSEL,A,LINE,,64,
LSEL,A,LINE,,67,
LESIZE,ALL,,, 7,
LSEL,ALL,
LSEL,S,LINE,,63,
LSEL,A,LINE,,65,
LSEL,A,LINE,,69,
LESIZE,ALL,,, 14,
LSEL,ALL,
LSEL,S,LINE,,60,
LSEL,A,LINE,,66,
LSEL,A,LINE,,68,
LSEL,A,LINE,,62,
LESIZE,ALL,,, 2,
LSEL,ALL,
/COM,
/COM,                              Mesh areas
/COM,                         first fuel, then tubes
MAT,14,
TYPE,1,
AMESH,31,
AMESH,20,
MAT, 3,
TYPE,1,
AMESH,27,30,1,
AMESH,21,22,1,
AMESH,19,
/COM,                              Copy tube mesh
/COM,
/COM,
AGEN,2,19,22,1,0.0,-(TUBE+2*PLTGAP+TWALL),0.0,0,0,
AGEN,2,27,31,1,0.0,-(TUBE+2*PLTGAP+TWALL),0.0,0,0,
AGEN,2,27,31,1,(TUBE+2*PLTGAP+TWALL),-(TUBE+2*PLTGAP+TWALL),0.0,0,0,
/COM,
/COM,*************************************************************************************************
/COM,                      Gaps between the tubes (row 1/2)
/COM,
K,85,   0.0,              GY26-TUBE-PLTGAP,                 0.0,
K,86,   TUBE/2,           GY26-TUBE-PLTGAP,                 0.0,
K,87,   0.0,              GY26-TUBE-PLTGAP-TWALL,           0.0,
K,88,   TUBE/2,           GY26-TUBE-PLTGAP-TWALL,           0.0,
K,89,   TUBE/2+PLTGAP,    GY26-TUBE-PLTGAP,                 0.0,
K,90,   TUBE/2+PLTGAP,    GY26-TUBE-PLTGAP-TWALL,           0.0,
K,91,   TUBE/2+PLTGAP+PWALL,    GY26-TUBE-PLTGAP,           0.0,
K,92,   TUBE/2+PLTGAP+PWALL,    GY26-TUBE-PLTGAP-TWALL,     0.0,
K,93,   TUBE/2+PLTGAP+PWALL+TWALL,    GY26-TUBE-PLTGAP,     0.0,
K,94,   TUBE/2+PLTGAP+PWALL+TWALL,    GY26-TUBE-PLTGAP-TWALL,      0.0,
K,95,   TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP,    GY26-TUBE-PLTGAP,     0.0,
K,96,   TUBE/2+PLTGAP+PWALL+TWALL+PLTGAP,    GY26-TUBE-PLTGAP-TWALL,       0.0,
K,97,   1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP,    GY26-TUBE-PLTGAP,           0.0,
K,98,   1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP,    GY26-TUBE-PLTGAP-TWALL,     0.0,
K,99,   TUBE/2+PLTGAP,    GY26-TUBE-PLTGAP-TWALL-PLTGAP,          0.0,
K,100,  TUBE/2+PLTGAP+PWALL,    GY26-TUBE-PLTGAP-TWALL-PLTGAP,    0.0,
K,101,  TUBE/2+PLTGAP+PWALL+TWALL,    GY26-TUBE-PLTGAP-TWALL-PLTGAP,      0.0,
K,102,  1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP+PLTGAP,    GY26-TUBE-PLTGAP-TWALL-PLTGAP,      0.0,
K,103,  1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP+PLTGAP+TWALL,    GY26-TUBE-PLTGAP-TWALL-PLTGAP,        0.0,
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L,46,85,
L,85,86,
L,86,47,
L,86,89,
L,89,48,
L,89,91,
L,91,49,
L,91,93,
L,50,93,
L,93,95,
L,95,51,
L,95,97,
L,97,53,
L,97,58,
L,57,53,
L,85,87,
L,88,87,
L,88,86,
L,90,88,
L,90,89,
L,92,90,
L,92,91,
L,94,92,
L,93,94,
L,96,94,
L,96,95,
L,98,96,
L,97,98,
L,98,59,
L,87,61,
L,64,88,
L,64,99,
L,99,90,
L,99,100,
L,100,92,
L,100,101,
L,94,101,
L,101,76,
L,76,96,
L,74,98,
L,74,102,
L,102,103,
L,84,103,
L,102,59,
AL,67,130,131,132
AL,131,145,146,147,
AL,146,159,98,160
AL,70,132,133,134
AL,133,147,148,149
AL,147,148,149,133
AL,148,160,161,162,
AL,72,134,135,136
AL,135,149,150,151
AL,150,162,163,164
AL,74,136,137,138
AL,137,151,152,153
AL,152,164,165,166
AL,139,153,154,155
AL,76,138,139,140
AL,154,166,167,168
AL,140,141,82,142
AL,144,142,143,89
AL,155,156,157,141
AL,143,157,158,88
AL,168,156,114,169
AL,158,169,170,173
AL,17,85,144,90
KSEL,S, , ,      82
KSEL,A, , ,      21
NUMMRG,KP, ,
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KSEL,ALL
AL,173,171,172,126,22,91
/COM,
/COM,*************************************************************************************************
/COM,        Plates between tubes (column 2/3)
/COM,
K,104,1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP+PLTGAP,GX26-TUBE,0.0,
K,105,1.5*TUBE+PLTGAP+PWALL+TWALL+PLTGAP+PLTGAP+TWALL,GX26-TUBE,0.0,
L,104,72,
L,105,104,
L,77,105,
L,104,102,
L,103,105,
AL,112,177,170,174,
AL,175,178,177,171
AL,172,178,129,176
/COM,
/COM,                    Mesh plates between tubes (1/2 column)
/COM,
LSEL,S,LINE,,53,
LSEL,A,LINE,,55,
LSEL,A,LINE,,72,
LSEL,A,LINE,,74,
LESIZE,ALL,,, 2,
LSEL,ALL,
LSEL,S,LINE,,71,75,2,
LESIZE,ALL,,, 14,
LSEL,ALL,
MAT,7,
TYPE,1,
AMESH,23,
AMESH,26,
MAT,18,
TYPE,1,
AMESH,24,
MAT,19,
TYPE,1,
AMESH,25,
AGEN,2,23,26,1,0.0,-(TUBE+PLTGAP+TWALL+PLTGAP),0.0,0,0,
/COM,
/COM,                    Mesh plates between tubes (2/3 column)
/COM,
LSEL,S,LINE,,177,
LSEL,A,LINE,,178,
LESIZE,ALL,,, 14,
LSEL,ALL,
LSEL,S,LINE,,171,
LSEL,S,LINE,,175,
LESIZE,ALL,,, 2,
LSEL,ALL,
MAT,7,
TYPE,1,
AMESH,72,
AMESH,74,
MAT,19,
TYPE,1,
AMESH,73,
/COM,
/COM,                    Copy tubes and plates (all rows)
/COM,
AGEN,2,19,31,1,0.0,-(4*TUBE+2*(2*PLTGAP+TWALL)+2*(2*PLTGAP+PWALL+TWALL)),0,0,
AGEN,2,35,48,1,0.0,-(TUBE+2*PLTGAP+PWALL+TWALL),0,0,
AGEN,2,72,78,1,0.0,-(TUBE+2*PLTGAP+PWALL+TWALL),0,0,
AGEN,2,35,48,1,0.0,-(2*TUBE+2*(2*PLTGAP+PWALL+TWALL)),0,0,
AGEN,2,72,78,1,0.0,-(2*TUBE+2*(2*PLTGAP+PWALL+TWALL)),0,0,
/COM,
/COM,                    Mesh plates between tubes ( 1/2 row)
/COM,
LSEL,S,LINE,,145,
LSEL,A,LINE,,147,
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LSEL,A,LINE,,149,
LSEL,A,LINE,,151,
LSEL,A,LINE,,153,
LSEL,A,LINE,,155,
LSEL,A,LINE,,157,
LSEL,A,LINE,,135,
LSEL,A,LINE,,150,
LSEL,A,LINE,,137,
LSEL,A,LINE,,152,
LESIZE,ALL,,, 2,
LSEL,ALL,
LSEL,S,LINE,,146,
LSEL,A,LINE,,131,
LESIZE,ALL,,, 7,
LSEL,ALL,
LSEL,S,LINE,,156,
LSEL,A,LINE,,141,
LESIZE,ALL,,, 14,
LSEL,ALL,
MAT,7,
TYPE,1,
AMESH,49,
AMESH,51,
AMESH,52,
AMESH,54,
AMESH,62,
AMESH,63,
AMESH,64,
AMESH,68,
AMESH,65,
AMESH,67,
AMESH,69,
MAT,19,
TYPE,1,
AMESH,50,
AMESH,53,
AMESH,56,
AMESH,59,
AMESH,61,
AMESH,66,
AMESH,58,
AMESH,60,
MAT,18,
TYPE,1,
AMESH,55,
AMESH,57,
/COM,                    Copy tubes and plates (all rows)
/COM,
AGEN,2,49,69,1,0.0,-(3*TUBE+(2*PLTGAP+TWALL)+2*(2*PLTGAP+PWALL+TWALL)),0,0,
NUMMRG,all, ,
/COM,                    Plates between the tubes (2/3 row)
/COM,
K,253,    0.0,                          TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,254,    0.0,                          TUBE/2+PLTGAP+PWALL,            0.0,
K,255, TUBE/2,                          TUBE/2+PLTGAP+PWALL,            0.0,
K,256, TUBE/2,                          TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,257,    0.0,                          TUBE/2+PLTGAP,                  0.0,
K,258, TUBE/2,                          TUBE/2+PLTGAP,                  0.0,
K,259, TUBE/2+PLTGAP,                   TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,260, TUBE/2+PLTGAP,                   TUBE/2+PLTGAP+PWALL,            0.0,
K,261, TUBE/2+PLTGAP,                   TUBE/2+PLTGAP,                  0.0,
K,262, TUBE/2+PLTGAP+PWALL,             TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,263, TUBE/2+PLTGAP+PWALL,             TUBE/2+PLTGAP+PWALL,            0.0,
K,264, TUBE/2+PLTGAP+PWALL,             TUBE/2+PLTGAP,                  0.0,
K,265, TUBE/2+PLTGAP+PWALL+TWALL,       TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,266, TUBE/2+PLTGAP+PWALL+TWALL,       TUBE/2+PLTGAP+PWALL,            0.0,
K,267, TUBE/2+PLTGAP+PWALL+TWALL,       TUBE/2+PLTGAP,                  0.0,
K,268, TUBE/2+2*PLTGAP+PWALL+TWALL,     TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,269, TUBE/2+2*PLTGAP+PWALL+TWALL,     TUBE/2+PLTGAP+PWALL,            0.0,
K,270, TUBE/2+2*PLTGAP+PWALL+TWALL,     TUBE/2+PLTGAP,                  0.0,
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K,271, 1.5*TUBE+2*PLTGAP+PWALL+TWALL,   TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,272, 1.5*TUBE+3*PLTGAP+PWALL+TWALL,   TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,273, 1.5*TUBE+3*PLTGAP+PWALL+2*TWALL, TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,274, 1.5*TUBE+4*PLTGAP+PWALL+2*TWALL, TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,275, 1.5*TUBE+2*PLTGAP+PWALL+TWALL,   TUBE/2+PLTGAP+PWALL,            0.0,
K,276, 1.5*TUBE+3*PLTGAP+PWALL+TWALL,   TUBE/2+PLTGAP+PWALL,            0.0,
K,277, 1.5*TUBE+3*PLTGAP+PWALL+2*TWALL, TUBE/2+PLTGAP+PWALL,            0.0,
K,278, 1.5*TUBE+4*PLTGAP+PWALL+2*TWALL, TUBE/2+PLTGAP+PWALL,            0.0,
K,279, 1.5*TUBE+2*PLTGAP+PWALL+TWALL,   TUBE/2+PLTGAP,          0.0,
K,280, 1.5*TUBE+3*PLTGAP+PWALL+TWALL,   TUBE/2+PLTGAP,                  0.0,
K,281, 1.5*TUBE+3*PLTGAP+PWALL+2*TWALL, TUBE/2+PLTGAP,          0.0,
K,282, 1.5*TUBE+4*PLTGAP+PWALL+2*TWALL, TUBE/2+PLTGAP,          0.0,
K,283, GY26,                            TUBE/2+PLTGAP+TWALL+PWALL,      0.0,
K,284, GY26,                            TUBE/2+PLTGAP+PWALL,            0.0,
K,285, GY26,                            TUBE/2+PLTGAP+PWALL,            0.0,
/COM,
L,67,253,
L,253,256,
L,256,68
L,253,254,
L,254,255,
L,255,256,
L,254,257,
L,258,257,
L,258,255,
L,257,137,
L,140,258,
/COM,
L,256,259,
L,259,107,
L,255,260,
L,260,259,
L,261,258,
L,261,260,
L,170,261,
/COM,
L,259,262,
L,262,110
L,260,263,
L,263,262,
L,261,264,
L,264,263,
L,173,264,
/COM,
L,262,265,
L,112,265,
L,263,266,
L,266,265,
L,264,267,
L,267,266
L,267,175,
/COM,
L,265,268,
L,268,69,
L,266,269,
L,269,268,
L,270,267,
L,270,269,
L,152,270,
/COM,
L,268,271,
L,271,72,
L,269,275,
L,271,275,
L,279,270,
L,275,279,
L,150,279,
L,271,272,
L,272,104,
L,275,276,
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L,276,272,
L,280,279,
L,280,276,
L,164,280,
/COM,
L,272,273,
L,105,273,
L,276,277,
L,277,273,
L,280,281,
L,281,277,
L,281,166,
/COM,
L,273,274,
L,274,77,
L,277,278,
L,278,274,
L,282,281,
L,282,278,
L,160,282,
/COM,
AL,103,179,182,183
AL,182,186,189,190,
AL,189,261,270,274,
AL,270,282,229,319,
AL,181,183,328,332,
AL,328,190,340,342,
AL,340,274,350,352,
AL,350,319,271,357,
AL,185,332,359,364,
AL,359,342,366,371,
AL,366,352,376,378,
AL,376,357,275,380,
AL,188,364,383,391,
AL,383,371,394,395,
AL,394,378,396,397,
AL,396,380,278,398,
AL,191,391,399,400,
AL,399,395,401,402,
AL,401,397,403,404,
AL,403,398,281,405,
AL,109,400,406,407,
AL,406,402,408,409,
AL,408,404,410,411,
AL,410,405,245,412,
AL,174,407,413,414,
AL,413,409,415,416,
AL,415,411,417,418,
AL,417,412,264,419,
AL,175,414,420,421,
AL,420,416,422,423,
AL,422,418,424,425,
AL,424,419,266,426,
AL,176,421,427,428,
AL,427,423,429,430,
AL,429,425,431,432,
AL,431,426,268,433,
LSEL,S,LINE,,182,
LSEL,A,LINE,,189,
LSEL,A,LINE,,269,
LESIZE,ALL,,, 7,
LSEL,ALL,
LSEL,S,LINE,,406,
LSEL,A,LINE,,408,
LSEL,A,LINE,,410,
LESIZE,ALL,,, 14,
LSEL,ALL,
LSEL,S,LINE,,186,
LSEL,A,LINE,,261,
LSEL,A,LINE,,190,
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LSEL,A,LINE,,274,
LSEL,A,LINE,,342,
LSEL,A,LINE,,352,
LSEL,A,LINE,,371,
LSEL,A,LINE,,378,
LSEL,A,LINE,,395,
LSEL,A,LINE,,397,
LSEL,A,LINE,,402,
LSEL,A,LINE,,404,
LSEL,A,LINE,,359,
LSEL,A,LINE,,383,
LSEL,A,LINE,,366,
LSEL,A,LINE,,394,
LSEL,A,LINE,,376,
LSEL,A,LINE,,396,
LSEL,A,LINE,,409,
LSEL,A,LINE,,411,
LSEL,A,LINE,,416,
LSEL,A,LINE,,418,
LSEL,A,LINE,,423,
LSEL,A,LINE,,425,
LSEL,A,LINE,,430,
LSEL,A,LINE,,432,
LESIZE,ALL,,, 2,
LSEL,ALL,
MAT,7,
TYPE,1,
AMESH,155,
AMESH,158,
AMESH,159,
AMESH,162,
AMESH,171,
AMESH,174,
AMESH,175,
AMESH,178,
AMESH,179,
AMESH,182,
AMESH,187,
AMESH,190,
MAT,19,
TYPE,1,
AMESH,167,169,1,
AMESH,170,
AMESH,183,186,1,
AMESH,156,
AMESH,176,
AMESH,160,
AMESH,172,
AMESH,180,
AMESH,188,
MAT,18,
TYPE,1,
AMESH,157,
AMESH,161,
AMESH,163,
AMESH,165,
AMESH,166,
AMESH,164,
AMESH,173,
AMESH,177,
AMESH,181,
AMESH,189,
/COM,                              Copy plates (all 2/3 row)
/COM,
AGEN,2,175,178,1,TUBE+2*PLTGAP+TWALL,0.0,0.0,
NUMMRG,all, ,
/COM,
/COM,
K,286,    0.0,                          -(TUBE/2+PLTGAP),              0.0,
K,287,    0.0,                          -(TUBE/2+PLTGAP+PWALL),        0.0,
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K,288,    0.0,                          -(TUBE/2+PLTGAP+TWALL+PWALL),   0.0,
K,289, TUBE/2,                          -(TUBE/2+PLTGAP),               0.0,
K,290, TUBE/2,                          -(TUBE/2+PLTGAP+PWALL),         0.0,
K,291, TUBE/2,                          -(TUBE/2+PLTGAP+TWALL+PWALL),   0.0,
K,292, TUBE/2+PLTGAP,                   -(TUBE/2+PLTGAP),               0.0,
K,293, TUBE/2+PLTGAP,                   -(TUBE/2+PLTGAP+PWALL),         0.0,
K,294, TUBE/2+PLTGAP,                   -(TUBE/2+PLTGAP+TWALL+PWALL),   0.0,
K,295, TUBE/2+PLTGAP+PWALL,             -(TUBE/2+PLTGAP),               0.0,
K,296, TUBE/2+PLTGAP+PWALL,             -(TUBE/2+PLTGAP+PWALL),         0.0,
K,297, TUBE/2+PLTGAP+PWALL,             -(TUBE/2+PLTGAP+TWALL+PWALL),   0.0,
K,298, TUBE/2+PLTGAP+PWALL+TWALL,       -(TUBE/2+PLTGAP),               0.0,
K,299, TUBE/2+PLTGAP+PWALL+TWALL,       -(TUBE/2+PLTGAP+PWALL),         0.0,
K,300, TUBE/2+PLTGAP+PWALL+TWALL,       -(TUBE/2+PLTGAP+TWALL+PWALL),   0.0,
K,301, TUBE/2+2*PLTGAP+PWALL+TWALL,     -(TUBE/2+PLTGAP),               0.0,
K,302, TUBE/2+2*PLTGAP+PWALL+TWALL,     -(TUBE/2+PLTGAP+PWALL),         0.0,
K,303, TUBE/2+2*PLTGAP+PWALL+TWALL,     -(TUBE/2+PLTGAP+TWALL+PWALL),   0.0,
K,304, 1.5*TUBE+2*PLTGAP+PWALL+TWALL,   -(TUBE/2+PLTGAP),               0.0,
K,305, 1.5*TUBE+2*PLTGAP+PWALL+TWALL,   -(TUBE/2+PLTGAP+PWALL),         0.0,
K,306, 1.5*TUBE+2*PLTGAP+PWALL+TWALL,   -(TUBE/2+PLTGAP+TWALL+PWALL),   0.0,
K,307, 1.5*TUBE+3*PLTGAP+PWALL+TWALL,   -(TUBE/2+PLTGAP),               0.0,
K,308, 1.5*TUBE+3*PLTGAP+PWALL+TWALL,   -(TUBE/2+PLTGAP+PWALL),         0.0,
K,309, 1.5*TUBE+3*PLTGAP+PWALL+TWALL,   -(TUBE/2+PLTGAP+TWALL+PWALL),   0.0,
K,310, 1.5*TUBE+3*PLTGAP+PWALL+2*TWALL, -(TUBE/2+PLTGAP),               0.0,
K,311, 1.5*TUBE+3*PLTGAP+PWALL+2*TWALL, -(TUBE/2+PLTGAP+PWALL),         0.0,
K,312, 1.5*TUBE+3*PLTGAP+PWALL+2*TWALL, -(TUBE/2+PLTGAP+TWALL+PWALL),   0.0,
K,313, 1.5*TUBE+4*PLTGAP+PWALL+2*TWALL, -(TUBE/2+PLTGAP),               0.0,
K,314, 1.5*TUBE+4*PLTGAP+PWALL+2*TWALL, -(TUBE/2+PLTGAP+PWALL),         0.0,
K,315, 1.5*TUBE+4*PLTGAP+PWALL+2*TWALL,-(TUBE/2+PLTGAP+TWALL+PWALL),    0.0,
K,316, GY26,                            -(TUBE/2+PLTGAP),               0.0,
K,317, GY26,                            -(TUBE/2+PLTGAP+PWALL),         0.0,
K,318, GY26,                            -(TUBE/2+PLTGAP+TWALL+PWALL),   0.0,
L,143,286,
L,286,289,
L,144,289,
L,286,287,
L,287,290,
L,289,290,
L,287,288,
L,291,288,
L,290,291,
L,288,179,
L,182,291,
L,289,292,
L,290,293,
L,293,292,
L,294,291,
L,294,293,
L,212,294,
L,292,171,
L,290,293,
L,293,292,
L,291,294,
L,294,293,
L,212,294,
L,292,295,
L,295,174,
L,293,296,
L,296,295,
L,297,294,
L,297,296,
L,215,297,
L,298,295,
L,176,298,
L,296,299,
L,299,298,
L,297,300,
L,300,299,
L,300,217,
L,298,301,
L,301,145,
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L,299,302,
L,302,301,
L,303,300,
L,303,302,
L,194,303,
L,301,304,
L,304,148,
L,302,305,
L,304,305,
L,306,303,
L,305,306,
L,192,306,
L,304,307,
L,307,163,
L,305,308,
L,308,307,
L,309,306,
L,309,308,
L,206,309,
L,307,310,
L,165,310,
L,308,311,
L,311,310,
L,309,312,
L,312,311,
L,312,208,
L,310,313,
L,313,153,
L,311,314,
L,314,313,
L,315,312,
L,315,314,
L,202,315,
AL,234,434,435,440,
AL,435,443,444,445,
AL,444,447,448,449,
AL,287,451,448,450,
AL,440,452,458,273,
AL,452,445,453,454,
AL,453,449,455,456,
AL,455,451,329,457,
AL,458,459,460,277,
AL,459,454,461,462,
AL,461,456,463,464,
AL,463,457,333,465,
AL,460,466,467,280,
AL,466,462,468,469,
AL,468,464,470,471,
AL,470,465,336,472,
AL,467,473,474,283,
AL,473,469,475,476,
AL,475,471,477,478,
AL,477,472,339,479,
AL,240,480,474,481,
AL,480,476,482,483,
AL,482,484,478,485,
AL,484,303,479,486,
AL,481,487,488,262,
AL,487,483,489,490,
AL,489,485,491,492,
AL,491,486,322,493,
AL,265,488,494,495,
AL,494,490,496,497,
AL,496,492,498,499,
AL,498,493,324,500,
AL,269,495,501,502,
AL,501,497,503,504,
AL,503,499,505,506,
AL,505,500,326,507,
LSEL,S,LINE,,435,
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LSEL,A,LINE,,444,
LSEL,A,LINE,,448,
LESIZE,ALL,,,7,
LSEL,S,LINE,,443,
LSEL,A,LINE,,447,
LSEL,A,LINE,,446,
LSEL,A,LINE,,454,
LSEL,A,LINE,,449,
LSEL,A,LINE,,456,
LSEL,A,LINE,,459,
LSEL,A,LINE,,461,
LSEL,A,LINE,,463,
LSEL,A,LINE,,462,
LSEL,A,LINE,,464,
LSEL,A,LINE,,466,
LSEL,A,LINE,,468,
LSEL,A,LINE,,470,
LSEL,A,LINE,,469,
LSEL,A,LINE,,471,
LSEL,A,LINE,,476,
LSEL,A,LINE,,478,
LESIZE,ALL,,,2,
LSEL,ALL,
LSEL,S,LINE,,480,
LSEL,A,LINE,,482,
LSEL,A,LINE,,484,
LESIZE,ALL,,,14,
LSEL,ALL,
LSEL,S,LINE,,483,
LSEL,A,LINE,,485,
LSEL,A,LINE,,485,
LSEL,A,LINE,,490,
LSEL,A,LINE,,492,
LSEL,A,LINE,,497,
LSEL,A,LINE,,499,
LSEL,A,LINE,,504,
LSEL,A,LINE,,506,
LESIZE,ALL,,,2,
LSEL,ALL,
MAT,7,
TYPE,1,
AMESH,195,
AMESH,198,
AMESH,199,
AMESH,202,
AMESH,211,
AMESH,214,
AMESH,215,
AMESH,218,
AMESH,219,
AMESH,222,
AMESH,227,
AMESH,230,
MAT,18,
TYPE,1,
AMESH,196,
AMESH,200,
AMESH,204,
AMESH,212,
AMESH,216,
AMESH,220,
AMESH,203,
AMESH,205,
AMESH,206,
AMESH,228,
MAT,19,
TYPE,1,
AMESH,197,
AMESH,201,
AMESH,208,
```

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AMESH,209,
AMESH,213,
AMESH,217,
AMESH,221,
AMESH,207,
AMESH,210,
AMESH,223,
AMESH,224,
AMESH,225,
AMESH,226,
AMESH,229,
AGEN,2,215,218,1,TUBE+2*PLTGAP+TWALL,0.0,0.0,
NUMMRG,all, ,
/COM,*************************************************************************************************
/COM,                    Side side guide
/COM,
K,319,GY25,TUBE/2+2*PLTGAP+TWALL+PWALL, 0.0,
K,320,GY25,TUBE/2+PLTGAP+TWALL+PWALL,   0.0,
K,321,GY25,TUBE/2+PLTGAP+PWALL,         0.0,
K,322,GY25,TUBE/2+PLTGAP,               0.0,
K,323,GY25,TUBE/2,                      0.0,
K,324,GY25,0.0,                         0.0,
K,325,GY24,GX23+PLTGAP,                 0.0,
K,326,GY24,GX23,                        0.0,
K,327,GY24,GX22,                        0.0,
K,328,GY24,GX22-PLTGAP,                 0.0,
K,329,GY24,0.0,                         0.0,
L,319,22,
L,320,319,
L,321,320,
L,322,321,
L,323,322,
L,324,323,
L,324,329,
L,23,325,
L,325,326,
L,326,327,
L,327,328,
L,328,329,
L,329,26,
L,80,319,
L,109,320,
L,111,321,
L,114,322,
L,158,323,
L,326,24,
L,25,327,
L,322,327,
L,323,328,
L,320,326,
L,319,325,
AL,23,124,508,528
AL,528,437,529,509,
AL,529,438,530,514,
AL,530,441,531,517,
AL,531,446,532,518,
AL,24,508,522,538,
AL,538,509,537,523
AL,537,514,517,535,524,
AL,535,518,536,525,
AL,536,521,519,526,
AL,25,522,523,533,
AL,533,524,534,26,
AL,534,525,526,527,27,
/COM,
LSEL,S,LINE,,38,
LSEL,A,LINE,,30,
LSEL,A,LINE,,12,
LESIZE,ALL,,,7,
LSEL,ALL,
```

