SARGENT & LUNDY CALCULATION 2013-11284, REVISION 0

MAXIMUM CLADDING AND FUEL TEMPERATURE ANALYSIS FOR UNCOVERED SPENT FUEL POOL

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1. PURPOSE AND EXECUTIVE SUMMARY

1.1 Purpose

The purpose of this calculation is to evaluate the effects of a complete loss of water inventory from the spent fuel pools (SFPs) on or after October 30, 2014. Specifically, this calculation determines whether or not the zirconium cladding will remain below the critical temperature of the cladding (defined in the acceptance criteria section below). This analysis is recommended by SECY-99-168 [Ref. 2.28].

1.2 Scope

The analysis described in Section 1.1 requires two major steps. First, maximum quasi steady-state air temperatures throughout the Fuel Handling Area (FHA), including the space between the storage racks and the concrete walls of the SFPs, are determined following a complete loss of water inventory from the SFPs. The maximum air temperature between the storage racks and the SFP walls is then used in the second step, the calculation of the maximum temperature of the zirconium cladding.

Two different sets of conditions are evaluated in the analysis. The first set corresponds to October 30, 2014, which was found through iteration to be the earliest date that acceptably low fuel cladding temperatures are produced. The second set corresponds to the following summer and is evaluated to demonstrate that when the summer of 2015 arrives, the spent fuel will have decayed enough to offset increasing outside temperatures and solar radiation. Winter conditions are not evaluated for two reasons. First, fall and summer conditions are bounding when determining maximum fuel cladding temperature. Second, as no liquid water is credited in the analysis, the threat of freezing water in the SFPs or the SFP cooling system is not a concern for this analysis.

Acceptance Criteria: The zirconium cladding must remain below the critical temperature of the cladding. Per NUREG/CR-6451 [Ref. 2.1, see Input 4.3], 565°C (1049°F) is the lowest temperature where incipient cladding failure might occur with an expected failure at 671°C (1240°F). Per SECY-99-168 [Ref. 2.28], 800°C (1472°F) is the lowest temperature where self-sustained oxidation would occur and 565°C is the minimum temperature where clad swelling might occur. NUREG-1738 [Ref. 2.5, pg. 3-7] states that runaway oxidation of zirconium occurs at 900°C and 565°C is associated with the 10 hour creep rupture time. For this analysis, 565°C (1049°F) is conservatively used as the critical temperature for the zirconium cladding.

1.3 Executive Summary

The results of this analysis, which are summarized in the table below, show that the surface temperature of the cladding in the spent fuel pools will not exceed the critical temperature for zirconium following a total loss of water from the pools on or after October 30, 2014. The cladding remains below the critical temperature due to adequate FHA ventilation and heat rejection to the outside through the FHA walls and roof.

Case	Maximum Cladding Temperature
October 30, 2014	1022°F / 550°C
May 2015	876°F / 469°C

2. REFERENCES

2.1 NUREG/CR-6451, "A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown Nuclear Power Plants," April 1997.

2.2 Computer Programs and User Manuals

2.2.1 GOTHIC Version 8.0(QA), Numerical Applications Inc., S&L Program No. 03.7.759-8.0.

2.2.2 NAI 8907-02, "GOTHIC Thermal Hydraulic Analysis Package User Manual," Rev. 20.

2.2.3 COBRA-SFS Version 1.0, Pacific Northwest Laboratory, S&L Program No. 03.7.672-1.0.

2.2.4 Document No. PNL-10782, "COBRA-SFS: A Thermal-Hydraulic Analysis Code for Spent Fuel Storage And Transportation Casks," Prepared for the US DOE by Pacific Northwest Laboratory, September 1995.

2.2.5 UHSSIM Version 1.0, S&L Program No. 03.7.870-1.0.

2.3 Kreith, Frank, Principles of Heat Transfer, Third Edition, Intext Press, Inc., 1973.

2.4 Sonntag, Borgnakke, Van Wylen, Fundamentals of Thermodynamics, Sixth Edition, John Wiley & Sons, Inc., 2003.

2.5 NUREG-1738, "Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants," February 2001.

2.6 Incropera & DeWitt, Fundamentals of Heat and Mass Transfer, Fifth Edition, John Wiley & Sons, Inc., 2002.

2.7 Holtec Report HI-992208

2.8 Docket No. 50-305, "Safety Evaluation by The Office of Nuclear Regulation Relating to the Modification of the Spent Fuel Storage Pool, Kewaunee Nuclear Power Plant," December 1, 1978.

2.9 Structural Drawings

2.9.1 Drawing No. M-234, "General Arrangement Spent Fuel Pool & New Fuel Storage," Rev. V.

2.9.2 Drawing No. M-235, "General Arrangement Spent Fuel Pool & New Fuel Storage," Rev. N.

2.9.3 Drawing No. S-410, "Fuel Handling Area Spent Fuel Pool Plan & Sections," Rev. V.

2.9.4 Drawing No. S-406, "Fuel Handling Area Spent Fuel Pool Sections & Details," Rev. W.

2.9.5 Drawing No. S-407, "Fuel Handling Area Spent Fuel Pool Sections & Details," Rev. U.

2.9.6 Drawing No. S-408, "Fuel Handling Area Spent Fuel Pool Sections & Details," Rev. AA.

2.9.7 Drawing No. S-409, "Fuel Handling Area Spent Fuel Pool Sections & Details," Rev. M.

2.9.8 Drawing No. S-415, "Spent Fuel Pool & Transfer Canal Liner," Rev. F.

2.9.9 Drawing No. S-413, Sheet 1, "Spent Fuel Pool & Transfer Canal Liner," Rev. H.

2.9.10 Drawing No. A-248, "Architectural Aux. Bldg. – Fuel Handling Area (606'-0")," Rev. L.

2.9.11 Drawing No. A-249, "Architectural Roof Plan," Rev. AB.

2.9.12 Drawing No. A-212, "General Arrangement Miscellaneous Plans and Sections," Rev. Z.

2.9.13 Drawing No. A-211, "General Arrangement Auxiliary and Turbine Building Cross Section," Rev. N.

2.9.14 Drawing No. A-210, "General Arrangement Reactor and Auxiliary Building Cross Section," Rev. Q.

2.9.15 Drawing No. A-208, "General Arrangement Reactor and Auxiliary Building," Rev. BX.

2.9.16 Drawing No. A-206, "General Arrangement Reactor and Auxiliary Building Mezzanine Floor," Rev. CC.

2.9.17 Drawing No. A-259, "Architectural Elevator Enclosure and Details," Rev. H.

2.9.18 Drawing No. XK-225-8, "Kewaunee Nuclear Power Plant – Unit #1 Fastening Schedules," Rev. 5.

2.9.19 Drawing No. XK-225-1, (Title Unreadable), Rev. 7.

2.9.20 Drawing No. XK-225-39, "Kewaunee Nuclear Power Plant – Unit #1 Partial North Elev – Fuel Handling," Rev. 8.

2.9.21 Drawing No. XK-225-40, "Kewaunee Nuclear Power Plant – Unit #1 North Elevation – Col 9 – Fuel Handling," Rev. 5.

2.9.22 Drawing No. XK-225-45, "Kewaunee Nuclear Power Plant Unit #1 West Elevation Fuel Handling Area," Rev. 4.

2.9.23 Drawing No. XK-225-47, "Kewaunee Nuclear Power Plant Unit #1 South Elev Col '6' – Fuel Handling Area," Rev. 4.

2.10 HVAC Drawings

2.10.1 Drawing No. M-626, "Ventilation – Aux. Bldg. Elevation 649'-6"," Rev. B.

2.11 Electrical Drawings

See Section 2 of Attachment 10

2.12 Marks' Standard Handbook for Mechanical Engineers, Eleventh Edition, The McGraw-Hill Companies, Inc., 2007.

2.13 ASHRAE Handbook of Fundamentals, I-P Edition, 2009.

2.14 ASHRAE Handbook of Fundamentals, I-P Edition, 1993.

2.15 Kewaunee Power Station USAR, Rev. 24.03.

2.15.1 Table 3.2-8 "Fuel Assembly and Component Descriptions."

2.15.2 Section 3.2 "Reactor Design."

2.15.3 Section 2.2 "Location"

2.16 NUREG-1754, "A New Comparative Analysis of LWR Fuel Designs," December 2001.

2.17 ETE-NAF-2013-0077, "Information for Kewaunee Spent Fuel Pool Postulated Loss of Inventory Calculation," July 10, 2013. (Included as Attachment 17)

2.18 Drawing KW-DWG-000-S-708, "Spent Fuel Pool Arrangement and Support Frame Assembly," Rev. D.

2.19 APS Materials, Inc., "Boron Carbide," http://www.apsmaterials.com/common/projects_cur.htm. (Included in Attachment 19)

2.20 ETE-NAF-2013-0119, Rev. 0, "Kewaunee Spent Fuel Pool Fuel Assembly Information for Spent Fuel Pool Postulated Loss of Inventory Calculation," October 24, 2013. (Included as Attachment 18)

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2.22 Crane Technical Paper No. 410, "Flow of Fluids Through Valves, Fittings, and Pipe," Crane Co., March 2006 printing.

2.23 ETE-KW-2013-0025, Rev. 0, "Ventilation Flow Rate Input for S&L Calc 2013-11284 'Maximum Cladding and Fuel Temperature Analysis for Uncovered Spent Fuel Pool.'" (Included as Attachment 16)

2.24 Kewaunee Project Design Manual, Section 4, Acct. No. 321.262, Sheet Nos. 2 & 6.

2.25 Siegel & Howell, Thermal Radiation Heat Transfer, Fourth Edition, Taylor & Francis, 2002.

2.26 Glasstone and Sesonske, Nuclear Reactor Engineering, Van Nostrand Reinhold Company, 1967.

2.27 NUREG-0800, Section 6.2.1.5, Rev. 2, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," July 1981.

2.28 SECY-99-168, "Improving Decommissioning Regulations for Nuclear Power Plants," June 30, 1999.

2.29 J. P. Holman, Heat Transfer, Seventh Edition, McGraw-Hill, Inc., 1990.

2.30 Ed. C. C. Heald, Cameron Hydraulic Data, Eighteenth Edition, Ingersoll-Dresser Pumps, 1998.

2.31 Roberson, John A. and Clayton T. Crowe, Engineering Fluid Mechanics, Houghton Mifflin Co., 1975. (Relevant pages included in Attachment 20)

2.32 S&L Calculation No. 2013-07050, "Maximum Cladding Temperature Analysis for an Uncovered Spent Fuel Pool with no Air Cooling," Rev. 2.

2.33 Correspondence from J. G. Lamb (NRC) to T. Contu (Kewaunee), "Kewaunee Nuclear Power Plant – Issuance of Amendment (TAC No. MB5718)", April 4, 2003, Adams Accession No. ML030940276.

2.34 ETE-NAF-2013-0130, Rev. 0, "Fuel Assembly Peak Pin Factor for Kewaunee Spent Fuel Pool Loss of Inventory Calculation," Nov. 6, 2013. (Included as Attachment 21)

2.35 ETE-NAF-2012-0054, Rev. 0, "Kewaunee Cycle 32 Nuclear Design Report," April 9, 2012.

2.36 NUREG/CR-6801, "Recommendations for Addressing Axial Burnup in PWR Burnup Credit Analyses," March 2003.

3. METHODOLOGY

As discussed in Section 1.2, this analysis is performed in two major steps. First, maximum quasi steady-state air temperatures throughout the Fuel Handling Area (FHA), including the space between the storage racks and the SFP walls (i.e., the "downcomers"), are determined following a complete loss of water inventory from the SFPs. This step is performed using the GOTHIC computer program. The maximum air temperature in the downcomers is then used in the second step, which is to calculate the maximum steady-state temperature of the zirconium cladding. This step is performed using the COBRA computer program.

Two runs are performed. The first run uses predicted conditions on October 30, 2014, and the second run uses predicted conditions for the summer of 2015. The October date was selected because it was found through iteration that this is the earliest date that acceptably low fuel cladding temperatures are produced. The summer case is run to demonstrate that when the summer of 2015 arrives, the spent fuel will have decayed enough to offset increasing outside temperatures and solar radiation. The October case is run with a consistent set of conditions (i.e., spent fuel heat load, outside temperature, and solar radiation are all evaluated for October 30, 2014). In contrast, the summer case is run with an inconsistent set of conditions that are selected to be conservative. Specifically, spent fuel heat load is evaluated for May 18, 2015, outside temperature is evaluated for July (the region's hottest month), and solar radiation is evaluated for June 21 (the summer solstice). Because this case uses the spent fuel heat load corresponding to May 18, 2015, this case is henceforth referred to as the May 2015 case. Winter conditions are not evaluated for two reasons. First, fall and summer conditions are bounding when determining maximum fuel cladding temperature. Second, as no liquid water is credited in the analysis, the threat of freezing water in the SFPs or the SFP cooling system is not a concern for this analysis. Therefore winter conditions are acceptable.

3.1 Determining FHA Air Temperature

Maximum quasi steady-state FHA air temperatures are determined using GOTHIC [Ref. 2.2.1]. GOTHIC (Generation of Thermal-Hydraulic Information for Containments) is a general purpose thermal-hydraulics software package for the analysis of nuclear power plant containments, confinement buildings, and system components. Refer to Section 6.1 for a description of the GOTHIC software package. Development of the GOTHIC model is documented in the proceeding subsections, and GOTHIC input tables are provided in Attachment 1.

3.1.1 Control Volumes

Three control volumes are included in the GOTHIC model. Two of these control volumes represent the FHA, dimensioned sketches of which are provided in Section 4.1, and one of the control volumes represents the outside environment. Both FHA control volumes are subdivided, meaning that dimensions in the x, y, and z directions are supplied and a mesh grid is overlaid to subdivide the control volume into subvolumes. The main advantage of using subdivided volumes is that spatial temperature variations and flow patterns are captured. The second advantage of using subdivided volumes is that GOTHIC automatically calculates the pertinent parameters (volume, hydraulic diameter, flow area, etc.) using the dimensions supplied by the user. Thus, these parameters are not calculated herein.

The first control volume (CV1) represents both spent fuel pools and the air above them extending to the ceiling. This control volume is wholly contained within CV2, which represents the entire FHA (see below). The reason for modeling the pools and the air above them separately in CV1 is so that a fine mesh grid can be applied to this region and a coarse mesh grid can be applied to the rest of the building. The finer mesh grid provides a higher degree of spatial resolution in the area of most

interest, and the coarser mesh grid reduces run-time. The dimensions of CV1 are assigned as shown in the sketch below based on Input 4.1. The mesh grid applied to CV1 is also shown in the sketch. The grid lines are positioned to provide (i) a line of 1-ft-wide cells around the perimeter of the pits and along the floor, and (ii) a layer of cells above the 1-ft-high bottom layer that is 159.775 inches high. The perimeter cells simulate the gap between the storage racks and the pit walls and floors. The width of this gap varies throughout the pools and is actually less than 1 ft, but it was found that the downcomer temperatures computed by GOTHIC are insensitive to the width of the gap and that a wider gap gives improved model performance (i.e., shorter run times). The layer of cells above the gap is assigned a height of 159.775 inches to correspond to the fuel rod length (Input 4.2).

The dark grey areas denote non-porous blockages that simulate the walls of the pools. Because these blockages are non-porous, flow is not permitted through them. The light grey areas denote semi-porous blockages that are used to account for the volume occupied by equipment (pedestals, racks, etc.). Input 4.13 gives that the volume occupied by equipment is 1,714 ft^3 in the north pit and 3,245 ft^3 in the south pit. The volume reduction is appropriately applied to the 159.775-inch-high layer of cells, excluding the cells along the perimeter and the southwest quadrant of the north pit, which does not contain any equipment. These volume reductions do not impede flow in the model. Flow restrictions due to equipment in the pools are discussed in Section 3.1.1.2.

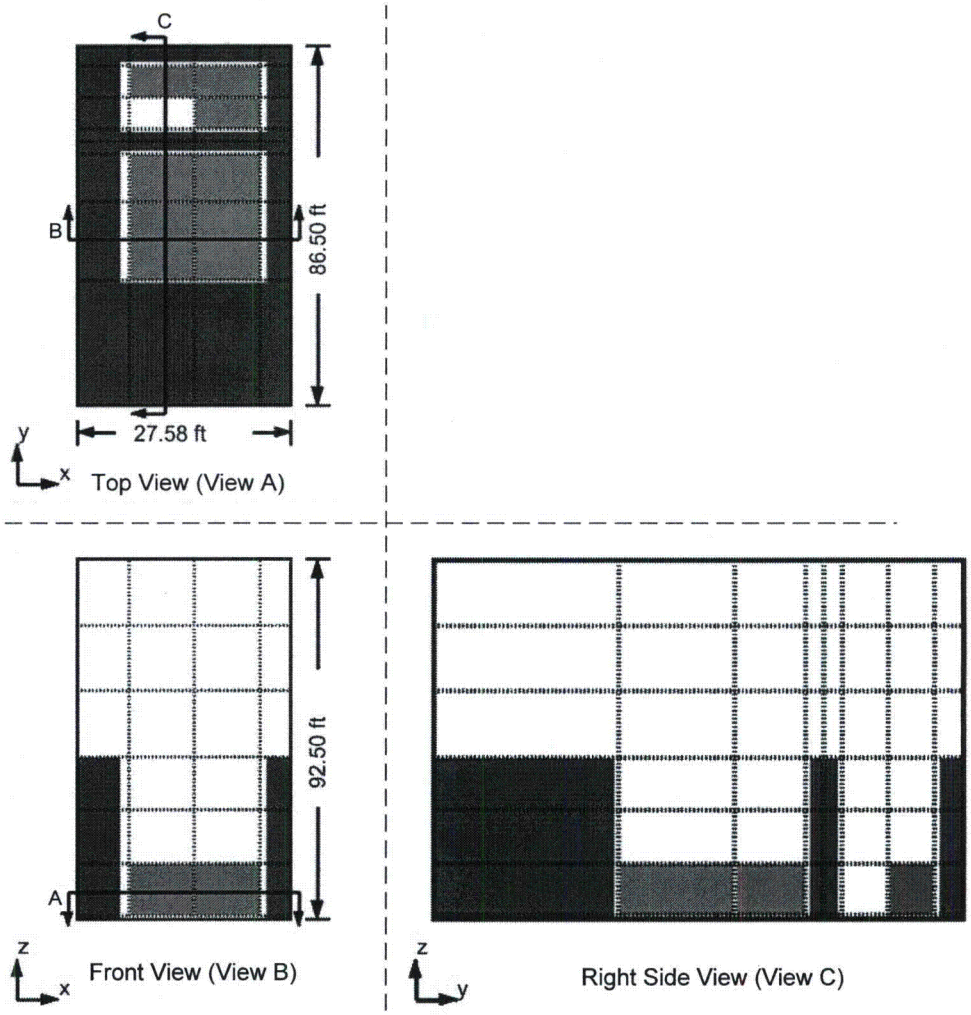

Figure 3.1: Sketch of CV1 Showing Dimensions, Mesh Grid, and Blockages (N.T.S.)