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LSEL,S,LINE,,29,
LSEL,A,LINE,,32,
LSEL,A,LINE,,33,
LESIZE,ALL,,,7,
LSEL,ALL,
LSEL,S,LINE,,37,
LSEL,A,LINE,,39,
LSEL,A,LINE,,46,
LSEL,A,LINE,,47,
LSEL,A,LINE,,44,
LSEL,A,LINE,,15,
LSEL,A,LINE,,13,
LSEL,A,LINE,,36,
LESIZE,ALL,,,2,
LSEL,ALL,
LSEL,S,LINE,,35,
LSEL,A,LINE,,45,
LESIZE,ALL,,,14,
LSEL,ALL,
LSEL,S,LINE,,14,
LESIZE,ALL,,,15,
LSEL,ALL,
/COM,
ESHAPE,0,
MAT,7,
TYPE,1,
AMESH,13,18,1,
AMESH,5,6,1,
MAT,3,
TYPE,1,
AMESH,7,12,1,
/COM,*********************************************************************************************
/COM,                          Mesh top corner guide
/COM,
LSEL,S,LINE,,90,
LSEL,A,LINE,,92,
LSEL,A,LINE,,93,
LESIZE,ALL,,,14,
LSEL,ALL,
LSEL,S,LINE,,91,
LESIZE,ALL,,,16,
LSEL,ALL,
LSEL,S,LINE,,18,
LSEL,A,LINE,,94,
LSEL,A,LINE,,88,
LSEL,A,LINE,,21,
LESIZE,ALL,,,2,
LSEL,ALL,
LSEL,S,LINE,,19,
LSEL,A,LINE,,20,
LESIZE,ALL,,,12,
LSEL,ALL,
MAT,7,
TYPE,1
AMESH,70,
AMESH,71,
AMESH,34,
MAT,3,
TYPE,1
AMESH,32,
AMESH,33,
/COM,
/COM,                          Mesh side side guide
/COM,
LSEL,S,LINE,,508,
LSEL,A,LINE,,522,
LSEL,A,LINE,,25,
LESIZE,ALL,,,14,
LSEL,ALL,
LSEL,S,LINE,,24,
```

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LSEL,A,LINE,,538,
LSEL,A,LINE,,537,
LSEL,A,LINE,,535,
LSEL,A,LINE,,536,
LSEL,A,LINE,,521,
LSEL,A,LINE,,524,
LSEL,A,LINE,,26,
LESIZE,ALL,,,2,
LSEL,ALL,
LSEL,S,LINE,,520,
LSEL,A,LINE,,526,
LSEL,A,LINE,,27,
LSEL,A,LINE,,533,
LSEL,A,LINE,,534,
LSEL,A,LINE,,527,
LSEL,A,LINE,,519,
LESIZE,ALL,,,7,
LSEL,ALL,
MAT,7,
TYPE,1
AMESH,235,239,1,
AMESH,245,
AMESH,247,
MAT,3,
TYPE,1
AMESH,240,244,1
AMESH,246,
/COM,
/COM,                          Mesh upper 1/4 inner barrier
/COM,
ESHAPE,0,
LSEL,S,LINE,,9,
LSEL,A,LINE,,8,
LESIZE,ALL,,,40,
LSEL,ALL,
LSEL,S,LINE,,10,
LSEL,A,LINE,,28,
LSEL,A,LINE,,11,
LESIZE,ALL,,,2,
LSEL,ALL,
MAT,15,
TYPE,1
AMESH,3,4,1
NUMMRG,all, ,
/COM,
/COM,                  Copy bottom 1/2 corner guides and inner barrier
/COM,
LOCAL,11,1,0.0,0.0,0.0,
AGEN,2,5,12,1,0.0,-90,0.0,
AGEN,2,14,18,1,0.0,-90,0.0,
AGEN,2,32,34,1,0.0,-90,0.0,
AGEN,2,65,69,2,0.0,-90,0.0,
AGEN,2,70,71,1,0.0,-90,0.0,
AGEN,2,235,247,1,0.0,-90,0.0,
AGEN,2,3,4,1,0.0,-90,0.0,
NUMMRG,all, ,
CSYS,0,
AL,519,551,255,532,563,
MAT,7,
TYPE,1,
AMESH,266,
L,121,365,
AL,200,540,636,623,
MAT,7,
TYPE,1,
AMESH,284,
/COM,
/COM,                          Mesh outer barrier
/COM,
LSEL,S,LINE,,4,
```

```
LSEL,A,LINE,,5,
LESIZE,ALL,,,80,
LSEL,ALL,
LSEL,S,LINE,,1,
LSEL,A,LINE,,2,
LSEL,A,LINE,,3,
LESIZE,ALL,,,7,
LSEL,ALL,
MAT,3,
TYPE,1
AMESH,1,2,1
NUMMRG,all, ,
/com,                   modify an area on the lower corner guide
ACLEAR,     262
ADELE,     262
ACLEAR,     268
ADELE,     268
LDELE,     585
LSTR,     315,     252
FLST,2,8,4
FITEM,2,582
FITEM,2,586
FITEM,2,388
FITEM,2,392
FITEM,2,578
FITEM,2,583
FITEM,2,552
FITEM,2,584
AL,P51X
FLST,2,4,4
FITEM,2,393
FITEM,2,221
FITEM,2,552
FITEM,2,605
AL,P51X
FLST,5,1,4,ORDE,1
FITEM,5,552
CM,_Y,LINE
LSEL,,,,P51X
!*
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,14,1,
CMDEL,_Y
CMDEL,_Y1
mat,3,
type,1
ASEL,S, , ,     262
amesh,all
ALLSEL,ALL
mat,7,
type,1
ASEL,S, , ,     268
amesh,all


/COM,
/COM,           DEVELOP DRIP SHIELD AND DRIFT
/COM,
```

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/BATCH
/COM,ANSYS RELEASE  5.4    UP19970828         08:41:33    05/14/1998
/COM,   ****************************************************************
/COM,   ANSYS REVISION  5.4                                      07/01/98
/COM,   2-D Thermal Model of 21 PWR WP with No Drip Shield    M. Plinski
/COM,   No Backfill
/COM,   ****************************************************************
/input,start,ans      ,/ansys54/docu/,,,,,,,,,,,,,,,1
/show,x11,
/menu,on,
/GRA,POWER
/GST,ON
/INPUT,drshlow,inp,,1,0

!*
/COM,
/COM,           DEFINE BACKFILL MATERIAL
/COM,

UIMP,20,EX, , , ,
UIMP,20,DENS, , ,2600*(1-.48),
UIMP,20,ALPX, , , ,
UIMP,20,REFT, , , ,
UIMP,20,NUXY, , , ,
UIMP,20,PRXY, , , ,
UIMP,20,GXY, , , ,
UIMP,20,MU, , , ,
UIMP,20,DAMP, , , ,
UIMP,20,KXX, , ,0.58,
UIMP,20,C, , ,840,
UIMP,20,ENTH, , , ,
UIMP,20,HF, , , ,
UIMP,20,EMIS, , ,0.85,
UIMP,20,QRATE, , , ,
UIMP,20,MURX, , , ,
UIMP,20,MGXX, , , ,
UIMP,20,RSVX, , , ,
UIMP,20,PERX, , , ,
UIMP,20,VISC, , , ,
UIMP,20,SONC, , , ,
!*
!*
/COM,
/COM,           DEFINE CONCRETE
/COM,

UIMP,21,EX, , , ,
UIMP,21,DENS, , ,2300,
UIMP,21,ALPX, , , ,
UIMP,21,REFT, , , ,
UIMP,21,NUXY, , , ,
UIMP,21,PRXY, , , ,
UIMP,21,GXY, , , ,
UIMP,21,MU, , , ,
UIMP,21,DAMP, , , ,
UIMP,21,KXX, , ,1.40,
UIMP,21,C, , ,880,
UIMP,21,ENTH, , , ,
UIMP,21,HF, , , ,
UIMP,21,EMIS, , ,0.88,
UIMP,21,QRATE, , , ,
UIMP,21,MURX, , , ,
UIMP,21,MGXX, , , ,
UIMP,21,RSVX, , , ,
UIMP,21,PERX, , , ,
UIMP,21,VISC, , , ,
UIMP,21,SONC, , , ,

allsel
VSEL,ALL
```

```
ASEL,ALL
LSEL,ALL
KSEL,ALL
ESEL,ALL
NSEL,ALL
!*
/COM,
/COM,   CREATE KEYPOINTS FOR DRIPSHIELD AND DRIFT
/COM,
K,1000,,-1.230203,,
K,1001,,-1.772203,,
K,1002,1.05,-1.230203,,
K,1003,1.07,-1.230203,,
K,1004,1.67,-1.230203,,
K,1005,1.67,1.67,,
K,1006,1.00,1.67,,
K,1007,1.07,,,
K,1008,,1.07,,
K,1009,,1.05,,
K,1010,1.05,,,
K,1011,,-2.75,,
K,1012,,2.75,,
K,1013,,2.55,,
K,1014,,-2.55,,
K,1015,2.233630,-1.230203,,
K,1016,1.67,,,
K,1017,,1.67,,
K,1018,2.195395,1.297205,,
K,1018,2.195395,1.297205,,


/COM,
/COM,           CREATE LINES FOR DRIP SHIELD AND DRIFT
/COM,

LSTR,       4,    1000
LSTR,    1000,    1001
LSTR,    1001,    1014
LSTR,    1014,    1011
/ZOOM,1,RECT,-0.103521,-0.493276,0.437324,-0.293326
LSTR,    1000,    1002
LSTR,    1002,    1003
/ZOOM,  1,  1.1168    , 0.00000E+00, 0.00000E+00,  6.4871
LSTR,    1003,    1004
LSTR,    1004,    1015
LPLOT
KPLOT,ALL
LSTR,    1017,    1006
LSTR,    1006,    1018
LSTR,    1017,    1013
LSTR,    1013,    1012

LSTR,    1017,    1008
LSTR,    1008,    1009

LSTR,    1009,       6
KPLOT,ALL

LSTR,       5,    1010
LSTR,    1010,    1007
LSTR,    1007,    1016
LSTR,    1016,    1004

LSTR,    1007,    1003
LSTR,    1010,    1002
!*
LARC,1014,1015,1,2.55,
!*
LARC,1015,1018,1,2.55,
KPLOT,ALL
```

```
!*
LARC,1018,1005,1,2.55,

!*
LARC,1005,1013,1,2.55,
FLST,2,2,4,ORDE,2
FITEM,2,604
FITEM,2,606
LDELE,P51X
KDELE,     1005


!*
LARC,1018,1013,1,2.55,

!*

!*

K,2000,2.75,,,
K,2000,2.75,,,
!*
LARC,1011,2000,1,2.75,
!*
LARC,2000,1012,1,2.75,


!*
LARC,1016,1017,1,1.67,

!*
LARC,1010,1009,1,1.05,
!*
LARC,1007,1008,1,1.07,

/COM,
/COM,   CREATE DRIP SHIELD AIR SPACE AREA AND MESH
/COM,

FLST,2,5,4
FITEM,2,562
FITEM,2,569
FITEM,2,601
FITEM,2,595
FITEM,2,4
AL,P51X

FLST,2,4,4
FITEM,2,595
FITEM,2,610
FITEM,2,594
FITEM,2,5
AL,P51X

!*
FLST,5,2,5,ORDE,2
FITEM,5,285
FITEM,5,-286
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,      20, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
MSHKEY,0
```

```
MOPT,AMESH,DEFA
MOPT,VMESH,DEFA
MOPT,TIMP,1
MOPT,PYRA,ON
MSHKEY,0
MSHMID,0
MSHPATTERN,0
KEYW,ACCEPT,0
!*
MSHA,0,2D
MSHA,1,3D
!*
SMRTSIZE,3
SMRTSIZE,3

MSHKEY,0
FLST,5,2,5,ORDE,2
FITEM,5,285
FITEM,5,-286
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*

AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*

/UI,MESH,OFF

/COM,
/COM,           CREATE DRIP SHIELD AREA AND MESH
/COM,

FLST,2,4,4
FITEM,2,570
FITEM,2,600
FITEM,2,596
FITEM,2,601
AL,P51X
FLST,2,4,4
FITEM,2,610
FITEM,2,596
FITEM,2,615
FITEM,2,593
AL,P51X

FLST,5,2,5,ORDE,2
FITEM,5,287
FITEM,5,-288
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,     20, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,2,5,ORDE,2
FITEM,5,287
FITEM,5,-288
CM,_Y,AREA
```

```
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*

AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*

!*
/COM,   ****************************************************************
/COM,           Define new material 25 for smeared WP internal
/COM,           Density:        DENS    (kg/m^3)
/COM,           Conductivity:   KXX     (W/m/K)
/COM,           Specific Heat:  C       (J/kg/K)
MPTEMP
MPTEMP,   1, .00000E+00,
MPDATA,DENS,25, 1, 3800,
MPDATA, KXX,25, 1, 1.6,
MPTEMP
MPTEMP,   1,  21.11,  37.78,  65.56,  93.33, 121.11, 148.89,
MPTEMP,   7, 176.67, 204.44, 232.22, 260.00, 287.78, 315.56,
MPTEMP,  13, 343.33, 371.11, 398.89, 426.67, 454.44, 482.22,
MPTEMP,  19, 510.00, 537.78, 565.56, 593.33, 621.11, 648.89,
MPTEMP,  25, 676.67, 704.44, 732.22, 760.00, 787.78, 815.56,
MPDATA,   C, 25, 1, 444.12, 460.92, 477.49, 493.98, 503.53, 513.45,
MPDATA,   C, 25, 7, 524.26, 535.63, 544.50, 556.26, 563.15, 570.39,
MPDATA,   C, 25,13, 582.39, 598.04, 610.25, 622.12, 633.29, 651.67,
MPDATA,   C, 25,19, 668.48, 688.99, 706.55, 719.45, 750.06, 789.29,
MPDATA,   C, 25,25, 835.25, 920.49,1134.00,1698.00, 837.70, 763.35,

/COM,
/COM,           CREATE BACKFILL AREA AND MESH
/COM,

FLST,2,4,4
FITEM,2,600
FITEM,2,572
FITEM,2,598
FITEM,2,597
AL,P51X
FLST,2,4,4
FITEM,2,615
FITEM,2,597
FITEM,2,608
FITEM,2,592
AL,P51X
FLST,2,6,4
FITEM,2,573
FITEM,2,603
FITEM,2,577
FITEM,2,576
FITEM,2,608
FITEM,2,598
AL,P51X

FLST,5,3,5,ORDE,2
FITEM,5,289
FITEM,5,-291
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,     20, ,   1,      0
```

```
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,3,5,ORDE,2
FITEM,5,289
FITEM,5,-291
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*

AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*


/UI,MESH,OFF

/COM,
/COM,            CREATE DRIFT AREA AND MESH
/COM,

FLST,2,7,4
FITEM,2,564
FITEM,2,566
FITEM,2,602
FITEM,2,573
FITEM,2,572
FITEM,2,570
FITEM,2,569
AL,P51X
/AUTO, 1
/REP


FLST,2,7,4
FITEM,2,604
FITEM,2,603
FITEM,2,602
FITEM,2,567
FITEM,2,606
FITEM,2,607
FITEM,2,590
AL,P51X

/UI,MESH,OFF
FLST,5,2,5,ORDE,2
FITEM,5,292
FITEM,5,-293
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,      21, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*

asel,,mat,,21

FLST,5,2,5,ORDE,2
```

```
FITEM,5,292
FITEM,5,-293
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*
FLST,5,2,5,ORDE,2
FITEM,5,292
FITEM,5,-293
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*

/UI,MESH,OFF
allsel
VSEL,ALL
ASEL,ALL
LSEL,ALL
KSEL,ALL
ESEL,ALL
NSEL,ALL

/COM,
/COM,           CREATE DRIFT AIR SPACE AREA AND MESH
/COM,

FLST,2,4,4
FITEM,2,585
FITEM,2,576
FITEM,2,577
FITEM,2,604
AL,P51X
CM,_Y,AREA
ASEL, , , ,     294
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,       8, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*


CM,_Y,AREA
ASEL, , , ,     294
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*

/UI,MESH,OFF
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```
/COM, ** MATT'S RADIATION MODIFICATION **
/COM,

ACLEAR,294,,,

LSEL,S,,,576,577,,

/com,com,NSLL,S,1,
MAT,20,
TYPE,7,
/com,com,ESURF,
LMESH,ALL
ALLSEL,,

/com,com,LSEL,S,,,604,604,,
/com,com,NSLL,S,1,
MAT,21,
TYPE,7,
LMESH,604
/com,com,ESURF,
ALLSEL,,
/COM,                   mesh air area
MAT,8
TYPE,1
AMESH,294
/COM, ************************************************************************
/COM,           delete WP internals and create homogenous material
/COM,
ASEL,S,MAT,,7
ASEL,A,MAT,,3
ASEL,A,MAT,,14
ASEL,A,MAT,,18
ASEL,A,MAT,,19
ASEL,A,MAT,,15
FLST,5,2,5,ORDE,2
FITEM,5,1
FITEM,5,-2
ASEL,U, , ,P51X
ACLEAR,ALL
ADELE,ALL,,,1
ALLSEL
/COM,
K,2020,DCIRD,0,0
K,2021,0,DCIRD,0
K,2022,0,-DCIRD,0
L,2020,8
L,2021,9
L,2022,7
L,1,2020
L,1,2021
L,1,2022
LARC,2021,2020,1,               DCIRD
LARC,2020,2022,1,               DCIRD
AL,11,16,10,8,9
AL,12,17,10,7,6
AL,14,13,16
AL,15,13,17
/COM,
FLST,5,2,4,ORDE,2
FITEM,5,16
FITEM,5,-17
LSEL, , , ,P51X
LESIZE,ALL, , ,80,,
/COM,
FLST,5,3,4,ORDE,2
FITEM,5,13
FITEM,5,-15
```

```
LSEL, , , ,P51X
LESIZE,ALL, , ,16,0.25,
/COM,
MOPT,AMESH,DEFA
MOPT,VMESH,DEFA
MOPT,TIMP,1
MOPT,PYRA,ON
MSHKEY,0
MSHMID,0
MSHPATTERN,0
KEYW,ACCEPT,0
!*
MSHA,0,2D
MSHA,1,3D
/COM,                    WP internal
MAT,25
TYPE,1
AMESH,5,6
ALLSEL
/COM,
MOPT,AMESH,DEFA
MOPT,VMESH,DEFA
MOPT,TIMP,1
MOPT,PYRA,ON
MSHKEY,1
MSHMID,0
MSHPATTERN,0
KEYW,ACCEPT,0
!*
MSHA,0,2D
MSHA,0,3D
/COM,                        inner barrier
LCCAT,8,9
LCCAT,7,6
MAT,15
TYPE,1
AMESH,3,4
LDELE,18,19,1
ALLSEL


/COM,   ****************************************************************
/COM,           Create element mesh plots to illustrate model
/COM,           View mesh for entire model
/RESET
/TRIAD,OFF,
/NUM, 1,
/PNUM,MAT, 1,
/TYPE,HIDP,
/GLINE,,0,
/FOCUS,1,(WPRAD/10.0),0.0,0.0,0,
/TITLE, 21 PWR WP No Drip Shield - 1/2 FEM Model
/SHOW,meshfull,grph,1,8,
EPLOT
ESEL,U,MAT,, 7,
/SHOW,meshgap,grph,1,8,
EPLOT
/COM,           View mesh for radiation substructure
/PNUM,MAT, 0,
/PNUM,TYPE, 1,
ESEL,S,TYPE,,7,
/TITLE, 21 PWR Waste Package and No Drip Shield - Radiation Matrix
/SHOW,meshrad,grph,1,8,
EPLOT
ESEL,ALL,
/TITLE, 21 PWR WP and No Drip Shield with 10 yr old, 48 GWD/MTU SNF
/COM,   ****************************************************************
/COM,           Generate super-elements
/AUX12,
ESEL,S,TYPE,,7,
```

```
NSLE,S,
STEF,5.67E-8,
GEOM,1,0,
EMIS,3,0.8
EMIS,18,0.07
EMIS,19,0.6
EMIS,15,0.87
EMIS,20,0.85
EMIS,21,0.88
VTYPE,0,800,
WRITE,plinrad,
ESEL,ALL,
NSEL,ALL,
FINISH
/PREP7,
TYPE,18,
SE,plinrad,
/COM,           Delete radiation edge elements
LSEL,S,TYPE,,7,
LCLEAR,ALL,
LSEL,ALL,

FINISH
/COM,   ***************************************************************
/COM,           Set solution parameters and apply B.C.'s
/COM,
/COM,           Solve steady-state for initial conditions
/COM,           with WP surface temperatures from repository
/COM,           steady-state solution.
/SOLU
ANTYPE,TRAN,NEW,
NROPT,AUTO,
TRNOPT,FULL,
TOFFST,273.15,
DK,1012,TEMP,(W4TOP(TM_START+TMI100)),,1,
DK,2000,TEMP,(W4SID(TM_START+TMI100)),,1,
DK,1011,TEMP,(W4BOT(TM_START+TMI100)),,1,
ASEL,S,MAT,,25,
ESLA,S,
BFE,ALL,HGEN,,(FUEL(TM_START+TMI100)),
ASEL,ALL,
ESEL,ALL,
TIMINT,OFF,
TIME,1e-6,
AUTOTS,ON,
KBC,0,
SOLVE
/COM,   ***************************************************************
/COM,           Set time integration parameters
TIMINT,ON,
AUTOTS,ON,
/COM,           Time substep ranges from 10 sec to 1/4 loadstep
NSUBST,10,40,5,ON
/COM,           Begin Transient
/COM,           Apply loads and solve for 100 to 190 years
*DO,TM,TM_START,TME90,TMI10
        TIME,TM,
        ASEL,S,MAT,,25,
        ESLA,S,
        BFE,ALL,HGEN,,(FUEL(TM+TMI100)),
        ASEL,ALL
        ESEL,ALL
        DK,1012,TEMP,(W4TOP(TM+TMI100)),,1,
        DK,2000,TEMP,(W4SID(TM+TMI100)),,1,
        DK,1011,TEMP,(W4BOT(TM+TMI100)),,1,
        SOLVE
*ENDDO


/COM,           Apply loads and solve for 200 to 1000 years
```

```
*DO,TM,TME100,TME500,TMI100
        TIME,TM,
        ASEL,S,MAT,,25,
        ESLA,S,
        BFE,ALL,HGEN,,(FUEL(TM+TMI100)),
        ASEL,ALL
        ESEL,ALL
        DK,1012,TEMP,(W4TOP(TM+TMI100)),,1,
        DK,2000,TEMP,(W4SID(TM+TMI100)),,1,
        DK,1011,TEMP,(W4BOT(TM+TMI100)),,1,
        SOLVE
*ENDDO
FINISH
SAVE
/COM,   ***************************************************************
/COM,           Create element contour plots of solution results
/COM,
/COM,           Sort through solution results for time of max temp.
/POST26,
NSOL,2,(NODE(0.0,0.0,0.0)),TEMP,,peakclad,
STORE,NEW,
*GET,TMTMAX,VARI,2,EXTREM,TMAX,
FINISH
/POST1,
/COM,           Create temperature contour plots of WP at peak
/RESET
/TRIAD,OFF,
/NUM, 1,
/PNUM,MAT, 1,
/TYPE,HIDP,
/GLINE,,-1,
/FOCUS,1,(WPRAD/10.0),0.0,0.0,0,

SET,NEAR,,,,TMTMAX,
/TITLE, 21 PWR WP/No Drip Shield at Time of Peak Temp. (%TMTMAX/3.15576E7% years)
/SHOW,solupk,grph,0,8,
/CONTOUR,1,128,AUTO,
PLNSOL,TEMP,
/COM,           Create temperature contour plots at 100, 150, and 500 yrs
SET,NEAR,,,,TME100,
/TITLE, 21 PWR WP/No Drip Shield at 100 years
/SHOW,solu10,grph,0,8,
/CONTOUR,1,128,USER,
PLNSOL,TEMP,
SET,NEAR,,,,TME150,
/TITLE, 21 PWR WP/No Drip Shield at 150 years
/SHOW,solu50,grph,0,8,
/CONTOUR,1,128,USER,
PLNSOL,TEMP,
SET,NEAR,,,,TME500,
/TITLE, 21 PWR WP/No Drip Shield at 500 years
/SHOW,solu100,grph,0,8,
/CONTOUR,1,128,USER,
PLNSOL,TEMP,
ESEL,ALL,
FINISH
CSYS,0,
/COM,   ***************************************************************
/COM,           Print time/temperature output at specific locations
/COM,           Save profile from center to edge
/COM,
/COM,           Variable Legend: A01i000
/COM,                c = center of WP
/COM,                i = inner barrier of WP
/COM,                o = outer barrier of WP
/COM,                d = drip shield
/COM,                b = bottom of invert
/COM,                w = drift wall
/COM,                f = back fill
/COM,                    ## = ID number of assembly (01 is center)
```

```
/COM,                          i = side of assembly toward center of WP
/COM,                          o = side of assembly toward edge of drift
/COM,                               000 = profile center down
/COM,                               045 = profile 45 deg down
/COM,                               090 = profile center side
/COM,                               135 = profile 45 deg up
/COM,                               180 = profile center up
/POST26,
NUMVAR,30,
/COM,
/COM,   ***************************************************************
/COM,   *   Temperature Profile from center to bottom of WP (0 deg.)   *
/COM,   ***************************************************************
NSOL, 2,(NODE(0.0,                                          0.0,0.0)),TEMP,,c01i000,
NSOL, 3,(NODE(0.0,                                   -0.7206028,0.0)),TEMP,,i01i000,
NSOL, 4,(NODE(0.0,                                   -0.7406028,0.0)),TEMP,,i01o000,
NSOL, 5,(NODE(0.0,                                   -0.8406028,0.0)),TEMP,,o01o000,
NSOL, 6,(NODE(0.0,                                    -1.230203,0.0)),TEMP,,b01i000,
NSOL, 7,(NODE(0.0,                                    -1.772203,0.0)),TEMP,,b01o000,
NSOL, 8,(NODE(0.0,                                    -2.550000,0.0)),TEMP,,w01i000,
NSOL, 9,(NODE(0.0,                                    -2.750000,0.0)),TEMP,,w03o000,
PRVAR, 2, 3, 4, 5, 6, 7,
PRVAR, 8, 9,
/COM,
/COM,   ***************************************************************
/COM,   *   Temperature Profile from center to bottom of WP (90 deg.)   *
/COM,   ***************************************************************
NSOL, 2,(NODE(0.0,                                          0.0,0.0)),TEMP,,c01i090,
NSOL, 3,(NODE(0.7206028,                                    0.0,0.0)),TEMP,,i01i090,
NSOL, 4,(NODE(0.7406028,                                    0.0,0.0)),TEMP,,i01o090,
NSOL, 5,(NODE(0.8406028,                                    0.0,0.0)),TEMP,,o01o090,
NSOL, 6,(NODE(2.550000,                                     0.0,0.0)),TEMP,,w01i090,
NSOL, 7,(NODE(2.750000,                                     0.0,0.0)),TEMP,,w01o090,
PRVAR, 2, 3, 4, 5, 6, 7,

/COM,
/COM,   ***************************************************************
/COM,   *   Temperature Profile from center to bottom of WP (180 deg.)   *
/COM,   ***************************************************************
NSOL, 2,(NODE(0.0,                                          0.0,0.0)),TEMP,,c01i180,
NSOL, 3,(NODE(0.0,                                   0.7206028,0.0)),TEMP,,i01i180,
NSOL, 4,(NODE(0.0,                                   0.7406028,0.0)),TEMP,,i01o180,
NSOL, 5,(NODE(0.0,                                   0.8406028,0.0)),TEMP,,o01o180,
NSOL, 6,(NODE(0.0,                                    2.550000,0.0)),TEMP,,w01i000,
NSOL, 7,(NODE(0.0,                                    2.750000,0.0)),TEMP,,w01o000,
PRVAR, 2, 3, 4, 5, 6, 7,


FINISH
/COM,   ***************************************************************
/COM,           End of batch input file
/COM,   ***************************************************************
/EXIT,
/EOF
```

```
/BATCH
/COM,ANSYS RELEASE  5.4    UP19970828        09:23:52    05/19/1998
/COM,   ************************************************************
/COM,   ANSYS REVISION  5.4                                  06/23/98
/COM,   2-D Thermal Model of 21 PWR WP with Above Drip Shield  M. Plinski
/COM,   ************************************************************
/input,start,ans     ,/ansys54/docu/,,,,,,,,,,,,,,,1
/show,x11,
/menu,on,
/GRA,POWER
/GST,ON
/INPUT,drshtop,inp,,1,0
allsel
VSEL,ALL
ASEL,ALL
LSEL,ALL
KSEL,ALL
ESEL,ALL
NSEL,ALL
/PNUM,KP,1
/PNUM,LINE,0
/PNUM,AREA,0
/PNUM,VOLU,0
/PNUM,NODE,0
/PNUM,SVAL,0
/NUM,0
!*
/PNUM,ELEM,0
/REPLOT
!*
LPLOT
/COM,
/COM,   CREATE KEYPOINTS FOR DRIP SHIELD AND DRIFT
/COM,
K,1000,0,-1.230203,,
K,1001,0,-1.772203,,
K,1002,2.233630,-1.230203,,
K,1003,0,-2.55,,
K,1004,0,-2.75,,
K,1005,0,2.55,,
K,1006,0,2.75,,
K,1007,2.55,0,,
K,1008,2.75,0,,
K,1009,0,1.6,,
K,1010,0,1.62,,
K,1011,2.345741,1.00,,
K,1012,1.550,1.00,,
K,1012,1.570,1.00,,
K,1012,1.570,1.00,,