The second control volume (CV2) represents the remainder of the FHA. The dimensions of CV2 are assigned as shown in the sketch below based on Input 4.1. The mesh grid applied to CV2 is also shown in the sketch. As with CV1, the dark grey areas denote non-porous blockages. The area above the SFPs is blocked in this control volume since the region is modeled in CV1. See Section 3.1.1.1 for a discussion on how these control volumes are connected.

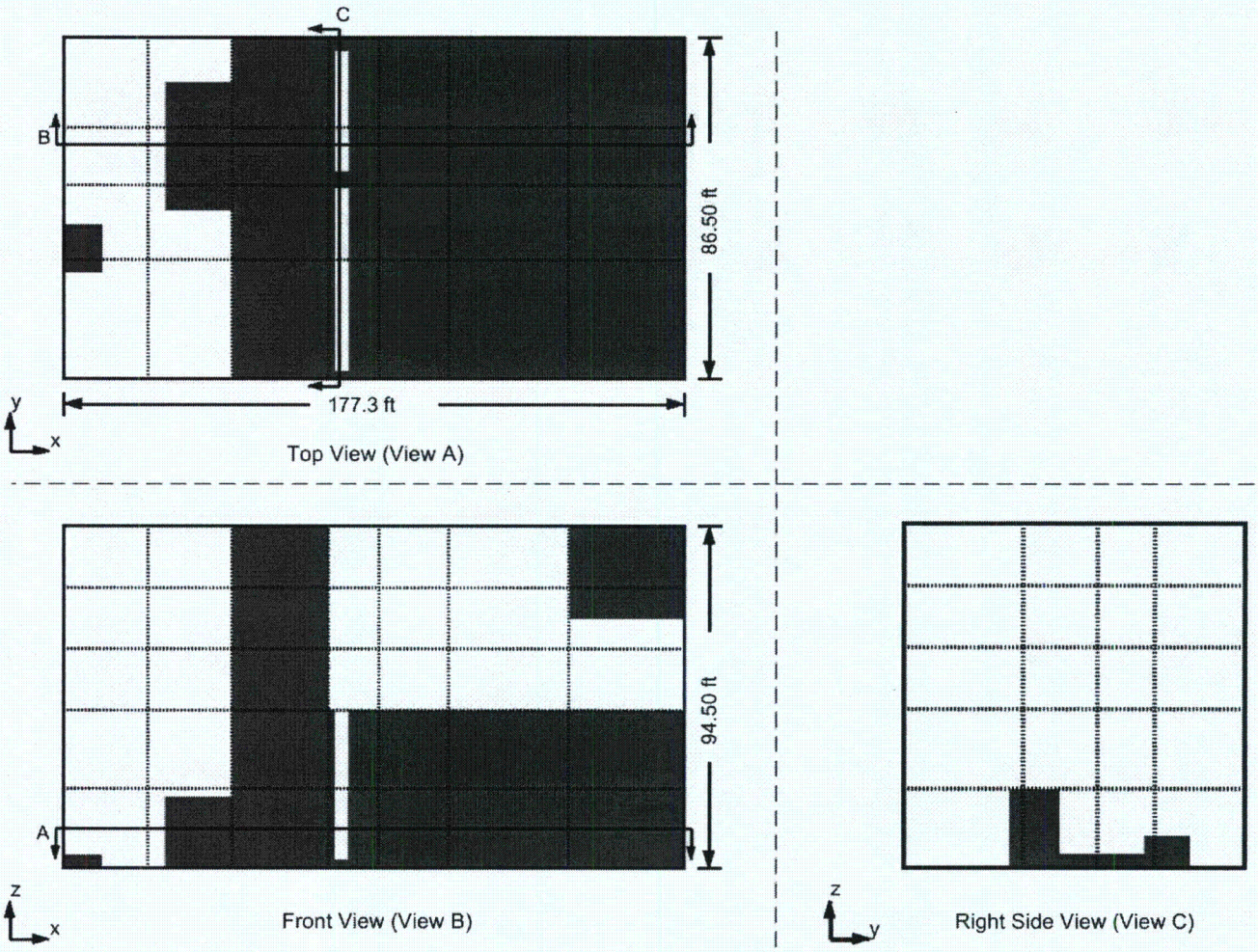

Figure 3.2: Sketch of CV2 Showing Dimensions, Mesh Grid, and Blockages (N.T.S.)

The third control volume (CV3) represents the outside air and serves as a boundary for the model with the temperature set per Section 3.1.5. The remaining parameters of this control volume are arbitrarily set so as to facilitate its function as a boundary node.

3.1.1.1 Connecting CV1 and CV2

As mentioned above, CV1 is wholly contained within CV2. Hydraulic connections between these two control volumes are accomplished using "3D connectors," as they are termed in GOTHIC. A 3D connector is different from a standard flow path in that its parameters (e.g., flow area, inertia length, hydraulic diameter, etc.) are automatically computed by GOTHIC by inheriting the properties of the connected cell faces. Two 3D connectors are used in total

in the GOTHIC model. The first 3D connector connects the west side of CV1 to the appropriate cells in CV2. The second 3D connector connects the east side of CV1 to the appropriate cells in CV2. GOTHIC then subdivides the 3D connectors so that flow through each cell face is computed separately, thus maintaining spatial discretization.

3.1.1.2 Modeling Rack Flow Restrictions

The default flow area, hydraulic diameter, and loss coefficient computed by GOTHIC for the 159.775-inch-high layer of cells (excluding the perimeter cells and the southwest quadrant of the north pit, which contains no equipment) are altered to account for the hydraulic restrictions imposed by the fuel racks. Specifically, (i) horizontal flow through these cells is prohibited by assigning an area porosity of zero to their x and y faces; (ii) vertical flow through these cells is restricted by assigning the area porosities computed below, a hydraulic diameter of 0.0472 ft, and a form loss coefficient of 39 to their z faces. The hydraulic diameter is taken from Attachment 7 and the form loss coefficient is taken from Section 3.2.8. Area porosity is computed as follows:

$$F = \frac{n_{filled} A_{filled} + n_{open} A_{open}}{A_{tot}} \qquad \textbf{Eq. 3.1-1}$$

where:

F = area porosity
n_{filled} = number of fuel storage cells that are filled with spent fuel
n_{open} = number of fuel storage cells that are empty
A_{filled} = flow area per filled storage cell = 0.288 ft^2 (Attachment 7)
A_{open} = flow area per empty storage cell = 8.3" x 8.3" (Input 4.2) = 0.478 ft^2
A_{tot} = total floor area covered by storage cells

North Pit Area Porosity

From ETE-NAF-2013-0119 [Ref. 2.20], there are a total of 270 storage cells in the north pit; 90 in the northwest quadrant, 90 in the northeast quadrant, and 90 in the southeast quadrant. Of these 270 storage cells, 53 are empty, and 51 of the 53 empty storage cells are in the northwest quadrant (see Attachment 12). Thus, the area porosities of the relatively empty northwest quadrant and the east two quadrants are computed separately, as follows:

Area Porosity of North Pit, Northwest Quadrant

$$F = \frac{(90-51)\cdot 0.288 + 51\cdot 0.478}{64.13^*} = 0.555$$

Area Porosity of North Pit, East Side (Northeast and Southeast Quadrants)

$$F = \frac{(180-2)\cdot 0.288 + 2\cdot 0.478}{128.26^*} = 0.407$$

* Values for A_{tot} are based on the dimensions of the appropriate cell(s) in the GOTHIC model. For example, the northwest quadrant of the north pit is modeled by cell 58 of Control Volume 1, which has dimensions 7.585 x 8.455 ft such that the footprint of the cell is 64.13 ft^2.

South Pit Area Porosity

From ETE-NAF-2013-0119 [Ref. 2.20], there are a total of 720 storage cells in the south pit. Of these 720 storage cells, 40 are empty (see Attachment 12). Thus, the area porosity of the south pit is computed as follows:

$$F = \frac{(720-40)\cdot 0.288 + 40\cdot 0.478}{515.76^{*}} = 0.417$$

* See above

3.1.1.3 Slip Conditions

By default, GOTHIC assumes that the boundaries of a subdivided volume are solid physical boundaries (i.e., a rough wall) and accordingly computes wall friction losses. This is appropriate for CV2, which is bounded on all four sides by walls, on top by the roof, and on the bottom by the floor. CV1, however, is wholly contained within CV2 and therefore is not bounded on all sides by solid physical boundaries. Specifically, the east and west vertical boundaries of CV1 above the operating floor are not physical boundaries but rather fictitious modeling boundaries. To account for this, the slip conditions of the east and west boundaries of CV1 are set to **SLIP**, which signals to GOTHIC that these boundaries are not physical. Thus, friction losses are not computed along these boundaries.