/COM,
/COM,   CREATE LINES FOR DRIP SHIELD AND DRIFT
/COM,
LSTR,       4,    1000
LSTR,    1000,    1001
LSTR,    1001,    1003
LSTR,    1003,    1004
LSTR,    1000,    1002
/ZOOM,1,RECT,-0.188028,0.222038,0.144366,0.990860
LSTR,    1006,    1005
LSTR,    1005,    1010
LSTR,    1010,    1009
LSTR,    1009,       6
klist,all,,,coord
K,1014,1.55,1,,
K,1014,1.55,1,,
klist,all,,,coord

/ZOOM,1,RECT,0.011972,-0.876279,1.623240,0.064331
/ZOOM,1,RECT,1.228873,-0.605924,1.482395,-0.344018
```

```
LSTR,     1009,     1014
LSTR,     1014,     1012
/ZOOM,  1, 0.86516     ,  1.3624     , 0.00000E+00,  1.5071
/ZOOM,1,RECT,-0.920423,0.261465,-0.692253,0.509290
LSTR,     1010,     1012
LPLOT
/ZOOM,  1, 0.86516     ,  1.3624     , 0.00000E+00,  1.5071
/ZOOM,  1, 0.30164     ,  1.8345     , 0.00000E+00,  2.4937
/ZOOM,  1,  1.3750     , 0.00000E+00, 0.00000E+00,  6.4871

/ZOOM, 1 ,BACK
LPLOT
KPLOT,ALL
LSTR,     1012,     1011
!*
LARC,1003,1002,1,2.55,
!*
LARC,1002,1007,1,2.55,
!*
LARC,1007,1011,1,2.55,
!*
LARC,1011,1005,1,2.55,
!*
LARC,1004,1008,1,2.75,
!*
LARC,1008,1006,1,2.75,
LPLOT

/COM,
/COM,   DEFINE BACKFILL MATERIAL
/COM,
UIMP,20,EX, , , ,
UIMP,20,DENS, , ,2600*(1-.48),
UIMP,20,ALPX, , , ,
UIMP,20,REFT, , , ,
UIMP,20,NUXY, , , ,
UIMP,20,PRXY, , , ,
UIMP,20,GXY, , , ,
UIMP,20,MU, , , ,
UIMP,20,DAMP, , , ,
UIMP,20,KXX, , ,0.58,
UIMP,20,C, , ,840,
UIMP,20,ENTH, , , ,
UIMP,20,HF, , , ,
UIMP,20,EMIS, , ,0.85,
UIMP,20,QRATE, , , ,
UIMP,20,MURX, , , ,
UIMP,20,MGXX, , , ,
UIMP,20,RSVX, , , ,
UIMP,20,PERX, , , ,
UIMP,20,VISC, , , ,
UIMP,20,SONC, , , ,
!*
!*
/COM,
/COM,   DEFINE CONCRETE
/COM,
UIMP,21,EX, , , ,
UIMP,21,DENS, , ,2300,
UIMP,21,ALPX, , , ,
UIMP,21,REFT, , , ,
UIMP,21,NUXY, , , ,
UIMP,21,PRXY, , , ,
UIMP,21,GXY, , , ,
UIMP,21,MU, , , ,
UIMP,21,DAMP, , , ,
UIMP,21,KXX, , ,1.40,
UIMP,21,C, , ,880,
UIMP,21,ENTH, , , ,
UIMP,21,HF, , , ,
```

```
UIMP,21,EMIS, , ,0.88,
UIMP,21,QRATE, , , ,
UIMP,21,MURX, , , ,
UIMP,21,MGXX, , , ,
UIMP,21,RSVX, , , ,
UIMP,21,PERX, , , ,
UIMP,21,VISC, , , ,
UIMP,21,SONC, , , ,
!*
!*
UIMP,21,EX, , , ,
UIMP,21,DENS, , ,2300,
UIMP,21,ALPX, , , ,
UIMP,21,REFT, , , ,
UIMP,21,NUXY, , , ,
UIMP,21,PRXY, , , ,
UIMP,21,GXY, , , , ,
UIMP,21,MU, , , ,
UIMP,21,DAMP, , , ,
UIMP,21,KXX, , ,1.40,
UIMP,21,C, , ,880,
UIMP,21,ENTH, , , ,
UIMP,21,HF, , , ,
UIMP,21,EMIS, , ,0.88,
UIMP,21,QRATE, , , ,
UIMP,21,MURX, , , ,
UIMP,21,MGXX, , , ,
UIMP,21,RSVX, , , ,
UIMP,21,PERX, , , ,
UIMP,21,VISC, , , ,
UIMP,21,SONC, , , ,
!*
/COM,   ************************************************************
/COM,           Define new material 25 for smeared WP internal
/COM,           Density:        DENS    (kg/m^3)
/COM,           Conductivity:   KXX     (W/m/K)
/COM,           Specific Heat:  C       (J/kg/K)
MPTEMP
MPTEMP,   1, .00000E+00,
MPDATA,DENS,25, 1, 3800,
MPDATA, KXX,25, 1, 1.6,
MPTEMP
MPTEMP,   1,   21.11,   37.78,   65.56,   93.33,  121.11,  148.89,
MPTEMP,   7,  176.67,  204.44,  232.22,  260.00,  287.78,  315.56,
MPTEMP,  13,  343.33,  371.11,  398.89,  426.67,  454.44,  482.22,
MPTEMP,  19,  510.00,  537.78,  565.56,  593.33,  621.11,  648.89,
MPTEMP,  25,  676.67,  704.44,  732.22,  760.00,  787.78,  815.56,
MPDATA,   C, 25, 1, 444.12, 460.92, 477.49, 493.98, 503.53, 513.45,
MPDATA,   C, 25, 7, 524.26, 535.63, 544.50, 556.26, 563.15, 570.39,
MPDATA,   C, 25,13, 582.39, 598.04, 610.25, 622.12, 633.29, 651.67,
MPDATA,   C, 25,19, 668.48, 688.99, 706.55, 719.45, 750.06, 789.29,
MPDATA,   C, 25,25, 835.25, 920.49,1134.00,1698.00, 837.70, 763.35,
/COM,
/COM,   CREATE BACKFILL AREA AND MESH
/COM,
/ZOOM,  1, 0.30164    ,  1.8345    , 0.00000E+00,  2.4937
/AUTO, 1
/REP
/ZOOM,1,RECT,0.364085,0.292443,0.488028,0.379745
/ZOOM,  1,  1.3750    , 0.00000E+00, 0.00000E+00,  6.4871
/ZOOM,1,RECT,-0.162676,-0.467930,0.730282,0.548717
/ZOOM,1,RECT,-0.520423,0.686711,0.859859,0.999308
/ZOOM,1,RECT,0.552817,-0.572130,1.242958,-0.259532
/ZOOM,  1, 0.97510    ,  1.4185    , 0.00000E+00,  1.7073
/ZOOM,  1,  1.2262    , 0.12219    , 0.00000E+00,  3.2976
/ZOOM,1,RECT,0.468310,0.506474,0.685211,0.664181
FLST,2,10,4
FITEM,2,585
FITEM,2,577
FITEM,2,576
```

```
FITEM,2,5
FITEM,2,4
FITEM,2,562
FITEM,2,569
FITEM,2,594
FITEM,2,595
FITEM,2,592
AL,P51X
/ZOOM,  1,  1.2262    , 0.12219    , 0.00000E+00,  3.2976
APLOT
/PNUM,KP,1
/PNUM,LINE,0
/PNUM,AREA,1
/PNUM,VOLU,0
/PNUM,NODE,0
/PNUM,SVAL,0
/NUM,0
!*
/PNUM,MAT,1
/REPLOT
!*
/PNUM,KP,1
/PNUM,LINE,0
/PNUM,AREA,1
/PNUM,VOLU,0
/PNUM,NODE,0
/PNUM,SVAL,0
/NUM,0
!*
/PNUM,MAT,1
/REPLOT
!*

CM,_Y,AREA
ASEL, , , ,     285
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,      20, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
APLOT
SMRT,6
SMRT,2
MSHAPE,0,2D
MSHKEY,0
!*
CM,_Y,AREA
ASEL, , , ,     285
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*

LPLOT
/UI,MESH,OFF

/COM,
/COM,   CREATE DRIP SHIELD AREA AND MESH
/COM,
/ZOOM,1,RECT,-0.531690,0.481128,0.837324,1.010573
```

```
/ZOOM,1,RECT,1.045775,-0.408790,1.178169,-0.259532
/ZOOM,  1, 0.94912     ,  1.2691     , 0.00000E+00,  1.6933
/ZOOM,1,RECT,-0.069718,-0.039868,0.527465,0.283994
/ZOOM,  1, 0.94912     ,  1.2691     , 0.00000E+00,  1.6933
/ZOOM,1,RECT,-0.889437,0.331870,-0.742958,0.568430
/ZOOM,  1, 0.94912     ,  1.2691     , 0.00000E+00,  1.6933
/ZOOM,1,RECT,-0.061268,0.008007,0.214789,0.267097
FLST,2,4,4
FITEM,2,585
FITEM,2,590
FITEM,2,573
FITEM,2,577
AL,P51X
CM,_Y,AREA
ASEL, , , ,      286
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,      15, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
APLOT
/ZOOM,  1, 0.94912     ,  1.2691     , 0.00000E+00,  1.6933
CM,_Y,AREA
ASEL, , , ,      286
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*
/UI,MESH,OFF

NLIST,ALL, , , ,NODE,NODE,NODE
/COM,
/COM,    CREATE AIR GAP AREA AND MESH
/COM,
LPLOT
/ZOOM,  1,  1.2262     , 0.12219     , 0.00000E+00,  3.2976
/ZOOM,  1,  1.3750     , 0.00000E+00, 0.00000E+00,  6.4871
/ZOOM,1,RECT,-0.145775,0.306524,0.721831,0.928904
FLST,2,4,4
FITEM,2,590
FITEM,2,592
FITEM,2,596
FITEM,2,572
AL,P51X
CM,_Y,AREA
ASEL, , , ,      287
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,       8, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
APLOT
CM,_Y,AREA
ASEL, , , ,      287
CM,_Y1,AREA
CHKMSH,'AREA'
```

```
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*
/UI,MESH,OFF

/COM,
/COM,   CREATE DRIFT AREA AND MESH
/COM,
LPLOT
/ZOOM,  1,  1.3750    , 0.00000E+00, 0.00000E+00,  6.4871
FLST,2,8,4
FITEM,2,596
FITEM,2,595
FITEM,2,594
FITEM,2,593
FITEM,2,567
FITEM,2,597
FITEM,2,598
FITEM,2,570
AL,P51X
FLST,2,4,4
FITEM,2,569
FITEM,2,564
FITEM,2,566
FITEM,2,593
AL,P51X
FLST,5,2,5,ORDE,2
FITEM,5,288
FITEM,5,-289
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,      21, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
APLOT
CM,_Y,AREA
ASEL, , , ,     289
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*
APLOT
CM,_Y,AREA
ASEL, , , ,     288
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
```

```
!*
/UI,MESH,OFF
NUMMRG,all,,
/COM,
/COM,   APPLY RADIATION ELEMENTS FOR DRIFT AND BACK FILL
/COM,
/PNUM,KP,1
/PNUM,LINE,1
/PNUM,AREA,0
/PNUM,VOLU,0
/PNUM,NODE,0
/PNUM,SVAL,0
/NUM,0
!*
/PNUM,MAT,1
/REPLOT
!*
/PNUM,KP,1
/PNUM,LINE,1
/PNUM,AREA,0
/PNUM,VOLU,0
/PNUM,NODE,0
/PNUM,SVAL,0
/NUM,0
!*
/PNUM,MAT,1
/REPLOT
!*
LPLOT
/ZOOM,1,RECT,-0.145775,0.241751,0.761268,0.954249
/PNUM,KP,1
/PNUM,LINE,1
/PNUM,AREA,0
/PNUM,VOLU,0
/PNUM,NODE,0
/PNUM,SVAL,0
/NUM,0
!*
/PNUM,MAT,0
/REPLOT
!*
/PNUM,KP,1
/PNUM,LINE,1
/PNUM,AREA,0
/PNUM,VOLU,0
/PNUM,NODE,0
/PNUM,SVAL,0
/NUM,0
!*
/PNUM,ELEM,0
/REPLOT
!*
CM,_Y,LINE
LSEL, , , ,     590
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,      15, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
LMESH,     590
CM,_Y,LINE
LSEL, , , ,     592
CM,_Y1,LINE
CMSEL,S,_Y
!*
```

```
CMSEL,S,_Y1
LATT,      20, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
LMESH,     592
CM,_Y,LINE
LSEL, , , ,     596
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,      21, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
LMESH,     596
/PNUM,KP,1
/PNUM,LINE,1
/PNUM,AREA,0
/PNUM,VOLU,0
/PNUM,NODE,0
/PNUM,SVAL,0
/NUM,0
!*
/PNUM,MAT,1
/REPLOT
!*
/PNUM,KP,1
/PNUM,LINE,1
/PNUM,AREA,0
/PNUM,VOLU,0
/PNUM,NODE,0
/PNUM,SVAL,0
/NUM,0
!*
/PNUM,MAT,1
/REPLOT
!*
!*
/PSF,DEFA, ,1
/PBF,DEFA, ,1
/PSYMB,CS,0
/PSYMB,NDIR,0
/PSYMB,ESYS,1
/PSYMB,LDIR,0
/PSYMB,ECON,0
/PSYMB,DOT,1
/PSYMB,PCONV,
/PSYMB,LAYR,0
!*
/PBC,ALL, ,1
/REP
!*
!*
/PSF,DEFA, ,1
/PBF,DEFA, ,1
/PSYMB,CS,0
/PSYMB,NDIR,0
/PSYMB,ESYS,0
/PSYMB,LDIR,1
/PSYMB,ECON,0
/PSYMB,DOT,1
/PSYMB,PCONV,
/PSYMB,LAYR,0
!*
/PBC,ALL, ,1
/REP
```

```
!*
!*
/PSF,DEFA, ,1
/PBF,DEFA, ,1
/PSYMB,CS,0
/PSYMB,NDIR,0
/PSYMB,ESYS,0
/PSYMB,LDIR,0
/PSYMB,ECON,1
/PSYMB,DOT,1
/PSYMB,PCONV,
/PSYMB,LAYR,0
!*
/PBC,ALL, ,1
/REP
!*
!*
/PSF,DEFA, ,1
/PBF,DEFA, ,1
/PSYMB,CS,0
/PSYMB,NDIR,0
/PSYMB,ESYS,1
/PSYMB,LDIR,0
/PSYMB,ECON,0
/PSYMB,DOT,1
/PSYMB,PCONV,
/PSYMB,LAYR,0
!*
/PBC,ALL, ,1
/REP
!*
EPLOT
/ZOOM,1,RECT,0.135916,-0.803058,1.302113,-0.287694
/ZOOM,1,RECT,-0.593662,-0.490460,0.180986,-0.059582

/ZOOM,  1,  1.7146    ,  1.2212    , 0.00000E+00,  1.0109
/ZOOM,  1,  1.2986    ,  1.8090    , 0.00000E+00,  2.3110
esel,type,7
EPLOT

allsel
VSEL,ALL
ASEL,ALL
LSEL,ALL
KSEL,ALL
ESEL,ALL
NSEL,ALL
EPLOT
/COM,
/COM, ************************************************************************
/COM,           delete WP internals and create homogenous material
/COM,
ASEL,S,MAT,,7
ASEL,A,MAT,,3
ASEL,A,MAT,,14
ASEL,A,MAT,,18
ASEL,A,MAT,,19
ASEL,A,MAT,,15
ASEL,U, , ,     286
FLST,5,2,5,ORDE,2
FITEM,5,1
FITEM,5,-2
ASEL,U, , ,P51X
ACLEAR,ALL
ADELE,ALL,,,1
ALLSEL
/COM,
K,1020,DCIRD,0,0
K,1021,0,DCIRD,0
K,1022,0,-DCIRD,0
```

```
L,1020,8
L,1021,9
L,1022,7
L,1,1020
L,1,1021
L,1,1022
LARC,1021,1020,1,              DCIRD
LARC,1020,1022,1,              DCIRD
AL,11,16,10,8,9
AL,12,17,10,7,6
AL,14,13,16
AL,15,13,17
/COM,
FLST,5,2,4,ORDE,2
FITEM,5,16
FITEM,5,-17
LSEL, , , ,P51X
LESIZE,ALL, , ,80,,
/COM,
FLST,5,3,4,ORDE,2
FITEM,5,13
FITEM,5,-15
LSEL, , , ,P51X
LESIZE,ALL, , ,16,0.25,
/COM,
MOPT,AMESH,DEFA
MOPT,VMESH,DEFA
MOPT,TIMP,1
MOPT,PYRA,ON
MSHKEY,0
MSHMID,0
MSHPATTERN,0
KEYW,ACCEPT,0
!*
MSHA,0,2D
MSHA,1,3D
/COM,                      WP internal
MAT,25
TYPE,1
AMESH,5,6
LDELE,18,19,1
ALLSEL
/COM,
MOPT,AMESH,DEFA
MOPT,VMESH,DEFA
MOPT,TIMP,1
MOPT,PYRA,ON
MSHKEY,1
MSHMID,0
MSHPATTERN,0
KEYW,ACCEPT,0
!*
MSHA,0,2D
MSHA,0,3D
/COM,                         inner barrier
LCCAT,8,9
LCCAT,7,6
MAT,15
TYPE,1
AMESH,3,4
LDELE,18,19,1
ALLSEL
/COM,   ****************************************************************
/COM,           Create element mesh plots to illustrate model
/COM,           View mesh for entire model
/RESET
/TRIAD,OFF,
/NUM, 1,
/PNUM,MAT, 1,
/TYPE,HIDP,
```

```
/GLINE,,0,
/FOCUS,1,(WPRAD/10.0),0.0,0.0,0,
/TITLE, 21 PWR AUCF - 1/2 FEM Model
/SHOW,meshfull,grph,1,8,
EPLOT
ESEL,U,MAT,, 7,
/SHOW,meshgap,grph,1,8,
EPLOT
/COM,           View mesh for radiation substructure
/PNUM,MAT, 0,
/PNUM,TYPE, 1,
ESEL,S,TYPE,,7,
/TITLE, 21 PWR AUCF/Waste Package - Radiation Matrix
/SHOW,meshrad,grph,1,8,
EPLOT
ESEL,ALL,
/TITLE, 21 PWR AUCF with 10 yr old, 48 GWD/MTU SNF
/SHOW,ON
/COM,   ************************************************************
/COM,           Generate super-elements
/AUX12,
ESEL,S,TYPE,,7,
NSLE,S,
STEF,5.67E-8,
GEOM,1,0,
/COM,EMIS,3,0.8
/COM,EMIS,18,0.07
/COM,EMIS,19,0.6
EMIS,15,0.87
EMIS,20,0.85
EMIS,21,0.88
VTYPE,0,800,
WRITE,spaces,
ESEL,ALL,
NSEL,ALL,
FINISH
/PREP7,
TYPE,18,
SE,spaces,
/COM,           Delete radiation edge elements
LSEL,S,TYPE,,7,
LCLEAR,ALL,
LSEL,ALL,
FINISH
SAVE
/COM,   ************************************************************
/COM,           Set solution parameters and apply B.C.'s
/COM,
/COM,           Solve steady-state for initial conditions
/COM,           with WP surface temperatures from repository
/COM,           steady-state solution.
/SOLU
ANTYPE,TRAN,NEW,
NROPT,AUTO,
TRNOPT,FULL,
TOFFST,273.15,
DK,1006,TEMP,(W4TOP(TM_START+TMI100)),,1,
DK,1008,TEMP,(W4SID(TM_START+TMI100)),,1,
DK,1004,TEMP,(W4BOT(TM_START+TMI100)),,1,
ASEL,S,MAT,,25,
ESLA,S,
BFE,ALL,HGEN,,(FUEL(TM_START+TMI100)),
ASEL,ALL,
ESEL,ALL,
TIMINT,OFF,
TIME,1e-6,
AUTOTS,ON,
KBC,0,
SOLVE
/COM,   ************************************************************
```

```
/COM,           Set time integration parameters
TIMINT,ON,
AUTOTS,ON,
/COM,           Time substep ranges from 10 sec to 1/4 loadstep
NSUBST,10,40,5,ON
/COM,           Begin Transient
/COM,           Apply loads and solve for 100 to 190 years
*DO,TM,TM_START,TME90,TMI10
        TIME,TM,
        ASEL,S,MAT,,25,
        ESLA,S,
        BFE,ALL,HGEN,,(FUEL(TM+TMI100)),
        ASEL,ALL
        ESEL,ALL
        DK,1006,TEMP,(W4TOP(TM+TMI100)),,1,
        DK,1008,TEMP,(W4SID(TM+TMI100)),,1,
        DK,1004,TEMP,(W4BOT(TM+TMI100)),,1,
        SOLVE
*ENDDO

/COM,           Apply loads and solve for 200 to 600 years
*DO,TM,TME100,TME500,TMI100
        TIME,TM,
        ASEL,S,MAT,,25,
        ESLA,S,
        BFE,ALL,HGEN,,(FUEL(TM+TMI100)),
        ASEL,ALL
        ESEL,ALL
        DK,1006,TEMP,(W4TOP(TM+TMI100)),,1,
        DK,1008,TEMP,(W4SID(TM+TMI100)),,1,
        DK,1004,TEMP,(W4BOT(TM+TMI100)),,1,
        SOLVE
*ENDDO
FINISH
SAVE
/COM,   ************************************************************************
/COM,           Create element contour plots of solution results
/COM,
/COM,           Sort through solution results for time of max temp.
/POST26,
NSOL,2,(NODE(0.0,0.0,0.0)),TEMP,,peakclad,
STORE,NEW,
*GET,TMTMAX,VARI,2,EXTREM,TMAX,
FINISH
/POST1,
/COM,           Create temperature contour plots of WP at peak
/RESET
/TRIAD,OFF,
/NUM, 1,
/PNUM,MAT, 1,
/TYPE,HIDP,
/GLINE,,-1,
/FOCUS,1,(WPRAD/10.0),0.0,0.0,0,

SET,NEAR,,,,TMTMAX,
/TITLE, 21 PWR WP/Above Drip Shield at Time of Peak Temp. (%TMTMAX/3.15576E7% years)
/SHOW,solupk,grph,0,8,
/CONTOUR,1,128,AUTO,
PLNSOL,TEMP,
/COM,           Create temperature contour plots at 100, 150, and 500 yrs
SET,NEAR,,,,TME100,
/TITLE, 21 PWR WP/Above Drip Shield at 100 years
/SHOW,solu10,grph,0,8,
/CONTOUR,1,128,USER,
PLNSOL,TEMP,
SET,NEAR,,,,TME150,
/TITLE, 21 PWR WP/Above Drip Shield at 150 years
/SHOW,solu50,grph,0,8,
/CONTOUR,1,128,USER,
PLNSOL,TEMP,
```

```
SET,NEAR,,,,TME500,
/TITLE, 21 PWR WP/Above Drip Shield at 500 years
/SHOW,solu100,grph,0,8,
/CONTOUR,1,128,USER,
PLNSOL,TEMP,
ESEL,ALL,
FINISH
CSYS,0,
CSYS,0,
/COM,   ***************************************************************
/COM,          Print time/temperature output at specific locations
/COM,          Save profile from center to edge
/COM,
/COM,          Variable Legend: A01i000
/COM,               c = center of WP
/COM,               i = inner barrier of WP
/COM,               o = outer barrier of WP
/COM,               d = drip shield
/COM,               b = bottom of invert
/COM,               w = drift wall
/COM,               f = back fill
/COM,                    ## = ID number of assembly (01 is center)
/COM,                         i = side of assembly toward center of WP
/COM,                         o = side of assembly toward edge of drift
/COM,                              000 = profile center down
/COM,                              045 = profile 45 deg down
/COM,                              090 = profile center side
/COM,                              135 = profile 45 deg up
/COM,                              180 = profile center up
/POST26,
NUMVAR,30,
/COM,
/COM,   ***************************************************************
/COM,   *   Temperature Profile from center to bottom of WP (0 deg.)   *
/COM,   ***************************************************************
NSOL, 2,(NODE(0.0,                                          0.0,0.0)),TEMP,,c01i000,
NSOL, 3,(NODE(0.0,                                       -0.7206028,0.0)),TEMP,,i01i000,
NSOL, 4,(NODE(0.0,                                       -0.7406028,0.0)),TEMP,,i01o000,
NSOL, 5,(NODE(0.0,                                       -0.8406028,0.0)),TEMP,,o01o000,
NSOL, 6,(NODE(0.0,                                        -1.230203,0.0)),TEMP,,b01i000,
NSOL, 7,(NODE(0.0,                                        -1.772203,0.0)),TEMP,,b01o000,
NSOL, 8,(NODE(0.0,                                        -2.550000,0.0)),TEMP,,w01i000,
NSOL, 9,(NODE(0.0,                                        -2.750000,0.0)),TEMP,,w03o000,
PRVAR, 2, 3, 4, 5, 6, 7,
PRVAR, 8, 9,
/COM,
/COM,   ***************************************************************
/COM,   *   Temperature Profile from center to bottom of WP (90 deg.)   *
/COM,   ***************************************************************
NSOL, 2,(NODE(0.0,                                          0.0,0.0)),TEMP,,c01i090,
NSOL, 3,(NODE(0.7206028,                                    0.0,0.0)),TEMP,,i01i090,
NSOL, 4,(NODE(0.7406028,                                    0.0,0.0)),TEMP,,i01o090,
NSOL, 5,(NODE(0.8406028,                                    0.0,0.0)),TEMP,,o01o090,
NSOL, 6,(NODE(2.550000,                                     0.0,0.0)),TEMP,,w01i090,
NSOL, 7,(NODE(2.750000,                                     0.0,0.0)),TEMP,,w01o090,
PRVAR, 2, 3, 4, 5, 6, 7,

/COM,
/COM,   ***************************************************************
/COM,   *   Temperature Profile from center to bottom of WP (180 deg.)   *
/COM,   ***************************************************************
NSOL, 2,(NODE(0.0,                                          0.0,0.0)),TEMP,,c01i180,
NSOL, 3,(NODE(0.0,                                       0.7206028,0.0)),TEMP,,i01i180,
NSOL, 4,(NODE(0.0,                                       0.7406028,0.0)),TEMP,,i01o180,
NSOL, 5,(NODE(0.0,                                       0.8406028,0.0)),TEMP,,o01o180,
NSOL, 6,(NODE(0.0,                                        1.600000,0.0)),TEMP,,d01i180,
NSOL, 7,(NODE(0.0,                                        1.620000,0.0)),TEMP,,d01o180,
NSOL, 8,(NODE(0.0,                                        2.550000,0.0)),TEMP,,w01i000,
NSOL, 9,(NODE(0.0,                                        2.750000,0.0)),TEMP,,w01o000,
PRVAR, 2, 3, 4, 5, 6, 7,
```

```
PRVAR, 8, 9,
/COM,
/COM,   ***************************************************************
/COM,   *   bottom end of the drip shield              *
/COM,   ***************************************************************
NSOL, 2,(NODE(1.550000,                                        1.000000,0.0)),TEMP,,d02i000,
NSOL, 3,(NODE(1.570000,                                        1.000000,0.0)),TEMP,,d02o000,
NSOL, 4,(NODE(2.345741,                                        1.000000,0.0)),TEMP,,f02o000,
PRVAR, 2, 3, 4,
FINISH
/COM,   ***************************************************************
/COM,          End of batch input file
/COM,   ***************************************************************
/EXIT,
/EOF
```

```
/BATCH
/COM,ANSYS RELEASE  5.4    UP19970828        14:49:55    06/15/1998
/COM,   ************************************************************
/COM,   ANSYS REVISION  5.4                                  06/18/98
/COM,   2-D Thermal Model of 21 PWR WP with Low Drip Shield  M. Plinski
/COM,
/COM,   ************************************************************
/input,start,ans     ,/ansys54/docu/,,,,,,,,,,,,,,,1
/show,x11,
/menu,on,
/GRA,POWER
/GST,ON
/INPUT,drshlow,inp,,1,0
allsel
VSEL,ALL
ASEL,ALL
LSEL,ALL
KSEL,ALL
ESEL,ALL
NSEL,ALL
!*
/COM,
/COM,   CREATE KEYPOINTS FOR DRIPSHIELD AND DRIFT
/COM,
KPLOT,ALL
klist,all,,,coord
k,1000,,-1.230203
k,1001,,-1.772203
k,1002,0.8406028,-1.230203
k,1003,0.8606028,-1.230203
k,1004,1.4606028,-1.230203
k,1005,1.4606028,1.4606028
k,1006,1,1.4606028
k,1008,,0.8606028
k,1007,0.8606028,,,
k,1010,0.842,,,
k,1011,,-2.75,,
k,1012,,2.75,,
k,1013,,2.55,,
k,1014,,-2.55,,
k,1015,2.233630,-1.230203,,
k,1016,1.4606028,,,
k,1017,,1.4606028,,
k,1018,2.195395,1.297205,,

/COM,
/COM,   CREATE LINES FOR DRIP SHIELD AND DRIFT
/COM,
LSTR,       4,    1000
LSTR,    1000,    1001
LSTR,    1001,    1014
LSTR,    1014,    1011
k,1019,2.75,,,
LSTR,    1000,    1002
LSTR,    1002,    1003
LSTR,    1003,    1004
LSTR,    1004,    1015
LSTR,    1017,    1006
LSTR,    1006,    1018
LSTR,    1017,    1013
LSTR,    1013,    1012
LSTR,    1017,    1008
LSTR,    1008,       6
LSTR,       5,    1010
LSTR,    1010,    1007
LSTR,    1007,    1016
LSTR,    1016,    1004
LSTR,    1007,    1003
LSTR,    1002,    1010
```

```
!*
LARC,1011,1019,1,2.75,
!*
LARC,1019,1012,1,2.75,
!*
LARC,1007,1008,1,0.8606028,

!*
LARC,1014,1015,1,2.55,
!*
LARC,1015,1018,1,2.55,
!*
LARC,1018,1013,1,2.55,
LPLOT
!*
LARC,1016,1017,1,1.4606028,

KDELE,     1005

/COM,
/COM,   CREATE DRIP SHIELD AIR SPACE AREA AND MESH
/COM,

FLST,2,5,4
FITEM,2,4
FITEM,2,562
FITEM,2,569
FITEM,2,600
FITEM,2,594
AL,P51X
!*
CM,_Y,AREA
ASEL, , , ,      285
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,       8, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
SMRT,6
SMRT,2
MSHAPE,0,2D
MSHKEY,0
!*
CM,_Y,AREA
ASEL, , , ,      285
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*


/COM,
/COM,            CREATE DRIP SHIELD AREA AND MESH
/COM,

/UI,MESH,OFF
/NUM,0
!*
/REPLOT
!*
```

```
FLST,2,4,4
FITEM,2,600
FITEM,2,570
FITEM,2,598
FITEM,2,595
AL,P51X
FLST,2,5,4
FITEM,2,593
FITEM,2,5
FITEM,2,594
FITEM,2,595
FITEM,2,603
AL,P51X
FLST,5,2,5,ORDE,2
FITEM,5,286
FITEM,5,-287
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,      15, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
CM,_Y,AREA
ASEL, , , ,      286
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*
CM,_Y,AREA
ASEL, , , ,      287
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*
/UI,MESH,OFF

/COM,
/COM,           DEFINE BACKFILL MATERIAL
/COM,

!*
UIMP,20,EX, , , ,
UIMP,20,DENS, , ,2600*(1-.48),
UIMP,20,ALPX, , , ,
UIMP,20,REFT, , , ,
UIMP,20,NUXY, , , ,
UIMP,20,PRXY, , , ,
UIMP,20,GXY, , , ,
UIMP,20,MU, , , ,
UIMP,20,DAMP, , , ,
UIMP,20,KXX, , ,0.58,
UIMP,20,C, , ,840,
UIMP,20,ENTH, , , ,
```

```
UIMP,20,HF, , , ,
UIMP,20,EMIS, , ,0.85,
UIMP,20,QRATE, , , ,
UIMP,20,MURX, , , ,
UIMP,20,MGXX, , , ,
UIMP,20,RSVX, , , ,
UIMP,20,PERX, , , ,
UIMP,20,VISC, , , ,
UIMP,20,SONC, , , ,
!*


/COM,
/COM,           DEFINE CONCRETE
/COM,

!*
UIMP,21,EX, , , ,
UIMP,21,DENS, , ,2300,
UIMP,21,ALPX, , , ,
UIMP,21,REFT, , , ,
UIMP,21,NUXY, , , ,
UIMP,21,PRXY, , , ,
UIMP,21,GXY, , , ,
UIMP,21,MU, , , ,
UIMP,21,DAMP, , , ,
UIMP,21,KXX, , ,1.40,
UIMP,21,C, , ,880,
UIMP,21,ENTH, , , ,
UIMP,21,HF, , , ,
UIMP,21,EMIS, , ,0.88,
UIMP,21,QRATE, , , ,
UIMP,21,MURX, , , ,
UIMP,21,MGXX, , , ,
UIMP,21,RSVX, , , ,
UIMP,21,PERX, , , ,
UIMP,21,VISC, , , ,
UIMP,21,SONC, , , ,
!*
/COM,   ****************************************************************
/COM,           Define new material 25 for smeared WP internal
/COM,           Density:        DENS    (kg/m^3)
/COM,           Conductivity:   KXX     (W/m/K)
/COM,           Specific Heat:  C       (J/kg/K)
MPTEMP
MPTEMP,   1, .00000E+00,
MPDATA,DENS,25, 1, 3800,
MPDATA, KXX,25, 1, 1.6,
MPTEMP
MPTEMP,   1,   21.11,   37.78,   65.56,   93.33,  121.11,  148.89,
MPTEMP,   7,  176.67,  204.44,  232.22,  260.00,  287.78,  315.56,
MPTEMP,  13,  343.33,  371.11,  398.89,  426.67,  454.44,  482.22,
MPTEMP,  19,  510.00,  537.78,  565.56,  593.33,  621.11,  648.89,
MPTEMP,  25,  676.67,  704.44,  732.22,  760.00,  787.78,  815.56,
MPDATA,   C, 25, 1, 444.12, 460.92, 477.49, 493.98, 503.53, 513.45,
MPDATA,   C, 25, 7, 524.26, 535.63, 544.50, 556.26, 563.15, 570.39,
MPDATA,   C, 25,13, 582.39, 598.04, 610.25, 622.12, 633.29, 651.67,
MPDATA,   C, 25,19, 668.48, 688.99, 706.55, 719.45, 750.06, 789.29,
MPDATA,   C, 25,25, 835.25, 920.49,1134.00,1698.00, 837.70, 763.35,

/COM,
/COM,           CREATE BACKFILL AREA AND MESH
/COM,

FLST,2,4,4
FITEM,2,598
FITEM,2,572
FITEM,2,597
FITEM,2,596
AL,P51X
```

```
FLST,2,4,4
FITEM,2,603
FITEM,2,596
FITEM,2,608
FITEM,2,592
AL,P51X
FLST,2,6,4
FITEM,2,576
FITEM,2,608
FITEM,2,597
FITEM,2,573
FITEM,2,606
FITEM,2,577
AL,P51X

FLST,5,3,5,ORDE,2
FITEM,5,288
FITEM,5,-290
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,      20, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
CM,_Y,AREA
ASEL, , , ,     289
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*

FLST,5,2,5,ORDE,2
FITEM,5,288
FITEM,5,290
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*

/UI,MESH,OFF

/COM,
/COM,           CREATE DRIFT AIR SPACE AREA AND MESH
/COM,

FLST,2,4,4
FITEM,2,585
FITEM,2,576
FITEM,2,577
FITEM,2,607
AL,P51X
```

```
CM,_Y,AREA
ASEL, , , ,     291
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,       8, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
CM,_Y,AREA
ASEL, , , ,     291
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*
/UI,MESH,OFF


/COM,
/COM,           CREATE DRIFT AREA AND MESH
/COM,

FLST,2,7,4
FITEM,2,573
FITEM,2,572
FITEM,2,570
FITEM,2,569
FITEM,2,564
FITEM,2,566
FITEM,2,604
AL,P51X
FLST,2,7,4
FITEM,2,590
FITEM,2,607
FITEM,2,606
FITEM,2,604
FITEM,2,567
FITEM,2,601
FITEM,2,602
AL,P51X

FLST,5,2,5,ORDE,2
FITEM,5,292
FITEM,5,-293
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,      21, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
asel,,mat,,21

FLST,5,2,5,ORDE,2
FITEM,5,292
FITEM,5,-293
CM,_Y,AREA
ASEL, , , ,P51X
```

```
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*

/UI,MESH,OFF

/COM,
/COM,           APPLY RADIATION ELEMENTS FOR DRIFT AND DRIP SHIELD
/COM,

!*
!*
/PSF,DEFA, ,1
/PBF,DEFA, ,1
/PSYMB,CS,0
/PSYMB,NDIR,0
/PSYMB,ESYS,1
/PSYMB,LDIR,0
/PSYMB,ECON,0
/PSYMB,DOT,1
/PSYMB,PCONV,
/PSYMB,LAYR,0
!*
/PBC,ALL, ,1
/REP
!*
CM,_Y,LINE
LSEL, , , ,     569
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,      21, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
LMESH,     569
CM,_Y,LINE
LSEL, , , ,     600
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,      15, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
LMESH,     600
CM,_Y,LINE
LSEL, , , ,       4
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,       3, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
LMESH,       4
/AUTO, 1
```