Slip conditions can also be applied to blockages so as to signal to GOTHIC that a particular blockage does not represent a physical object. Most of the blockages included in the GOTHIC model do indeed represent physical objects, so the default no-slip condition is left unchanged. However, the blockage in CV2 representing CV1 (recall that CV1 is wholly contained in CV2 and so the volume of CV1 is blocked out of CV2 to avoid double counting) is not a physical object but rather a modeling boundary. Thus, the slip conditions for this blockage are set to **SLIP** so that friction losses are not computed along the blockage.

Lastly, a number of additional zero-thickness blockages are assigned to the outer boundaries of the cells in which storage racks are modeled so that the storage rack walls are taken into account when computing friction losses in the downcomer cells. Zero thickness is assigned so as not to alter the free volume of the boundary cells. It has been determined that assigning zero thickness does not cause GOTHIC to ignore the blockage.

3.1.2 Heat Sinks

The heat sinks included in the model are the insulated metal siding walls, the roof, the walls and floors of the spent fuel pools and transfer canals, and the Shield Building wall. Parameters for these heat sinks are defined below. Large heat sinks that exist in reality but are not included in the model because they are not expected to have a significant impact on building temperatures are the floor of the truck bay, the floor of the "basketball court" (see Figure 4.1), the Control Complex wall, and the walls and ceilings of the various rooms east of the "basketball court" on elevation 633'-6", such as the decontamination rooms, the boric acid tank room, and the contaminated materials storage area.

3.1.2.1 Surface Area

Heat sink surface areas are computed in Table 3.1 based on the dimensions given in Input 4.1 and on plant drawings [Ref. 2.9].

Table 3.1: Heat Sink Surface Areas

Description	Computation	Area (ft^2)
North Pit North Wall	18'-11" x (649'-6" – 608')	785
North Pit West Wall	17'-2" x (649'-6" – 608')	712
North Pit South Wall (Dividing Wall)	18'-11" x (649'-6" – 608') – 2'-6" x (649'-6" – 622'-1")	717
North Pit East Wall	17'-2" x (649'-6" – 608') – 2'-6" x (649'-6" – 622'-1")	644
North Pit Floor	17'-2" x 18'-11"	325
South Pit West Wall	32'-6" x (649'-6" – 608')	1349
South Pit South Wall	18'-11" x (649'-6" – 608')	785
South Pit NE Wall (to North Canal)	(30'-6" – 17'-2" – 4') x (649'-6" – 608')	387
South Pit SE Wall (to South Canal)	16'-10" x (649'-6" – 608') + 2'-6" x (622'-1" – 608')	734
South Pit Floor	32'-6" x 18'-11"	615
North Canal North Wall	4' x (649'-6" – 608')	166
North Canal East Wall (below BBall court)	30'-6" x (633'-6" – 608')	778
North Canal East Wall (above BBall court)	30'-6" x (649'-6" – 633'-6")	488
North Canal Floor	30'-6" x 4'	122
South Canal West Wall	(11'-7-5/8" + 4' + 7'-8-3/8" + 4') x (649'-6" – 608')	1134
South Canal East Wall (below BBall court)	46'-8" x (633'-6" – 608')	1190
South Canal East Wall (above BBall court)	46'-8" x (649'-6" – 633'-6")	747
South Canal Floor	46'-8" x 4'	187
Truck Bay North Wall*	48' x (700'-6" – 606' – 5') – 19'-5" x (614'-9" – 606' – 5') – 22' x 17'	3849
Truck Bay West Wall*	86'-6" x (700'-6" – 606' – 5') – 12' x (614'-9" – 606' – 5') – 12'-6" x (628' – 606' – 5')	7484
Truck Bay South Wall*	48' x (700'-6" – 606' – 5') – 22' x 17'	3922
Shield Building Wall	2π x 60' x ¼** x (700'-6" – 649'-6")	4807
Operating Floor North Wall (in CV1)	27.58' x (700'-6" – 649'-6")	1407
Operating Floor North Wall (in CV2)	(177'-4" – 48' – 27.58') x (700'-6" – 649'-6") – 33' x (700'-6" – 647'-10½")	3453
Operating Floor East Wall	86'-6" x (700'-6" – 675')	2206
Roof (over CV1)	86'-6" x 27.58'	2386
Roof (over CV2)	(144'-4" – 27.58') x 86'-6"	10099
Lower Roof	33' x 86'-6"	2855

* The 5-ft-high concrete sill wall around the Truck Bay is conservatively ignored. Because this wall is small, thick, and located in an area where temperatures are relatively low, its effect is negligible.

** One quarter of the Shield Building's circumference is estimated to be inside the FHA (Assumption 5.7).

3.1.2.2 Thickness and Material Properties

The insulated metal siding is composed of, from inside to outside, a 1½-inch-thick layer of glass fiber insulation and a 1¾-inch-thick air gap (Input 4.5) enclosed by galvanized steel panels. The material properties of glass fiber insulation are given in Input 4.5. The air gap is modeled in GOTHIC as a solid to which the thermal properties of air given in Input 4.4 are assigned. Modeling the air gap as a solid material is conservative because it ignores convection and thermal radiation heat transfer. Due to this conservatism and because the thermal resistance of metal is very small, it is acceptable to neglect the metal sheets as is done in the GOTHIC model.

The upper roof is composed of, from bottom to top, a 1½-inch-thick metal deck, a 2-inch-thick layer of Perlite insulation, a Trocal roof membrane, and a ¾-inch to 1½-inch-thick layer of gravel (Input 4.6). It is assumed that the metal deck is made of plain steel (Assumption 5.6), the thermal properties of which are given in Input 4.14. The thermal properties of Perlite and gravel are also given in Input 4.14. For conservatism, the gravel layer is taken to be 1½ inches thick throughout. Additionally, a ¼-inch-thick layer of air is modeled between each layer to account for contact resistance. As with the insulated metal siding, the air is modeled as a solid material. Due to these conservatisms, it is acceptable to neglect the Trocal roof membrane. These properties are also applied to the lower roof.

The material properties of concrete, which are given in Input 4.14, are assigned to the walls and floors of the spent fuel pits and the transfer canals, as well as to the Shield Building wall. Thicknesses for the walls and floors of the spent fuel pits and transfer canals vary and are taken from Drawing S-410 [Ref. 2.9.3]. Assumption 5.7 provides that the thickness of the Shield Building wall is approximately 2.5 ft.

3.1.2.3 Heat Transfer

The heat transfer modes depicted in Figure 3.3 are included in the GOTHIC model and detailed in the proceeding subsections.

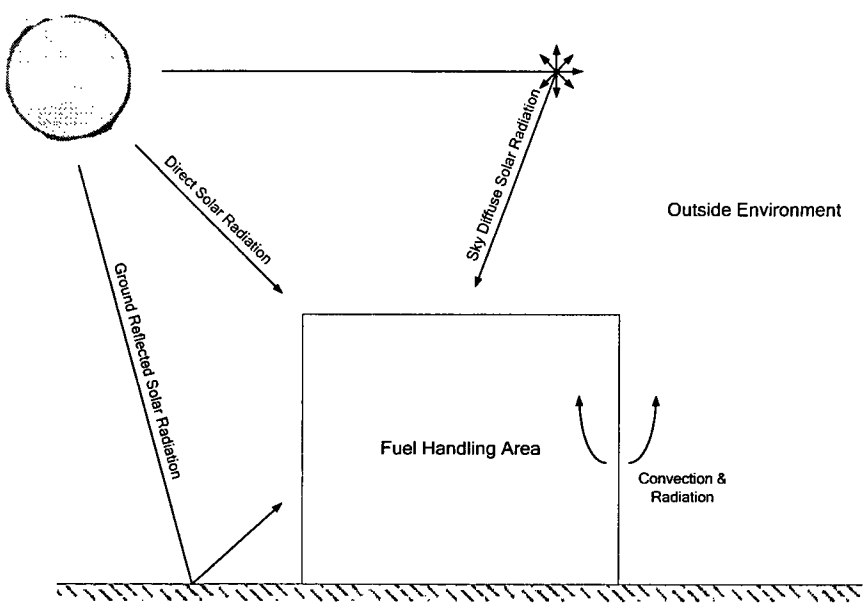

Figure 3.3: Heat Transfer Modes

a. Convection

For the surfaces in CV1 and CV2, natural convection heat transfer coefficients are determined by GOTHIC at each time step using its built-in correlations. The **FACE DOWN** option is used for the ceiling (i.e., underside of the roof), the **VERTICAL SURFACE** option is used for the walls, and the **FACE UP** option is used for the floors. These options signal to GOTHIC which correlation to use based on the orientation of the heat sink. Refer to the GOTHIC user manual [Ref. 2.2.2] for details on the correlations corresponding to these options. Forced convection due to ventilation is expected to be small and is conservatively ignored for these surfaces.

For the surfaces exposed to outside air, a heat transfer coefficient of 4.0 Btu/hr-ft^2-°F is used. This is a typical value used in building design that includes radiant heat transfer and convection heat transfer with a 7.5 mph wind, which is characteristic of the summer months [Ref. 2.13, Chapter 26, Table 1].

For vertical surfaces exposed to lower elevations of the Auxiliary Building, such as the walls of the SFPs, a heat transfer coefficient of 1.46 Btu/hr-ft^2-°F is used. For horizontal surfaces exposed to lower elevations of the Auxiliary Building, namely the floors of the SFPs, a heat transfer coefficient of 1.08 Btu/hr-ft^2-°F is used. These heat transfer coefficients are typical values used in building design that include convective and radiant heat transfer [Ref. 2.13, Chapter 26, Table 1]. These heat transfer coefficients are used in conjunction with an ambient temperature equal to the maximum temperature of the air being exhausted from the FHA, which is shown in Figure 7.3. This is appropriate because the lower elevations of the Auxiliary Building receive supply air from the FHA through Stairwell K and various ducts and doors (see Section 3.1.3).

The surface exposed to the Shield Building is conservatively modeled as adiabatic because this area of the plant is not normally ventilated [Ref. 2.24]. As such, only the heat capacitance of the concrete is credited.

b. Solar Radiation

The combined surface heat flux from the three modes of solar irradiance depicted in Figure 3.3 are computed using the UHSSIM computer program [Ref. 2.2.5], a S&L proprietary software package that follows the ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) methodology for calculating solar irradiance. Inputs for the UHSSIM program are provided in Input 4.8. As discussed in Section 3, solar flux is evaluated for two dates: October 30 and June 21. Shading from the Shield Building and other structures is conservatively ignored. Based on this approach, the following incident solar heat fluxes are computed (data tables are provided in Attachment 3):

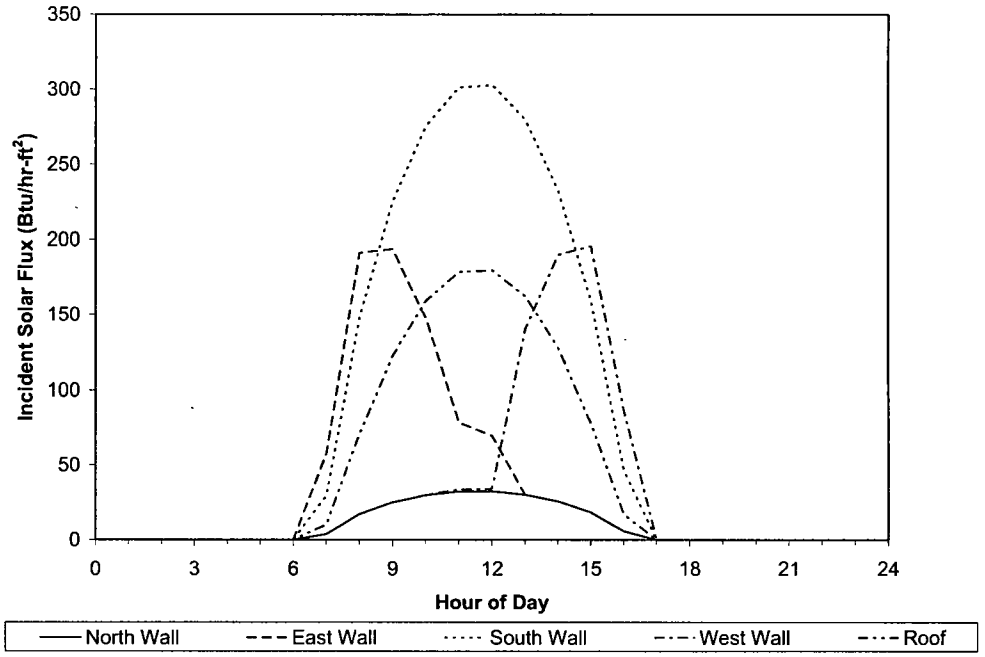

Figure 3.4: Solar Heat Flux on October 30

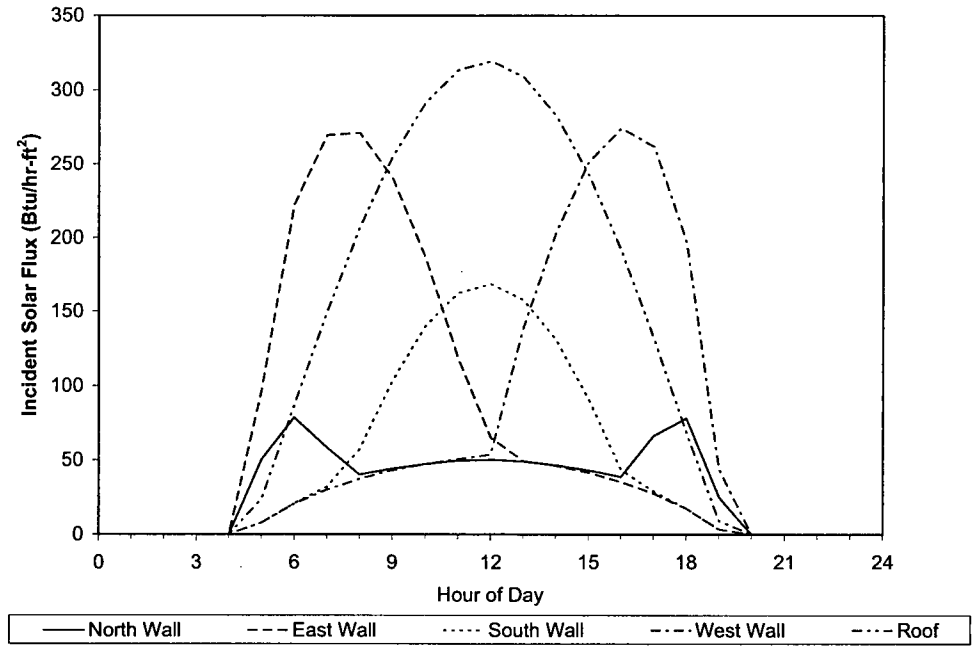

Figure 3.5: Solar Heat Flux on June 21

The above solar heat fluxes are applied as internal heat generation in the terminal (outermost) node of each heat sink exposed to solar radiation (heat sinks are nodalized to capture spatial temperature variations). A reducing multiplier is applied in the GOTHIC model to convert the incident solar radiation to absorbed solar radiation because only a portion of the incident solar radiation is actually absorbed. Per Input 4.8.5, the reducing multiplier is set to 0.26 for the walls and 0.29 for the rooftop.

c. Surface-to-Vapor Radiation

Radiant heat transfer occurs between a surface and the surrounding vapor unless the vapor is 100% transparent. Humid air is not 100% transparent and thus radiation heat transfer occurs between a surface and humid air. GOTHIC's built-in correlations for computing this heat transfer mode, discussed in Section 15.3.2 of the GOTHIC user manual [Ref. 2.2.2], are utilized on the inside surfaces of the FHA (radiation heat transfer from outside surfaces is instead captured by the heat transfer coefficient applied to these surfaces; see Section 3.1.2.3a). These correlations require the user to input the surface emissivity. A value of 0.9 is used per Input 4.7.

3.1.3 Ventilation

Input 4.12 provides that the following ventilation flow rates exist in the postulated scenario. Note that these flow rates are based on an off-design alignment of the ventilation system that requires operator action (see Limitation 3 in Section 8).

- Supply air is drawn through the open garage doors and exhausted from the FHA. There are two garage doors: one on the ground floor at the southwest corner of the FHA, and one on the ground floor at the northwest corner of the FHA. The doors are 17 ft. wide by 22 ft. high. The doors are each modeled using two parallel flow paths: one for the bottom half of the door, and one for the top half. This allows GOTHIC to compute simultaneous bi-directional flow through the door, which occurs when buoyancy forces dictate flow. Because forced ventilation is modeled, buoyancy forces are not dominant in this analysis. However, the parallel flow paths are retained so that the model is set up for any future runs in which the ventilation is turned off. See below for a discussion on how flow paths are defined in GOTHIC. The flow paths are connected to the appropriate cell in Control Volume 2 on one side, and to Control Volume 3 (the control volume simulating the environment) on the other side.

- 12,128 cfm of the total flow is exhausted from the FHA down through Stairwell K, which is located south of the SFPs and is open to the FHA. This flow is modeled using the combination of a flow boundary and a flow path. Other than the specified flow rate, the parameters of the flow boundary condition (i.e., temperature, pressure, humidity, and gas composition) are arbitrarily defined because they have no impact on the system. The flow path connects the boundary condition to the south face of Control Volume 1, cell 129, which is the southwestern-most cell of Control Volume 1 on the operating floor elevation (649'-6"). This cell was chosen because it creates the shortest path from the roll-up doors on the ground level to the stairwell. This cell is shown in View A of Figure 3.1. Note that under GOTHIC's cell numbering convention, the lowest and southwestern-most cell is cell number 1, and from there cell numbers are assigned in succession from west to east, south to north, and bottom to top. The elevation, height, area, and hydraulic diameter of the south face of Control Volume 1, cell 129 are assigned to the flow path.

- 13,747 cfm of the total flow travels west to east across the "basketball court" (see Figure 4.1) and is exhausted from the FHA through doors or ductwork to other areas of the Auxiliary Building. This flow is modeled using the combination of a flow boundary and a flow path. Other than the specified flow rate, the parameters of the flow boundary condition (i.e., temperature, pressure, humidity, and gas composition) are arbitrarily defined because they have no impact on the system. The flow path connects the boundary condition to the east face of Control Volume 2, cell 70, which is the middle cell in the eastern-most row of cells of Control Volume 2 on the operating floor elevation (649'-6"). This cell was chosen because it

creates the desired flow pattern. The elevation, height, area, and hydraulic diameter of the east face of Control Volume 2, cell 70 are assigned to the flow path.