```
/REP

FLST,5,2,4,ORDE,2
FITEM,5,576
FITEM,5,-577
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,      20, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,2,2,4,ORDE,2
FITEM,2,576
FITEM,2,-577
LMESH,P51X
CM,_Y,LINE
LSEL, , , ,     607
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,      21, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
LMESH,     607
SAVE
/COM, ************************************************************************
/COM,            delete WP internals and create homogenous material
/COM,
ASEL,S,MAT,,7
ASEL,A,MAT,,3
ASEL,A,MAT,,14
ASEL,A,MAT,,18
ASEL,A,MAT,,19
ASEL,A,MAT,,15
ASEL,U, , ,     286
ASEL,U, , ,     287
FLST,5,2,5,ORDE,2
FITEM,5,1
FITEM,5,-2
ASEL,U, , ,P51X
ACLEAR,ALL
ADELE,ALL,,,1
ALLSEL
/COM,
K,1020,DCIRD,0,0
K,1021,0,DCIRD,0
K,1022,0,-DCIRD,0
L,1020,8
L,1021,9
L,1022,7
L,1,1020
L,1,1021
L,1,1022
LARC,1021,1020,1,              DCIRD
LARC,1020,1022,1,              DCIRD
AL,11,16,10,8,9
AL,12,17,10,7,6
AL,14,13,16
AL,15,13,17
/COM,
FLST,5,2,4,ORDE,2
FITEM,5,16
```

```
FITEM,5,-17
LSEL, , , ,P51X
LESIZE,ALL, , ,80,,
/COM,
FLST,5,3,4,ORDE,2
FITEM,5,13
FITEM,5,-15
LSEL, , , ,P51X
LESIZE,ALL, , ,16,0.25,
/COM,
MOPT,AMESH,DEFA
MOPT,VMESH,DEFA
MOPT,TIMP,1
MOPT,PYRA,ON
MSHKEY,0
MSHMID,0
MSHPATTERN,0
KEYW,ACCEPT,0
!*
MSHA,0,2D
MSHA,1,3D
/COM,                    WP internal
MAT,25
TYPE,1
AMESH,5,6
ALLSEL
/COM,
MOPT,AMESH,DEFA
MOPT,VMESH,DEFA
MOPT,TIMP,1
MOPT,PYRA,ON
MSHKEY,1
MSHMID,0
MSHPATTERN,0
KEYW,ACCEPT,0
!*
MSHA,0,2D
MSHA,0,3D
/COM,                       inner barrier
LCCAT,8,9
LCCAT,7,6
MAT,15
TYPE,1
AMESH,3,4
LDELE,18,19,1
ALLSEL
/COM,   ***************************************************************
/COM,           Create element mesh plots to illustrate model
/COM,           View mesh for entire model
/RESET
/TRIAD,OFF,
/NUM, 1,
/PNUM,MAT, 1,
/TYPE,HIDP,
/GLINE,,0,
/FOCUS,1,(WPRAD/10.0),0.0,0.0,0,
/TITLE, 21 PWR Low Drip Shield - 1/2 FEM Model
/SHOW,meshfull,grph,1,8,
EPLOT
ESEL,U,MAT,, 7,
/SHOW,meshgap,grph,1,8,
EPLOT
/COM,           View mesh for radiation substructure
/PNUM,MAT, 0,
/PNUM,TYPE, 1,
ESEL,S,TYPE,,7,
/TITLE, 21 PWR Waste Package and Low Drip Shield - Radiation Matrix
/SHOW,meshrad,grph,1,8,
EPLOT
ESEL,ALL,
```

```
/TITLE, 21 PWR WP and Low Drip Shield with 10 yr old, 48 GWD/MTU SNF
/COM,   ************************************************************
/COM,           Generate super-elements
/AUX12,
ESEL,S,TYPE,,7,
NSLE,S,
STEF,5.67E-8,
GEOM,1,0,
EMIS,3,0.8
EMIS,18,0.07
EMIS,19,0.6
EMIS,15,0.87
EMIS,20,0.85
EMIS,21,0.88
VTYPE,0,800,
WRITE,spaces,
ESEL,ALL,
NSEL,ALL,
FINISH
/PREP7,
TYPE,18,
SE,spaces,
/COM,           Delete radiation edge elements
LSEL,S,TYPE,,7,
LCLEAR,ALL,
LSEL,ALL,
FINISH
/COM,   ************************************************************
/COM,           Set solution parameters and apply B.C.'s
/COM,
/COM,           Solve steady-state for initial conditions
/COM,           with WP surface temperatures from repository
/COM,           steady-state solution.
/SOLU
ANTYPE,TRAN,NEW,
NROPT,AUTO,
TRNOPT,FULL,
SOLCONTROL,ON,0
TOFFST,273.15,
DK,1012,TEMP,(W4TOP(TM_START+TMI100)),,1,
DK,1019,TEMP,(W4SID(TM_START+TMI100)),,1,
DK,1011,TEMP,(W4BOT(TM_START+TMI100)),,1,
ASEL,S,MAT,,25,
ESLA,S,
BFE,ALL,HGEN,,(FUEL(TM_START+TMI100)),
ASEL,ALL,
ESEL,ALL,
TIMINT,OFF,
TIME,1e-6,
AUTOTS,ON,
KBC,0,
SOLVE
/COM,   ************************************************************
/COM,           Set time integration parameters
TIMINT,ON,
AUTOTS,ON,
/COM,           Time substep ranges from 10 sec to 1/4 loadstep
NSUBST,10,40,5,ON
/COM,           Begin Transient
/COM,           Apply loads and solve for 100 to 190 years
*DO,TM,TM_START,TME90,TMI10
        TIME,TM,
        ASEL,S,MAT,,25,
        ESLA,S,
        BFE,ALL,HGEN,,(FUEL(TM+TMI100)),
        ASEL,ALL
        ESEL,ALL
        DK,1012,TEMP,(W4TOP(TM+TMI100)),,1,
        DK,1019,TEMP,(W4SID(TM+TMI100)),,1,
        DK,1011,TEMP,(W4BOT(TM+TMI100)),,1,
```

```
        SOLVE
*ENDDO
SAVE

/COM,           Apply loads and solve for 200 to 1000 years
*DO,TM,TME100,TME500,TMI100
        TIME,TM,
        ASEL,S,MAT,,25,
        ESLA,S,
        BFE,ALL,HGEN,,(FUEL(TM+TMI100)),
        ASEL,ALL
        ESEL,ALL
        DK,1012,TEMP,(W4TOP(TM+TMI100)),,1,
        DK,1019,TEMP,(W4SID(TM+TMI100)),,1,
        DK,1011,TEMP,(W4BOT(TM+TMI100)),,1,
        SOLVE
*ENDDO
FINISH
SAVE,
/COM,   ***************************************************************
/COM,           Create element contour plots of solution results
/COM,
/COM,           Sort through solution results for time of max temp.
/POST26,
NSOL,2,(NODE(0.0,0.0,0.0)),TEMP,,peakclad,
STORE,NEW,
*GET,TMTMAX,VARI,2,EXTREM,TMAX,
FINISH
/POST1,
/COM,           Create temperature contour plots of WP at peak
/RESET
/TRIAD,OFF,
/NUM, 1,
/PNUM,MAT, 1,
/TYPE,HIDP,
/GLINE,,-1,
/FOCUS,1,(WPRAD/10.0),0.0,0.0,0,

SET,NEAR,,,,TMTMAX,
/TITLE, 21 PWR WP/Low Drip Shield at Time of Peak Temp. (%TMTMAX/3.15576E7% years)
/SHOW,solupk,grph,0,8,
/CONTOUR,1,128,AUTO,
PLNSOL,TEMP,
/COM,           Create temperature contour plots at 100, 150, and 500 yrs
SET,NEAR,,,,TME100,
/TITLE, 21 PWR WP/Low Drip Shield at 100 years
/SHOW,solu10,grph,0,8,
/CONTOUR,1,128,USER,
PLNSOL,TEMP,
SET,NEAR,,,,TME150,
/TITLE, 21 PWR WP/Low Drip Shield at 150 years
/SHOW,solu50,grph,0,8,
/CONTOUR,1,128,USER,
PLNSOL,TEMP,
SET,NEAR,,,,TME500,
/TITLE, 21 PWR WP/Low Drip Shield at 500 years
/SHOW,solu100,grph,0,8,
/CONTOUR,1,128,USER,
PLNSOL,TEMP,
ESEL,ALL,
FINISH
CSYS,0,
/COM,   ***************************************************************
/COM,           Print time/temperature output at specific locations
/COM,           Save profile from center to edge
/COM,
/COM,           Variable Legend: A01i000
/COM,                c = center of WP
/COM,                i = inner barrier of WP
/COM,                o = outer barrier of WP
```

```
/COM,                d = drip shield
/COM,                b = bottom of invert
/COM,                w = drift wall
/COM,                f = back fill
/COM,                     ## = ID number of assembly (01 is center)
/COM,                          i = side of assembly toward center of WP
/COM,                          o = side of assembly toward edge of drift
/COM,                               000 = profile center down
/COM,                               045 = profile 45 deg down
/COM,                               090 = profile center side
/COM,                               135 = profile 45 deg up
/COM,                               180 = profile center up
/POST26,
NUMVAR,30,
/COM,
/COM,    ****************************************************************
/COM,    *   Temperature Profile from center to bottom of WP (0 deg.)   *
/COM,    ****************************************************************
NSOL, 2,(NODE(0.0,                                              0.0,0.0)),TEMP,,c01i000,
NSOL, 3,(NODE(0.0,                                    -0.7206028,0.0)),TEMP,,i01i000,
NSOL, 4,(NODE(0.0,                                    -0.7406028,0.0)),TEMP,,i01o000,
NSOL, 5,(NODE(0.0,                                    -0.8406028,0.0)),TEMP,,o01o000,
NSOL, 6,(NODE(0.0,                                     -1.230203,0.0)),TEMP,,b01i000,
NSOL, 7,(NODE(0.0,                                     -1.772203,0.0)),TEMP,,b01o000,
NSOL, 8,(NODE(0.0,                                     -2.550000,0.0)),TEMP,,w01i000,
NSOL, 9,(NODE(0.0,                                     -2.750000,0.0)),TEMP,,w03o000,
PRVAR, 2, 3, 4, 5, 6, 7,
PRVAR, 8, 9,
/COM,
/COM,    ****************************************************************
/COM,    *   Temperature Profile from center to bottom of WP (90 deg.)   *
/COM,    ****************************************************************
NSOL, 2,(NODE(0.0,                                              0.0,0.0)),TEMP,,c01i090,
NSOL, 3,(NODE(0.7206028,                                        0.0,0.0)),TEMP,,i01i090,
NSOL, 4,(NODE(0.7406028,                                        0.0,0.0)),TEMP,,i01o090,
NSOL, 5,(NODE(0.8406028,                                        0.0,0.0)),TEMP,,o01o090,
NSOL, 6,(NODE(0.8606028,                                        0.0,0.0)),TEMP,,d01o090,
NSOL, 7,(NODE(2.550000,                                         0.0,0.0)),TEMP,,w01i090,
NSOL, 8,(NODE(2.750000,                                         0.0,0.0)),TEMP,,w01o090,
PRVAR, 2, 3, 4, 5, 6, 7,
PRVAR, 8,
/COM,
/COM,    ****************************************************************
/COM,    *   Temperature Profile from center to bottom of WP (180 deg.)   *
/COM,    ****************************************************************
NSOL, 2,(NODE(0.0,                                              0.0,0.0)),TEMP,,c01i180,
NSOL, 3,(NODE(0.0,                                    0.7206028,0.0)),TEMP,,i01i180,
NSOL, 4,(NODE(0.0,                                    0.7406028,0.0)),TEMP,,i01o180,
NSOL, 5,(NODE(0.0,                                    0.8406028,0.0)),TEMP,,o01o180,
NSOL, 6,(NODE(0.0,                                    0.8606028,0.0)),TEMP,,d01o180,
NSOL, 7,(NODE(0.0,                                     1.460603,0.0)),TEMP,,f01o000,
NSOL, 8,(NODE(0.0,                                     2.550000,0.0)),TEMP,,w01i000,
NSOL, 9,(NODE(0.0,                                     2.750000,0.0)),TEMP,,w01o000,
PRVAR, 2, 3, 4, 5, 6, 7,
PRVAR, 8, 9,
/COM,
/COM,    ****************************************************************
/COM,    *   bottom end of the drip shield              *
/COM,    ****************************************************************
NSOL, 2,(NODE(0.8406028,                                -1.230203,0.0)),TEMP,,d02i000,
NSOL, 3,(NODE(0.8606028,                                -1.230203,0.0)),TEMP,,d02o000,
PRVAR, 2, 3,
FINISH
/COM,    ****************************************************************
/COM,            End of batch input file
/COM,    ****************************************************************
/EXIT,
/EOF
```

```
/BATCH
/COM,ANSYS RELEASE  5.4    UP19970828         08:41:33    05/14/1998
/COM,   ************************************************************
/COM,   ANSYS REVISION  5.4                                    10/29/98
/COM,   2-D Thermal Model of 21 PWR WP with Low Drip Shield   M. Plinski
/COM,   with Air Gap Between WP and Drip Shield
/COM,   ************************************************************
/input,start,ans      ,/ansys54/docu/,,,,,,,,,,,,,,,,1
/show,x11,
/menu,on,
/GRA,POWER
/GST,ON
/INPUT,drshlow,inp,,1,0
allsel
VSEL,ALL
ASEL,ALL
LSEL,ALL
KSEL,ALL
ESEL,ALL
NSEL,ALL
LPLOT
/PNUM,KP,1
/PNUM,LINE,0
/PNUM,AREA,0
/PNUM,VOLU,0
/PNUM,NODE,0
/PNUM,SVAL,0
/NUM,0
!*
/PNUM,ELEM,0
/REPLOT
!*
/COM,
/COM,   CREATE KEYPOINTS FOR DRIPSHIELD AND DRIFT
/COM,
K,1000,,-1.230203,,
K,1001,,-1.772203,,
K,1002,1.05,-1.230203,,
K,1003,1.07,-1.230203,,
K,1004,1.67,-1.230203,,
K,1005,1.67,1.67,,
K,1006,1.00,1.67,,
K,1007,1.07,,,
K,1008,,1.07,,
K,1009,,1.05,,
K,1010,1.05,,,
K,1011,,-2.75,,
K,1012,,2.75,,
K,1013,,2.55,,
K,1014,,-2.55,,
K,1015,2.233630,-1.230203,,
K,1016,1.67,,,
K,1017,,1.67,,
K,1018,2.195395,1.297205,,
K,1018,2.195395,1.297205,,


/COM,
/COM,           CREATE LINES FOR DRIP SHIELD AND DRIFT
/COM,

LSTR,       4,    1000
LSTR,    1000,    1001
LSTR,    1001,    1014
LSTR,    1014,    1011
/ZOOM,1,RECT,-0.103521,-0.493276,0.437324,-0.293326
LSTR,    1000,    1002
LSTR,    1002,    1003
/ZOOM,  1,  1.1168    , 0.00000E+00, 0.00000E+00,  6.4871
LSTR,    1003,    1004
```

```
LSTR,     1004,     1015
LPLOT
KPLOT,ALL
LSTR,     1017,     1006
LSTR,     1006,     1018
LSTR,     1017,     1013
LSTR,     1013,     1012
/ZOOM,1,RECT,-0.064084,0.326237,0.065493,0.641651
LSTR,     1017,     1008
LSTR,     1008,     1009
LPLOT
/ZOOM,1,RECT,0.017606,-0.912889,0.403521,-0.749550
/ZOOM,   1,  0.11162     ,   1.4639     , 0.00000E+00,   1.0231
/ZOOM,   1,   1.1168     , 0.00000E+00, 0.00000E+00,   6.4871
/ZOOM,1,RECT,-0.064084,0.264281,0.037324,0.419172
LSTR,     1009,        6
/AUTO, 1
/REP
KPLOT,ALL
/ZOOM,1,RECT,0.231690,-0.014523,0.626056,0.095309
LSTR,        5,     1010
LSTR,     1010,     1007
LSTR,     1007,     1016
/AUTO, 1
/REP
LPLOT

/ZOOM,1,RECT,0.299296,-0.484828,0.710563,0.146001
LSTR,     1016,     1004
/ZOOM,1,RECT,-0.351408,-0.836852,-0.069718,0.768380
LSTR,     1007,     1003
LSTR,     1002,     1010
/AUTO, 1
/REP

!*
LARC,1014,1015,1,2.55,
!*
LARC,1015,1018,1,2.55,
KPLOT,ALL
!*
LARC,1018,1005,1,2.55,
LPLOT
!*
LARC,1005,1013,1,2.55,
FLST,2,2,4,ORDE,2
FITEM,2,604
FITEM,2,606
LDELE,P51X
KDELE,     1005

/REPLOT
!*
LARC,1018,1013,1,2.55,

!*

!*

K,2000,2.75,,,
K,2000,2.75,,,
!*
LARC,1011,2000,1,2.75,
!*
LARC,2000,1012,1,2.75,

LPLOT
!*
LARC,1016,1017,1,1.67,
/ZOOM,1,RECT,-0.311972,-0.079295,0.335916,0.452966
```

```
!*
LARC,1010,1009,1,1.05,
!*
LARC,1007,1008,1,1.07,

/AUTO, 1
/REP
/COM,
/COM,   CREATE DRIP SHIELD AIR SPACE AREA AND MESH
/COM,
/ZOOM,1,RECT,-0.140141,-0.493276,0.324648,0.405091
FLST,2,5,4
FITEM,2,562
FITEM,2,569
FITEM,2,601
FITEM,2,595
FITEM,2,4
AL,P51X
/ZOOM,1,RECT,-0.235915,0.038985,0.735916,0.923271
FLST,2,4,4
FITEM,2,595
FITEM,2,610
FITEM,2,594
FITEM,2,5
AL,P51X

APLOT
/AUTO, 1
/REP
/PNUM,KP,1
/PNUM,LINE,0
/PNUM,AREA,1
/PNUM,VOLU,0
/PNUM,NODE,0
/PNUM,SVAL,0
/NUM,0
!*
/PNUM,MAT,1
/REPLOT
!*
/PNUM,KP,1
/PNUM,LINE,0
/PNUM,AREA,1
/PNUM,VOLU,0
/PNUM,NODE,0
/PNUM,SVAL,0
/NUM,0
!*
/PNUM,MAT,1
/REPLOT
!*
FLST,5,2,5,ORDE,2
FITEM,5,285
FITEM,5,-286
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,      8, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
MSHKEY,0
MOPT,AMESH,DEFA
MOPT,VMESH,DEFA
MOPT,TIMP,1
MOPT,PYRA,ON
```

```
MSHKEY,0
MSHMID,0
MSHPATTERN,0
KEYW,ACCEPT,0
!*
MSHA,0,2D
MSHA,1,3D
!*
SMRTSIZE,3
SMRTSIZE,3
SMRTSIZE,STAT
MSHKEY,0
FLST,5,2,5,ORDE,2
FITEM,5,285
FITEM,5,-286
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*