- 9,000 cfm of the total flow is exhausted through the twelve SFP exhaust registers on the west side of the SFPs. This flow is modeled using the combination of a flow boundary, a network node, and thirteen network links. Twelve of the thirteen network links simulate the exhaust registers and are assigned a flow area and hydraulic diameter corresponding to the register dimensions (36 in. wide by 8 in. high). The midpoint elevation of these network links is set to a value that is 3.7 ft above the operating floor. These network links are connected to the appropriate cell in Control Volume 1 on one side, and to the network node on the other side. The thirteenth network link connects the network node to the flow boundary condition. With this configuration, flows from the twelve network links simulating the exhaust registers mix in the network node and then exit the system through the thirteenth network link and the flow boundary condition. This configuration is illustrated in the diagram below and is used in lieu of traditional flow paths because it allows multiple hydraulic connections to a single boundary condition. (The alternative to this configuration would be twelve flow paths connected to twelve boundary conditions.)

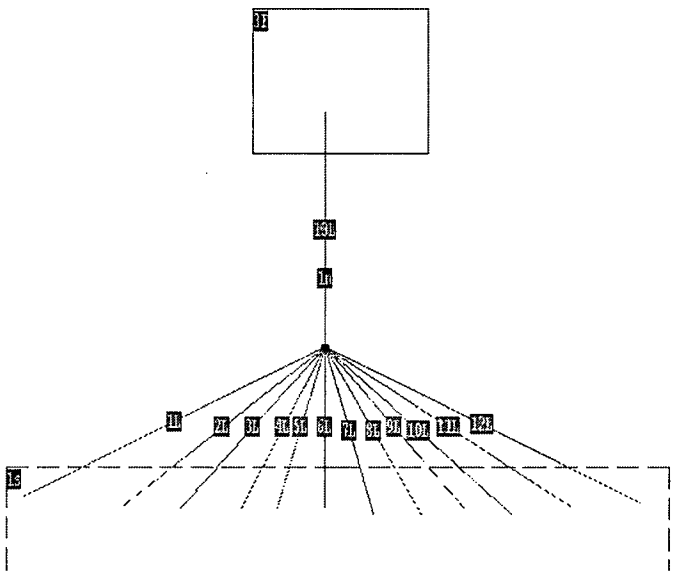

Figure 3.6: Network Diagram of Exhaust Registers

As for the boundary condition, the parameters other than the specified flow rate (i.e., temperature, pressure, humidity, and gas composition) are arbitrarily defined because they have no impact on the system.

The above flows are illustrated in the diagram below.

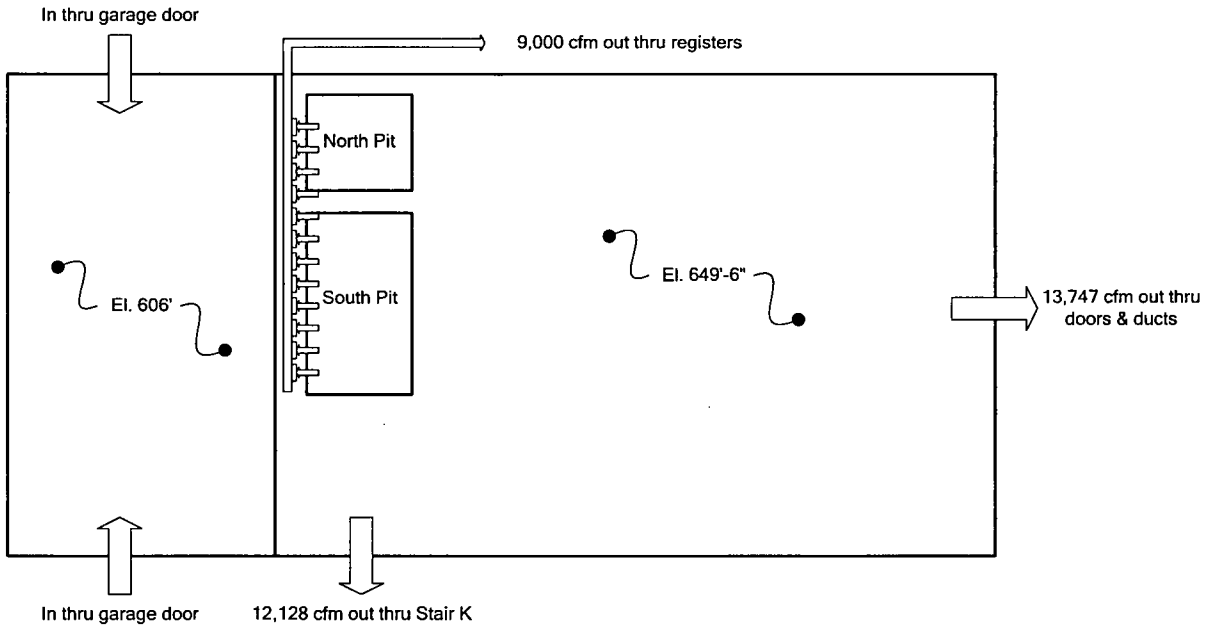

Figure 3.7: Ventilation Flow Diagram.

Note that the total exhaust flow rate is 34,875 cfm, which equates to an air exchange rate of 2.3 turnovers/hr.

GOTHIC flow paths and network links, collectively referred to here as junctions, are generally defined by the following parameters:

- Bottom elevation (flow paths) or midpoint elevation (network links)
- Height (flow paths only)
- Flow area
- Hydraulic diameter (defined as $4A/P$, where A is the area and P is the perimeter [Ref. 2.2.2, Eq. 12.1])
- Inertia length
- Loss coefficient

The parameters that warrant further explanation are discussed below.

Elevation – The reference elevation used in the model is 606', which is the elevation of the ground floor of the FHA, such that all junction elevations are relative to this elevation. For example, the bottom elevation of the garage doors is set to 0 (for the bottom halves) since these doors are flush with the ground floor.

Inertia length – The product of inertia length and flow area defines an effective junction volume, and the mass contained in this volume is the mass that will be accelerated by the application of a pressure differential across the junction. The inertia term in the momentum balance is significant only for short term response to a rapid change in the junction pressure drop. For example, the inertia term is significant in calculating room pressures a few seconds after a high energy line break. In contrast, the inertia length is not a significant parameter in slowly evolving transients like that analyzed herein. This characterization is supported by the code author [Ref. 2.2.2, Section 25.6.4]. Thus, an arbitrary inertia length of 10 ft is applied to all junctions in the model.

Loss coefficient – A loss coefficient of 2.78 is assigned to the garage doors. This is a reasonable value for a simple, sharp-edged orifice in a wall that is much larger than the opening [Ref. 2.2.2, Section 25.6.4]. This parameter does not have a significant impact on results, primarily because ventilation flow rates are specified. A loss coefficient of 1 is assigned to each of the twelve network links simulating the SFP exhaust registers. This loss coefficient was found to balance the specified flow between the network links (750 cfm through each) without creating a significant pressure drop. For all other junctions, no loss coefficient is assigned.

3.1.4 Heat Loads

3.1.4.1 Spent Fuel Decay Heat

As discussed in Input 4.10, the total heat load from spent fuel (2.93 x 10^6 Btu/hr on October 30, 2014; 2.52 x 10^6 Btu/hr on May 18, 2015) is split between the two pits, with 24% of the heat load in the north pit and 76% in the south pit. These heat loads are entered into the model using thermal conductors (i.e., fictitious heat sinks). An internal heat generation rate is uniformly applied to the thermal conductors equaling the spent fuel decay heat load. For example, the thermal conductor simulating the spent fuel decay heat load in the south pit is assigned an internal heat generation rate of 618.6 Btu/s for the October case (2.93e6 x 76% ÷ 3600 s/hr). Each thermal conductor is spanned across the light grey cells of its corresponding pit shown in Figure 3.1 such that the heat load is evenly distributed. It should be noted that this approach of evenly distributing the spent fuel heat load is appropriate only for the purpose of determining average temperatures in regions removed from the fuel, such as in the downcomers. It does not capture local temperature gradients, nor is it intended to determine the maximum fuel temperature. The analysis of the maximum fuel temperature is performed in COBRA (see Section 3.2).

3.1.4.2 Electrical Equipment Heat Loads

The electrical equipment heat loads computed in Attachment 10 and summarized in Input 4.11 are positioned in the model to match their approximate physical location in the FHA as determined from Drawing Nos. E-864 (Input 2.2 of Attachment 10) and E-867 (Input 2.3 of Attachment 10). Underwater lighting is not included (see Limitation 2 in Section 8).

3.1.5 Computing and Applying the Outside Air Temperature

Outside air temperatures are calculated in Attachment 11 for the months of October and July (see Section 3 for a discussion of these dates) using the methodology provided in Chapter 14 of ASHRAE 2009 [Ref. 2.13], which is summarized by the following relationship:

$$t_{db,h} = t_{db,des} - f(DR) \qquad \textbf{Eq. 3.1-2}$$

where:

$t_{db,h}$ = hourly dry-bulb temperature, °F
$t_{db,des}$ = design dry-bulb temperature = 69.6°F for October, 86.0°F for July (Input 4.9)
f = hourly daily range fraction (Table 3.2)
DR = daily range of dry-bulb temperature = 14.9°F for October, 16.9°F for July (Input 4.9)

The hourly daily range fraction (f) is taken from Table 6 of Chapter 14 of ASHRAE 2009 [Ref. 2.13] and given in Table 3.2 below.

Table 3.2: Fraction of Daily Temperature Range [Ref. 2.13]

Time, h	Fraction	Time, h	Fraction	Time, h	Fraction
1	0.88	9	0.55	17	0.14
2	0.92	10	0.38	18	0.24
3	0.95	11	0.23	19	0.39
4	0.98	12	0.13	20	0.50
5	1.00	13	0.05	21	0.59
6	0.98	14	0.00	22	0.68
7	0.91	15	0.00	23	0.75
8	0.74	16	0.06	24	0.82

Based on these inputs and methodology, the following outside air temperatures are computed (see Attachment 11 for tabulated data):

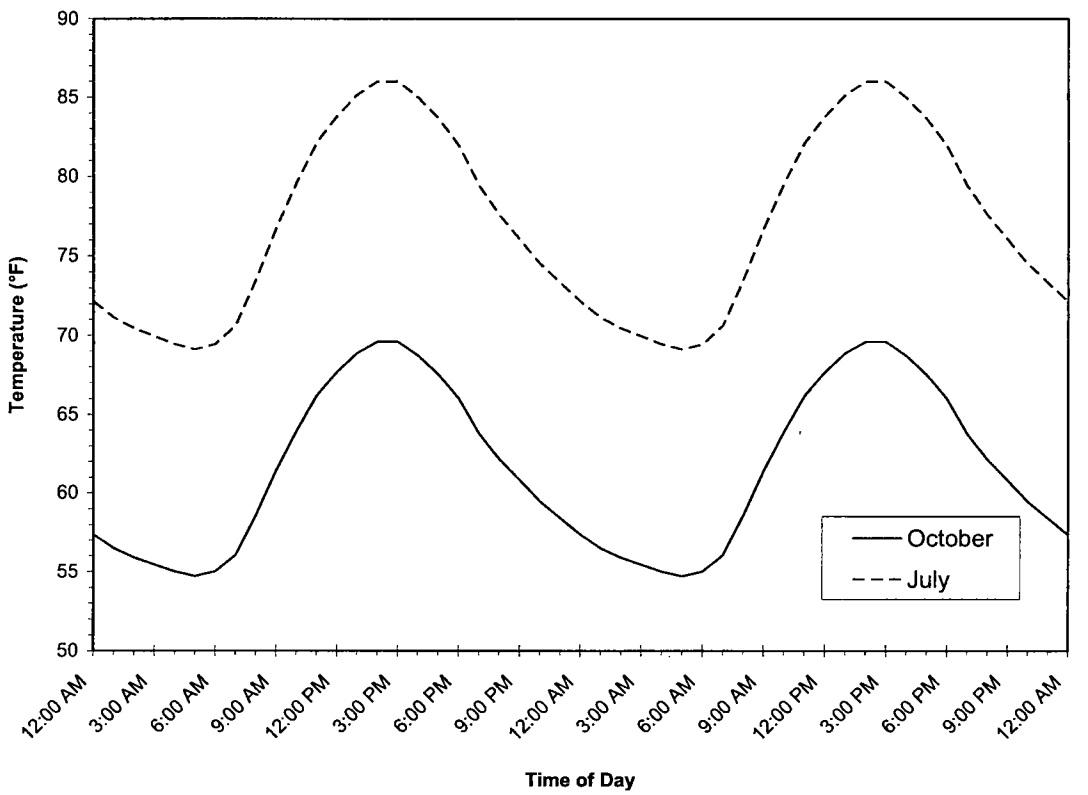

Figure 3.8: Outside Air Temperature Cycles

The above daily temperature cycles are applied to the outside air (CV3) by means of the "flow-through" method, which involves inundating the control volume with air set to the temperatures given above, atmospheric pressure (14.7 psia), and the relative humidities given in Input 4.9 (57% for October and 53% for July). This method requires two boundary conditions (one for inflow and one for outflow) and two flow paths (each connecting the control volume to one of the boundary conditions). Parameters for the boundary conditions and flow paths are arbitrarily set to produce the desired effect of forcing the temperature, pressure, and humidity in CV3.

3.1.6 Initial Conditions

Initial conditions have no impact on results since the models are run until quasi steady-state is achieved. Thus, GOTHIC's default values are used.

3.2 Determining Maximum Cladding Surface Temperature

The maximum steady-state temperature of the spent fuel zirconium cladding is calculated using the computer program COBRA-SFS [Ref. 2.2.3]. COBRA was developed by Pacific Northwest Laboratories in the 1990s [Ref. 2.2.4]. The COBRA User's Manual cites PNL and EPRI documents that have been used to validate single and multi assembly models [Ref. 2.2.4]. COBRA models the heat transfer inside and between assemblies/storage cells. The inputs needed for the model are discussed in the following sections. The sections are named based on the input deck sections, as discussed in the COBRA User's Manual [Ref. 2.2.4].

3.2.1 COBRA Inputs

The COBRA input section sets up the problem. This code does not have a CPU time limit assigned to it, and the input deck is copied in the output.

3.2.2 PROP Inputs

The PROP input section assigns fluid and solid properties for the model. This code requires properties for air and for the walls of each storage cell. The air properties are taken from Input 4.4, and are converted to the appropriate units for the model in Attachment 4. The walls of the storage cell are made out of stainless steel. The thermal conductivity of stainless steel at 527°F is used (Input 4.3) as a mid range temperature for the analysis.

3.2.3 CHAN Inputs

The CHAN input section describes the fluid channels in the model. The channels are where the air flows between the fuel rods. The cooling of the fuel rods occurs due to convective heat transfer to the air in these channels.

Because COBRA is used to evaluate the heat transfer from the rods to the air and the maximum temperature of the cladding, only the heated length of the rods is used for the COBRA analysis. The heated length of the rods is 143.25 inches long (Input 4.2). To simplify the analysis, the heated length is modeled as being 144 inches. This slightly reduces (by 0.5%) the heat load per unit volume in the rods, but the total heat load remains the same. The difference would only apply to the temperature gradient between the air at the top of the assembly and the cladding surface temperature, which is on the order of 20°F per Attachment 9. Therefore, the effect of this modeling simplification is on the order of 1°F (= 5% x 20°F). This is negligible compared to the other conservatisms in the analysis (see Section 8). The channels are split into 24 sections for the heat transfer to occur. Also, the rods, and therefore channels, are oriented vertically (Input 4.2).

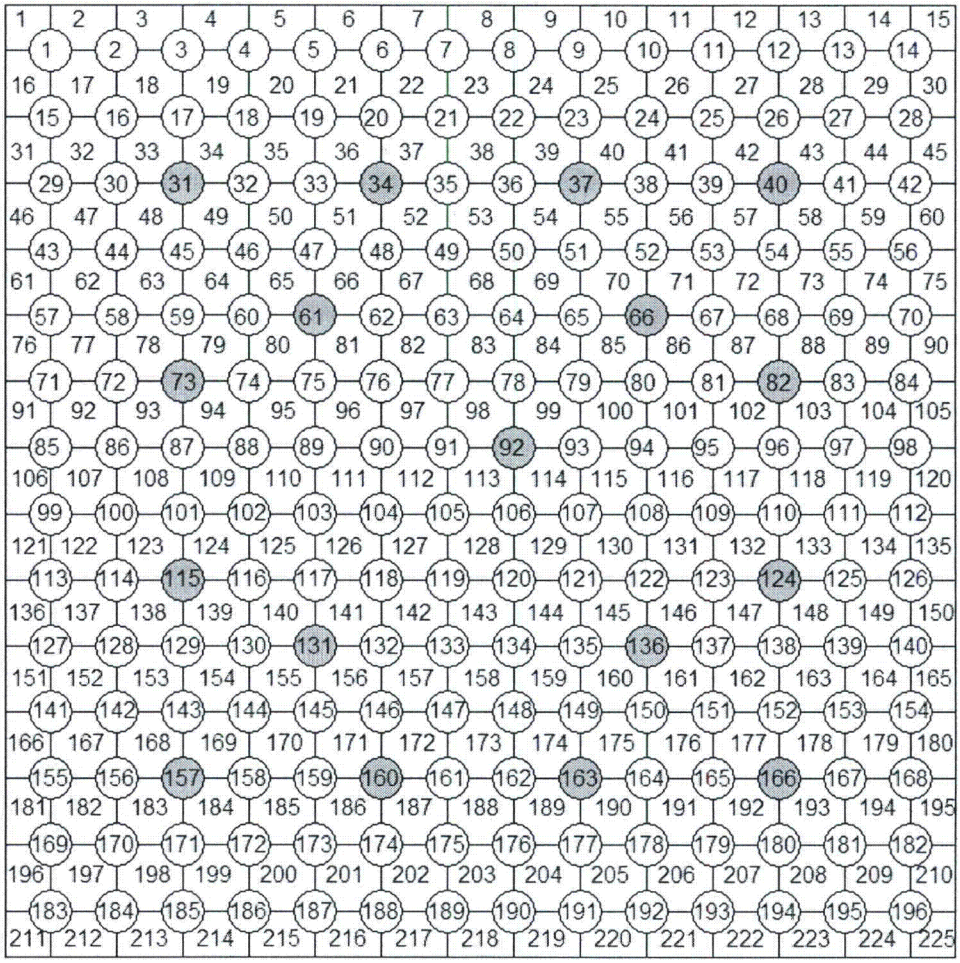

Figure 3.9: The rods and channels for the assembly are shown. There are 196 rods and 225 channels. There are 179 heated rods, one instrument tube (Rod #92), and 16 guide tubes (the shaded rods not including #92). See Reference 2.16, Figure 2-3 for the locations of the non-heated rods.