/UI,MESH,OFF

/COM,
/COM,            CREATE DRIP SHIELD AREA AND MESH
/COM,

LPLOT
/ZOOM,1,RECT,0.183803,-0.434136,0.302113,0.033353
FLST,2,4,4
FITEM,2,570
FITEM,2,600
FITEM,2,596
FITEM,2,601
AL,P51X
/ZOOM,  1,  1.3750    , 0.00000E+00, 0.00000E+00,  6.4871
/ZOOM,1,RECT,-0.148591,-0.017339,0.293662,0.399458
FLST,2,4,4
FITEM,2,610
FITEM,2,596
FITEM,2,615
FITEM,2,593
AL,P51X

APLOT
/AUTO, 1
/REP
FLST,5,2,5,ORDE,2
FITEM,5,287
FITEM,5,-288
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,      15, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,2,5,ORDE,2
FITEM,5,287
```

```
FITEM,5,-288
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*

!*
/COM,
/COM,           DEFINE BACKFILL MATERIAL
/COM,

UIMP,20,EX, , , ,
UIMP,20,DENS, , ,2600*(1-.48),
UIMP,20,ALPX, , , ,
UIMP,20,REFT, , , ,
UIMP,20,NUXY, , , ,
UIMP,20,PRXY, , , ,
UIMP,20,GXY, , , ,
UIMP,20,MU, , , ,
UIMP,20,DAMP, , , ,
UIMP,20,KXX, , ,0.58,
UIMP,20,C, , ,840,
UIMP,20,ENTH, , , ,
UIMP,20,HF, , , ,
UIMP,20,EMIS, , ,0.85,
UIMP,20,QRATE, , , ,
UIMP,20,MURX, , , ,
UIMP,20,MGXX, , , ,
UIMP,20,RSVX, , , ,
UIMP,20,PERX, , , ,
UIMP,20,VISC, , , ,
UIMP,20,SONC, , , ,
!*
!*
/COM,
/COM,           DEFINE CONCRETE
/COM,

UIMP,21,EX, , , ,
UIMP,21,DENS, , ,2300,
UIMP,21,ALPX, , , ,
UIMP,21,REFT, , , ,
UIMP,21,NUXY, , , ,
UIMP,21,PRXY, , , ,
UIMP,21,GXY, , , ,
UIMP,21,MU, , , ,
UIMP,21,DAMP, , , ,
UIMP,21,KXX, , ,1.40,
UIMP,21,C, , ,880,
UIMP,21,ENTH, , , ,
UIMP,21,HF, , , ,
UIMP,21,EMIS, , ,0.88,
UIMP,21,QRATE, , , ,
UIMP,21,MURX, , , ,
UIMP,21,MGXX, , , ,
UIMP,21,RSVX, , , ,
UIMP,21,PERX, , , ,
UIMP,21,VISC, , , ,
UIMP,21,SONC, , , ,
!*
!*
UIMP,21,EX, , , ,
```

```
UIMP,21,DENS, , ,2300,
UIMP,21,ALPX, , , ,
UIMP,21,REFT, , , ,
UIMP,21,NUXY, , , ,
UIMP,21,PRXY, , , ,
UIMP,21,GXY, , , ,
UIMP,21,MU, , , ,
UIMP,21,DAMP, , , ,
UIMP,21,KXX, , ,1.40,
UIMP,21,C, , ,880,
UIMP,21,ENTH, , , ,
UIMP,21,HF, , , ,
UIMP,21,EMIS, , ,0.88,
UIMP,21,QRATE, , , ,
UIMP,21,MURX, , , ,
UIMP,21,MGXX, , , ,
UIMP,21,RSVX, , , ,
UIMP,21,PERX, , , ,
UIMP,21,VISC, , , ,
UIMP,21,SONC, , , ,
!*
/COM,   ************************************************************************
/COM,           Define new material 25 for smeared WP internal
/COM,           Density:        DENS    (kg/m^3)
/COM,           Conductivity:   KXX     (W/m/K)
/COM,           Specific Heat:  C       (J/kg/K)
MPTEMP
MPTEMP,   1, .00000E+00,
MPDATA,DENS,25, 1, 3800,
MPDATA, KXX,25, 1, 1.6,
MPTEMP
MPTEMP,   1,   21.11,   37.78,   65.56,   93.33,  121.11,  148.89,
MPTEMP,   7,  176.67,  204.44,  232.22,  260.00,  287.78,  315.56,
MPTEMP,  13,  343.33,  371.11,  398.89,  426.67,  454.44,  482.22,
MPTEMP,  19,  510.00,  537.78,  565.56,  593.33,  621.11,  648.89,
MPTEMP,  25,  676.67,  704.44,  732.22,  760.00,  787.78,  815.56,
MPDATA,   C, 25, 1, 444.12, 460.92, 477.49, 493.98, 503.53, 513.45,
MPDATA,   C, 25, 7, 524.26, 535.63, 544.50, 556.26, 563.15, 570.39,
MPDATA,   C, 25,13, 582.39, 598.04, 610.25, 622.12, 633.29, 651.67,
MPDATA,   C, 25,19, 668.48, 688.99, 706.55, 719.45, 750.06, 789.29,
MPDATA,   C, 25,25, 835.25, 920.49,1134.00,1698.00, 837.70, 763.35,
/COM,
/COM,           CREATE BACKFILL AREA AND MESH
/COM,

LPLOT
/ZOOM,1,RECT,-0.162676,-0.467930,0.933099,0.700792
/ZOOM,1,RECT,-0.007746,-0.924154,0.144366,-0.631270
/ZOOM,  1,  1.5329    , 0.35220    , 0.00000E+00,  3.7908
FLST,2,4,4
FITEM,2,600
FITEM,2,572
FITEM,2,598
FITEM,2,597
AL,P51X
FLST,2,4,4
FITEM,2,615
FITEM,2,597
FITEM,2,608
FITEM,2,592
AL,P51X
FLST,2,6,4
FITEM,2,573
FITEM,2,603
FITEM,2,577
FITEM,2,576
FITEM,2,608
FITEM,2,598
AL,P51X
```

```
FLST,5,3,5,ORDE,2
FITEM,5,289
FITEM,5,-291
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,      20, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,3,5,ORDE,2
FITEM,5,289
FITEM,5,-291
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*

LPLOT
/UI,MESH,OFF
/AUTO, 1
/REP
/ZOOM,1,RECT,-0.168310,-0.870647,0.673944,-0.251083

/COM,
/COM,           CREATE DRIFT AREA AND MESH
/COM,

FLST,2,7,4
FITEM,2,564
FITEM,2,566
FITEM,2,602
FITEM,2,573
FITEM,2,572
FITEM,2,570
FITEM,2,569
AL,P51X
/AUTO, 1
/REP

APLOT
LPLOT

FLST,2,7,4
FITEM,2,604
FITEM,2,603
FITEM,2,602
FITEM,2,567
FITEM,2,606
FITEM,2,607
FITEM,2,590
AL,P51X

APLOT
/UI,MESH,OFF
FLST,5,2,5,ORDE,2
FITEM,5,292
FITEM,5,-293
```

```
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,      21, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
APLOT
/ZOOM,1,RECT,0.544366,-0.479195,0.789437,-0.208840
/ZOOM,  1,  1.3750    , 0.00000E+00, 0.00000E+00,  6.4871
/ZOOM,1,RECT,0.507747,-0.510173,1.116197,0.728954

asel,,mat,,21
APLOT
/AUTO, 1
/REP
FLST,5,2,5,ORDE,2
FITEM,5,292
FITEM,5,-293
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*
FLST,5,2,5,ORDE,2
FITEM,5,292
FITEM,5,-293
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*

/UI,MESH,OFF
allsel
VSEL,ALL
ASEL,ALL
LSEL,ALL
KSEL,ALL
ESEL,ALL
NSEL,ALL
APLOT
EPLOT
LPLOT

/COM,
/COM,           CREATE DRIFT AIR SPACE AREA AND MESH
/COM,

FLST,2,4,4
FITEM,2,585
FITEM,2,576
FITEM,2,577
FITEM,2,604
AL,P51X
CM,_Y,AREA
ASEL, , , ,     294
CM,_Y1,AREA
```

```
CMSEL,S,_Y
!*
CMSEL,S,_Y1
AATT,       8, ,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
APLOT

CM,_Y,AREA
ASEL, , , ,     294
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
!*
AMESH,_Y1
!*
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
!*
EPLOT
/UI,MESH,OFF


/COM,
/COM,   APPLY RADIATION ELEMENTS FOR DRIFT AND DRIP SHIELD
/COM,

/ZOOM,1,RECT,-0.176761,-0.467930,0.324648,0.100942
CM,_Y,LINE
LSEL, , , ,     569
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,      21, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
LMESH,     569
CM,_Y,LINE
LSEL, , , ,     601
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,      15, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
LMESH,     601
CM,_Y,LINE
LSEL, , , ,       4
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,       3, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
LMESH,       4

/ZOOM,  1,  1.3740    , 0.00000E+00, 0.00000E+00,  6.4846
```

```
/ZOOM,1,RECT,-0.238732,-0.039868,0.307747,0.419172
CM,_Y,LINE
LSEL, , , ,       5
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,       3, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
LMESH,       5
CM,_Y,LINE
LSEL, , , ,     610
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,      15, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
LMESH,     610

/ZOOM,  1,  1.3740    , 0.00000E+00, 0.00000E+00,  6.4846
/ZOOM,1,RECT,0.775352,0.385377,-0.207746,0.951433
FLST,5,2,4,ORDE,2
FITEM,5,576
FITEM,5,-577
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,      20, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,2,2,4,ORDE,2
FITEM,2,576
FITEM,2,-577
LMESH,P51X
CM,_Y,LINE
LSEL, , , ,     604
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,      21, ,   7,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
LMESH,     604
/AUTO, 1
/REP
EPLOT
SAVE
/COM, ************************************************************************
/COM,           delete WP internals and create homogenous material
/COM,
ASEL,S,MAT,,7
ASEL,A,MAT,,3
ASEL,A,MAT,,14
ASEL,A,MAT,,18
ASEL,A,MAT,,19
```

```
ASEL,A,MAT,,15
ASEL,U, , ,     287
ASEL,U, , ,     288
FLST,5,2,5,ORDE,2
FITEM,5,1
FITEM,5,-2
ASEL,U, , ,P51X
ACLEAR,ALL
ADELE,ALL,,,1
ALLSEL
/COM,
K,2020,DCIRD,0,0
K,2021,0,DCIRD,0
K,2022,0,-DCIRD,0
L,2020,8
L,2021,9
L,2022,7
L,1,2020
L,1,2021
L,1,2022
LARC,2021,2020,1,              DCIRD
LARC,2020,2022,1,              DCIRD
AL,11,16,10,8,9
AL,12,17,10,7,6
AL,14,13,16
AL,15,13,17
/COM,
FLST,5,2,4,ORDE,2
FITEM,5,16
FITEM,5,-17
LSEL, , , ,P51X
LESIZE,ALL, , ,80,,
/COM,
FLST,5,3,4,ORDE,2
FITEM,5,13
FITEM,5,-15
LSEL, , , ,P51X
LESIZE,ALL, , ,16,0.25,
/COM,
MOPT,AMESH,DEFA
MOPT,VMESH,DEFA
MOPT,TIMP,1
MOPT,PYRA,ON
MSHKEY,0
MSHMID,0
MSHPATTERN,0
KEYW,ACCEPT,0
!*
MSHA,0,2D
MSHA,1,3D
/COM,                    WP internal
MAT,25
TYPE,1
AMESH,5,6
ALLSEL
/COM,
MOPT,AMESH,DEFA
MOPT,VMESH,DEFA
MOPT,TIMP,1
MOPT,PYRA,ON
MSHKEY,1
MSHMID,0
MSHPATTERN,0
KEYW,ACCEPT,0
!*
MSHA,0,2D
MSHA,0,3D
/COM,                       inner barrier
LCCAT,8,9
LCCAT,7,6
```

```
MAT,15
TYPE,1
AMESH,3,4
LDELE,18,19,1
ALLSEL
/COM,   ***********************************************************************
/COM,           Create element mesh plots to illustrate model
/COM,           View mesh for entire model
/RESET
/TRIAD,OFF,
/NUM, 1,
/PNUM,MAT, 1,
/TYPE,HIDP,
/GLINE,,0,
/FOCUS,1,(WPRAD/10.0),0.0,0.0,0,
/TITLE, 21 PWR Low Drip Shield with air gap - 1/2 FEM Model
/SHOW,meshfull,grph,1,8,
EPLOT
ESEL,U,MAT,, 7,
/SHOW,meshgap,grph,1,8,
EPLOT
/COM,           View mesh for radiation substructure
/PNUM,MAT, 0,
/PNUM,TYPE, 1,
ESEL,S,TYPE,,7,
/TITLE, 21 PWR Waste Package and Low Drip Shield - Radiation Matrix
/SHOW,meshrad,grph,1,8,
EPLOT
ESEL,ALL,
/TITLE, 21 PWR WP and Low Drip Shield with 10 yr old, 48 GWD/MTU SNF
/COM,   ***********************************************************************
/COM,           Generate super-elements
/AUX12,
ESEL,S,TYPE,,7,
NSLE,S,
STEF,5.67E-8,
GEOM,1,0,
EMIS,3,0.8
EMIS,18,0.07
EMIS,19,0.6
EMIS,15,0.87
EMIS,20,0.85
EMIS,21,0.88
VTYPE,0,800,
WRITE,spaces,
ESEL,ALL,
NSEL,ALL,
FINISH
/PREP7,
TYPE,18,
SE,spaces,
/COM,           Delete radiation edge elements
LSEL,S,TYPE,,7,
LCLEAR,ALL,
LSEL,ALL,
FINISH
/COM,   ***********************************************************************
/COM,           Set solution parameters and apply B.C.'s
/COM,
/COM,           Solve steady-state for initial conditions
/COM,           with WP surface temperatures from repository
/COM,           steady-state solution.
/SOLU
ANTYPE,TRAN,NEW,
NROPT,AUTO,
TRNOPT,FULL,
SOLCONTROL,ON,0
TOFFST,273.15,
DK,1012,TEMP,(W4TOP(TM_START+TMI100)),,1,
DK,2000,TEMP,(W4SID(TM_START+TMI100)),,1,
```

```
DK,1011,TEMP,(W4BOT(TM_START+TMI100)),,1,
ASEL,S,MAT,,25,
ESLA,S,
BFE,ALL,HGEN,,(FUEL(TM_START+TMI100)),
ASEL,ALL,
ESEL,ALL,
TIMINT,OFF,
TIME,1e-6,
AUTOTS,ON,
KBC,0,
SOLVE
/COM,   ***************************************************************
/COM,           Set time integration parameters
TIMINT,ON,
AUTOTS,ON,
/COM,           Time substep ranges from 10 sec to 1/4 loadstep
NSUBST,10,40,5,ON
/COM,           Begin Transient
/COM,           Apply loads and solve for 100 to 190 years
*DO,TM,TM_START,TME90,TMI10
        TIME,TM,
        ASEL,S,MAT,,25,
        ESLA,S,
        BFE,ALL,HGEN,,(FUEL(TM+TMI100)),
        ASEL,ALL
        ESEL,ALL
        DK,1012,TEMP,(W4TOP(TM+TMI100)),,1,
        DK,2000,TEMP,(W4SID(TM+TMI100)),,1,
        DK,1011,TEMP,(W4BOT(TM+TMI100)),,1,
        SOLVE
*ENDDO


/COM,           Apply loads and solve for 200 to 1000 years
*DO,TM,TME100,TME500,TMI100
        TIME,TM,
        ASEL,S,MAT,,25,
        ESLA,S,
        BFE,ALL,HGEN,,(FUEL(TM+TMI100)),
        ASEL,ALL
        ESEL,ALL
        DK,1012,TEMP,(W4TOP(TM+TMI100)),,1,
        DK,2000,TEMP,(W4SID(TM+TMI100)),,1,
        DK,1011,TEMP,(W4BOT(TM+TMI100)),,1,
        SOLVE
*ENDDO
FINISH
SAVE
/COM,   ***************************************************************
/COM,           Create element contour plots of solution results
/COM,
/COM,           Sort through solution results for time of max temp.
/POST26,
NSOL,2,(NODE(0.0,0.0,0.0)),TEMP,,peakclad,
STORE,NEW,
*GET,TMTMAX,VARI,2,EXTREM,TMAX,
FINISH
/POST1,
/COM,           Create temperature contour plots of WP at peak
/RESET
/TRIAD,OFF,
/NUM, 1,
/PNUM,MAT, 1,
/TYPE,HIDP,
/GLINE,,-1,
/FOCUS,1,(WPRAD/10.0),0.0,0.0,0,

SET,NEAR,,,,TMTMAX,
/TITLE, 21 PWR WP/Low Drip Shield at Time of Peak Temp. (%TMTMAX/3.15576E7% years)
/SHOW,solupk,grph,0,8,
```

```
/CONTOUR,1,128,AUTO,
PLNSOL,TEMP,
/COM,           Create temperature contour plots at 100, 150, and 500 yrs
SET,NEAR,,,,TME100,
/TITLE, 21 PWR WP/Low Drip Shield at 100 years
/SHOW,solu10,grph,0,8,
/CONTOUR,1,128,USER,
PLNSOL,TEMP,
SET,NEAR,,,,TME150,
/TITLE, 21 PWR WP/Low Drip Shield at 150 years
/SHOW,solu50,grph,0,8,
/CONTOUR,1,128,USER,
PLNSOL,TEMP,
SET,NEAR,,,,TME500,
/TITLE, 21 PWR WP/Low Drip Shield at 500 years
/SHOW,solu100,grph,0,8,
/CONTOUR,1,128,USER,
PLNSOL,TEMP,
ESEL,ALL,
FINISH
CSYS,0,
/COM,   ***************************************************************
/COM,           Print time/temperature output at specific locations
/COM,           Save profile from center to edge
/COM,
/COM,           Variable Legend: A01i000
/COM,                c = center of WP
/COM,                i = inner barrier of WP
/COM,                o = outer barrier of WP
/COM,                d = drip shield
/COM,                b = bottom of invert
/COM,                w = drift wall
/COM,                f = back fill
/COM,                    ## = ID number of assembly (01 is center)
/COM,                         i = side of assembly toward center of WP
/COM,                         o = side of assembly toward edge of drift
/COM,                              000 = profile center down
/COM,                              045 = profile 45 deg down
/COM,                              090 = profile center side
/COM,                              135 = profile 45 deg up
/COM,                              180 = profile center up
/POST26,
NUMVAR,30,
/COM,
/COM,   ***************************************************************
/COM,   *   Temperature Profile from center to bottom of WP (0 deg.)   *
/COM,   ***************************************************************
NSOL, 2,(NODE(0.0,                                          0.0,0.0)),TEMP,,c01i000,
NSOL, 3,(NODE(0.0,                                   -0.7206028,0.0)),TEMP,,i01i000,
NSOL, 4,(NODE(0.0,                                   -0.7406028,0.0)),TEMP,,i01o000,
NSOL, 5,(NODE(0.0,                                   -0.8406028,0.0)),TEMP,,o01o000,
NSOL, 6,(NODE(0.0,                                    -1.230203,0.0)),TEMP,,b01i000,
NSOL, 7,(NODE(0.0,                                    -1.772203,0.0)),TEMP,,b01o000,
NSOL, 8,(NODE(0.0,                                    -2.550000,0.0)),TEMP,,w01i000,
NSOL, 9,(NODE(0.0,                                    -2.750000,0.0)),TEMP,,w03o000,
PRVAR, 2, 3, 4, 5, 6, 7,
PRVAR, 8, 9,
/COM,
/COM,   ***************************************************************
/COM,   *   Temperature Profile from center to bottom of WP (90 deg.)   *
/COM,   ***************************************************************
NSOL, 2,(NODE(0.0,                                          0.0,0.0)),TEMP,,c01i090,
NSOL, 3,(NODE(0.7206028,                                    0.0,0.0)),TEMP,,i01i090,
NSOL, 4,(NODE(0.7406028,                                    0.0,0.0)),TEMP,,i01o090,
NSOL, 5,(NODE(0.8406028,                                    0.0,0.0)),TEMP,,o01o090,
NSOL, 6,(NODE(1.050000,                                     0.0,0.0)),TEMP,,d01i090,
NSOL, 7,(NODE(1.070000,                                     0.0,0.0)),TEMP,,d01o090,
NSOL, 8,(NODE(2.550000,                                     0.0,0.0)),TEMP,,w01i090,
NSOL, 9,(NODE(2.750000,                                     0.0,0.0)),TEMP,,w01o090,
PRVAR, 2, 3, 4, 5, 6, 7,
```

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PRVAR, 8, 9,
/COM,
/COM,   ***************************************************************
/COM,   *   Temperature Profile from center to bottom of WP (180 deg.)   *
/COM,   ***************************************************************
NSOL, 2,(NODE(0.0,                                              0.0,0.0)),TEMP,,c01i180,
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NSOL, 4,(NODE(0.0,                                          0.7406028,0.0)),TEMP,,i01o180,
NSOL, 5,(NODE(0.0,                                          0.8406028,0.0)),TEMP,,o01o180,
NSOL, 6,(NODE(0.0,                                           1.050000,0.0)),TEMP,,d01i180,
NSOL, 7,(NODE(0.0,                                           1.070000,0.0)),TEMP,,d01o180,
NSOL, 8,(NODE(0.0,                                           1.670000,0.0)),TEMP,,f01o000,
NSOL, 9,(NODE(0.0,                                           2.550000,0.0)),TEMP,,w01i000,
NSOL,10,(NODE(0.0,                                           2.750000,0.0)),TEMP,,w01o000,
PRVAR, 2, 3, 4, 5, 6, 7,
PRVAR, 8, 9,10,
/COM,
/COM,   ***************************************************************
/COM,   *   bottom end of the drip shield              *
/COM,   ***************************************************************
NSOL, 2,(NODE(1.0500000,                                    -1.230203,0.0)),TEMP,,d02i000,
NSOL, 3,(NODE(1.0700000,                                    -1.230203,0.0)),TEMP,,d02o000,
PRVAR, 2, 3,
FINISH
/COM,   ***************************************************************
/COM,           End of batch input file
/COM,   ***************************************************************
/EXIT,
/EOF
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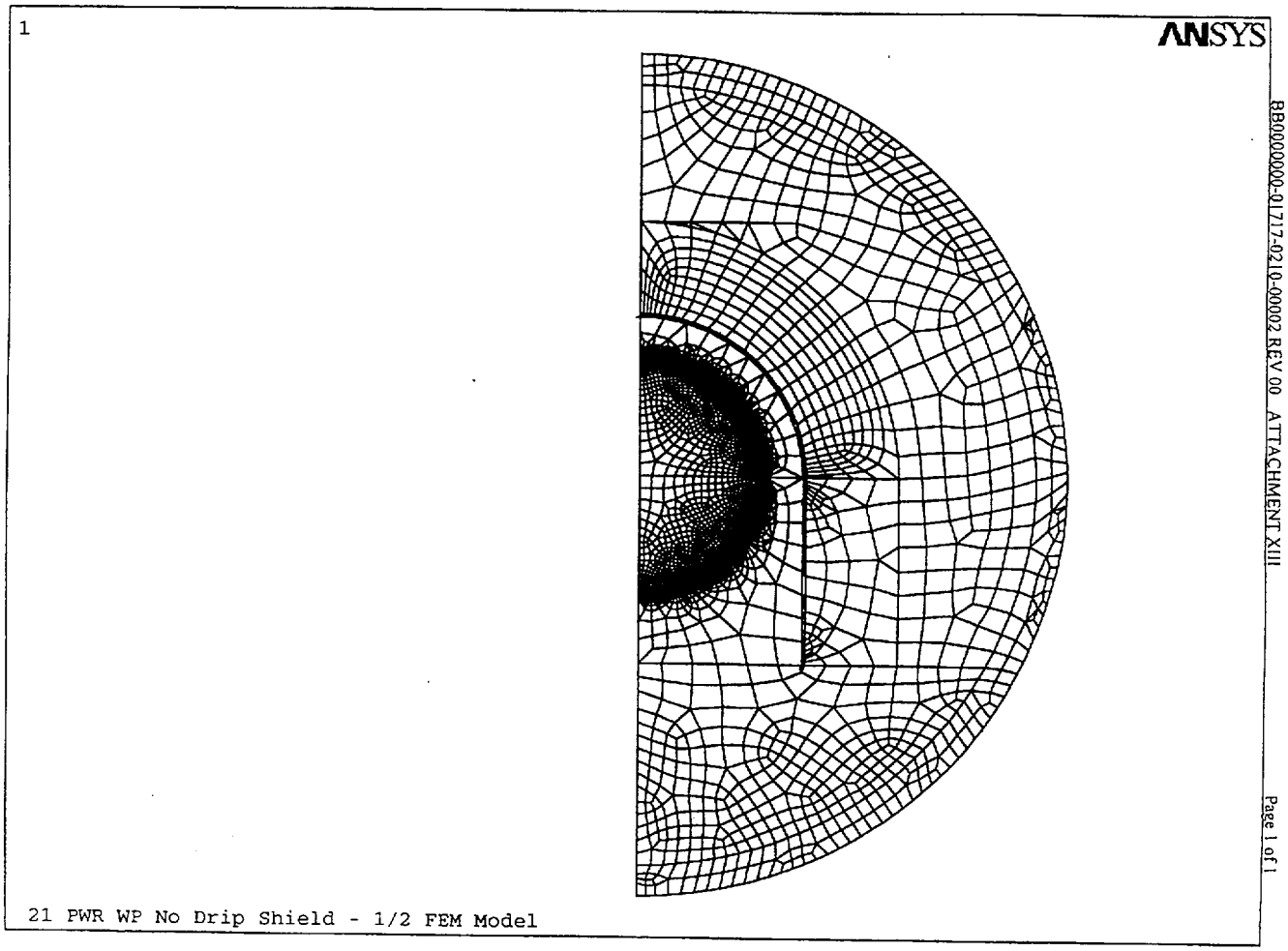
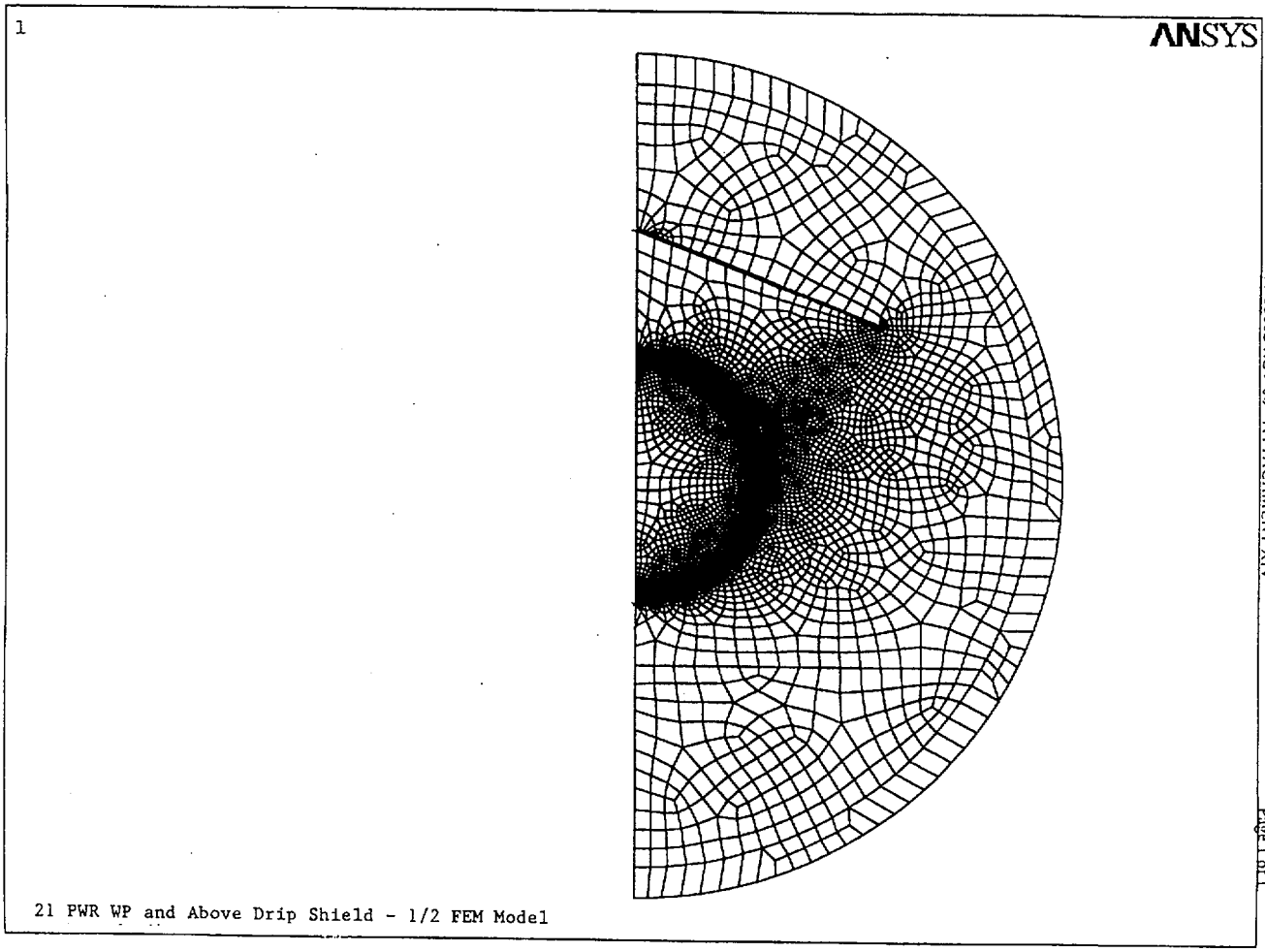
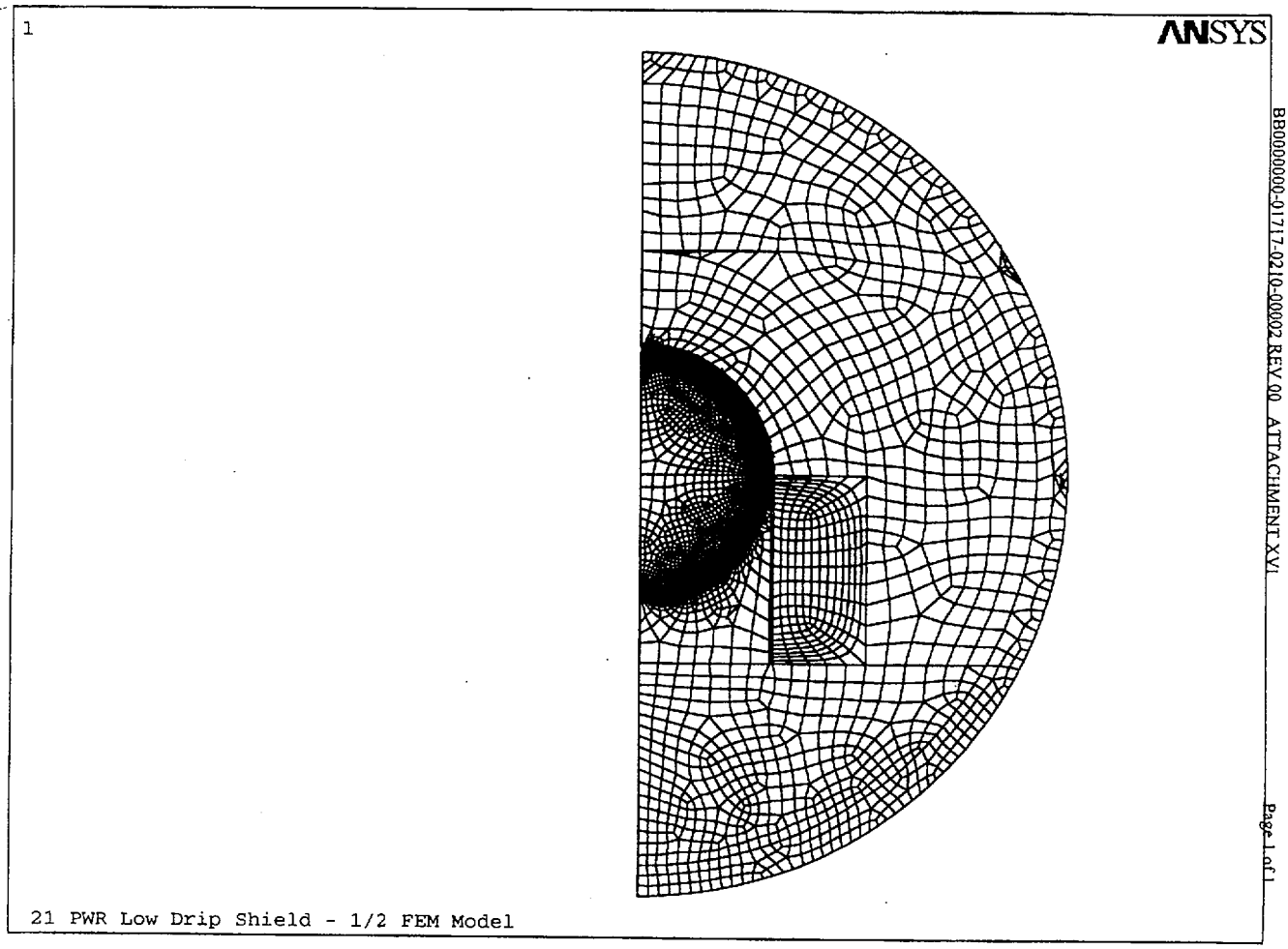

1
ANSYS
21 PWR WP No Drip Shield - 1/2 FEM Model

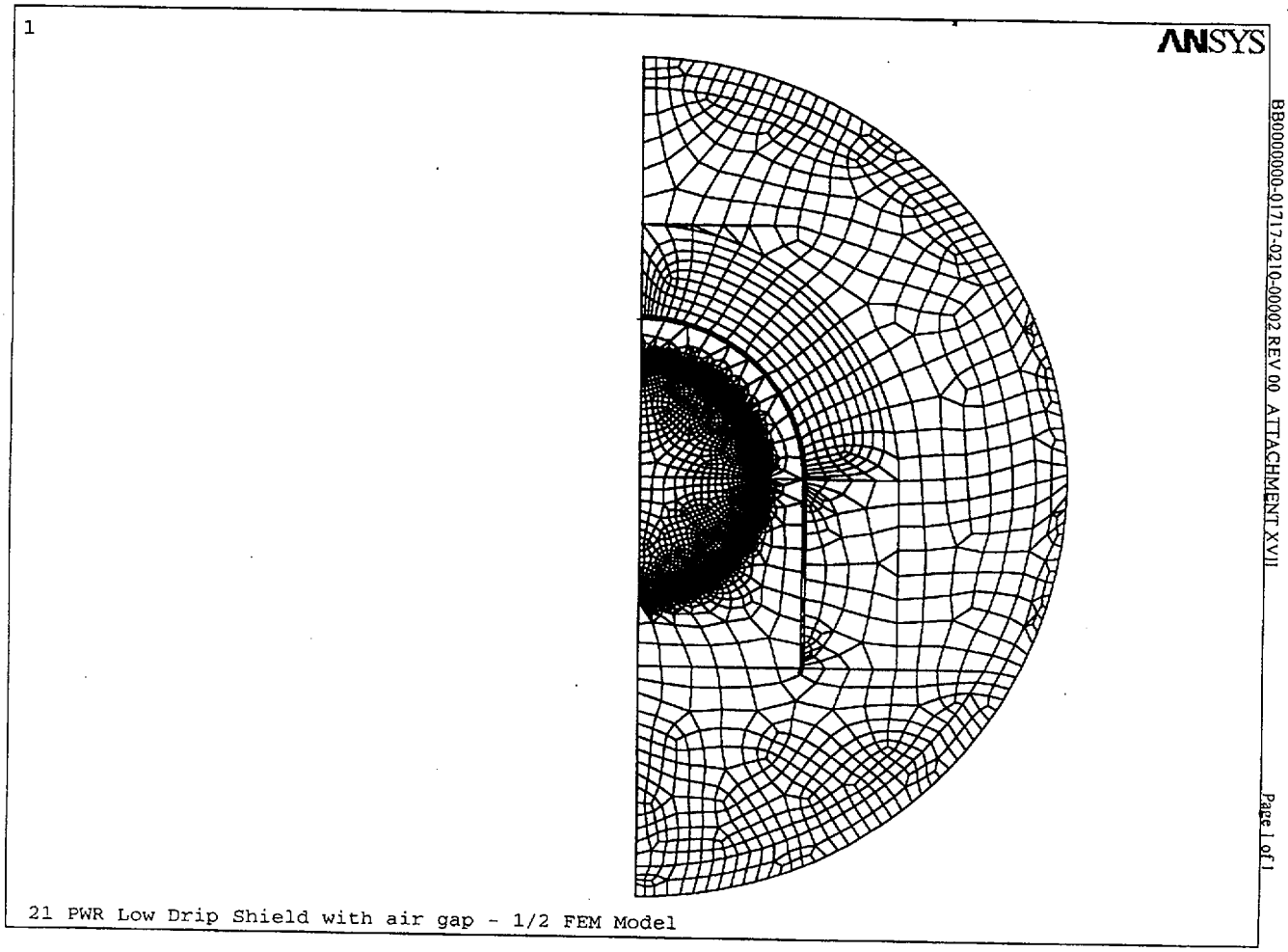


21 PWR WP and Above Drip Shield - 1/2 FEM Model

This attachment contains a list of the ANSYS output files for the *Thermal Calculation of the Waste Package with Drip Shield.* The output files are contained on a tape of this calculation (Reference 7.22). The file sizes listed in the following table are the file sizes as they appear on the Hewlett Packard (HP) Series 9000 workstation.

File Name	File Type	File Size (bytes)	Date File Copied to Tape
Nodrsh-o.out	ASCII	716437	2/21/99
Abvdrsh-.out	ASCII	1597795	2/21/99
Drshcon-.out	ASCII	764106	2/21/99
Dslwag-o.out	ASCII	748426	2/21/99


1
ANSYS
21 PWR Low Drip Shield - 1/2 FEM Model


1
ANSYS
21 PWR Low Drip Shield with air gap - 1/2 FEM Model

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