In this analysis, the rods are spaced in a 14x14 grid (Input 4.2, see Figure 3.9). Outside of the rods are the walls of the storage cell. There is a channel between all the rods and between the edge rods and the walls of the storage cell. Therefore, the channels are modeled as a 15x15 grid, a total of 225 channels.

Each channel requires input for the area of the channel, the wetted perimeter of the channel, and the heated perimeter. In addition, each channel requires the channel number, connection width, and connection length of adjacent channels. Only those connecting channels with a larger channel ID number are listed. This prevents possible errors due to double counting channel connections.

The dimensions of each channel are dependent on whether the channel is in a corner, on an edge, or in the middle of the assembly. The area of the channel is the pitch area less the area taken up by the fuel rod and cladding. The wetted perimeter is the length of the cross section that touches a solid surface. The heated perimeter is the length of the cross section that touches a rod.

Channel Location	Middle	Edge	Corner	
Area (in^2)	$P^2 - \pi D^2/4$	$PC - \pi D^2/8$	$C^2 - \pi D^2/16$	**Eq. 3.2-1**
Wetted Perimeter (in)	πD	$\pi D/2 + P$	$\pi D/4 + 2C$	**Eq. 3.2-2**
Heated Perimeter (in)	πD	$\pi D/2$	$\pi D/4$	**Eq. 3.2-3**

where:

P = pitch from rod centerline to centerline = 0.556 in (Input 4.2)
D = cladding outer diameter = 0.422 in (Input 4.2)
C = distance from the storage cell wall to the center of the first rod (in)
W = inner width of the storage cell walls = 8.3 in (Input 4.2)
L = inner length of the storage cell walls = 8.3 in (Input 4.2)
t = thickness of the storage cell walls =0.125 in (Input 4.2)

The cladding diameter of the fuel rods is used for all of the modeled rods. This is for the dual purpose of accounting for the fact that RADGEN (see Section 3.2.6) cannot model radiation from differently sized rods and to simplify the model. In reality, the guide tubes are slightly larger than the fuel rods (0.526 in diameter vs 0.422 in diameter per Input 4.2). This would slightly reduce the flow rate in the channels adjacent to those fuel rods. The limiting rod for this analysis (see Attachment 9) is rod #105. This rod is not adjacent to any of the guide tubes so the slight change in channel area would not affect heat removal from that rod or the temperature of that rod. It is adjacent to the instrument tube which has a diameter of 0.422 inches (Input 4.2).

The distance from the storage cell wall to the center of the first row of fuel rods (C) is equal to:

$$C = \frac{L - 13 \times P}{2} = \frac{8.3 - 13 \times 0.556}{2} = 0.536 \text{ inches}$$

Channel Location	Middle	Edge	Corner
Area (in^2)	0.1692	0.2281	0.2523
Wetted Perimeter (in)	1.326	1.219	1.403
Heated Perimeter (in)	1.326	0.6629	0.3314

(see Attachment 5 for calculations of above values)

The connection width is the open length between each channel. The connection length is the distance from the center of one channel to the center of the next channel. There are four types of connections between two channels (see Figure 3.9 for channel ID numbers): middle channel connections (e.g. 18 to 19), middle to edge connections (e.g. 2 to 17), edge to edge connections (e.g. 2 to 3), and edge to corner connections (e.g. 1 to 2).

Connection Location	Middle	Middle/Edge	Edge	Edge/Corner	
Connection Width (in)	$P - D$	$P - D$	$C - D/2$	$C - D/2$	**Eq. 3.2-4**
Connection Length (in)	P	$(P + C)/2$	P	$(P + C)/2$	**Eq. 3.2-5**

Connection Location	Middle	Middle/Edge	Edges	Edge/Corner
Connection Width (in)	0.134	0.134	0.325	0.325
Connection Length (in)	0.556	0.546	0.556	0.546

(see Attachment 5 for calculations of above values)

This analysis uses a three assembly model in order to model heat transfer from one assembly to another. Per Ref. 2.20, the most recently offloaded assemblies (Cycle 32) are arranged in a one out of five grid such that no Cycle 32 assembly is adjacent to any other Cycle 32 assembly. There are thirteen locations in the spent fuel pool where there is a Cycle 32 assembly immediately adjacent to a Cycle 31 assembly and a Cycle 30 assembly, as shown in Figure 3.10 (the full spent fuel pool map is in Attachment 14). These are the worst configurations; that is, the amount of heat transfer from the Cycle 32 assembly to an adjacent assembly is minimized. A common assembly configuration is shown in Figure 3.11 below. This five assembly arrangement is then replicated throughout the spent fuel pool.

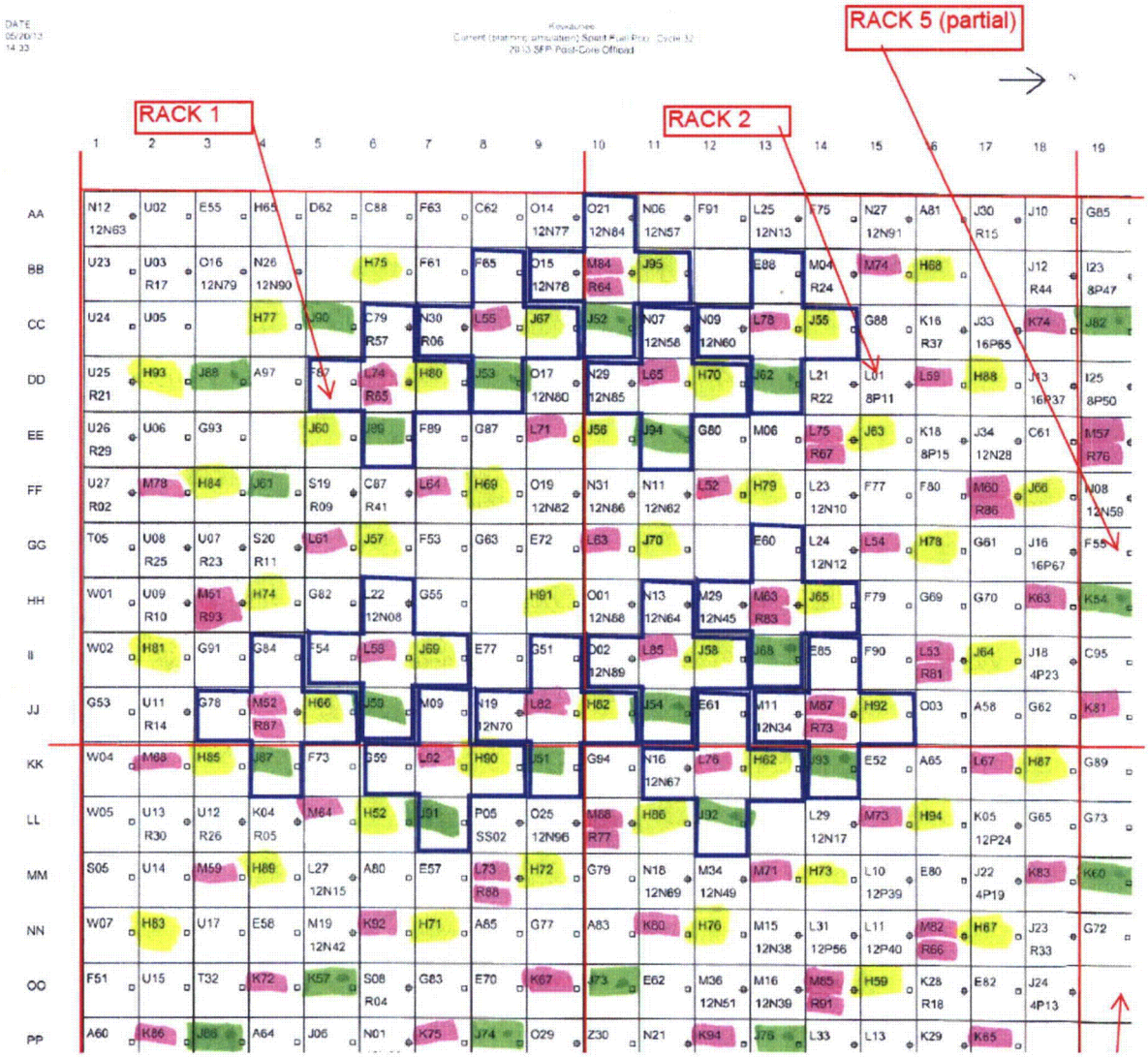

Figure 3.10: The thirteen worst case five assembly arrangement locations are shown.

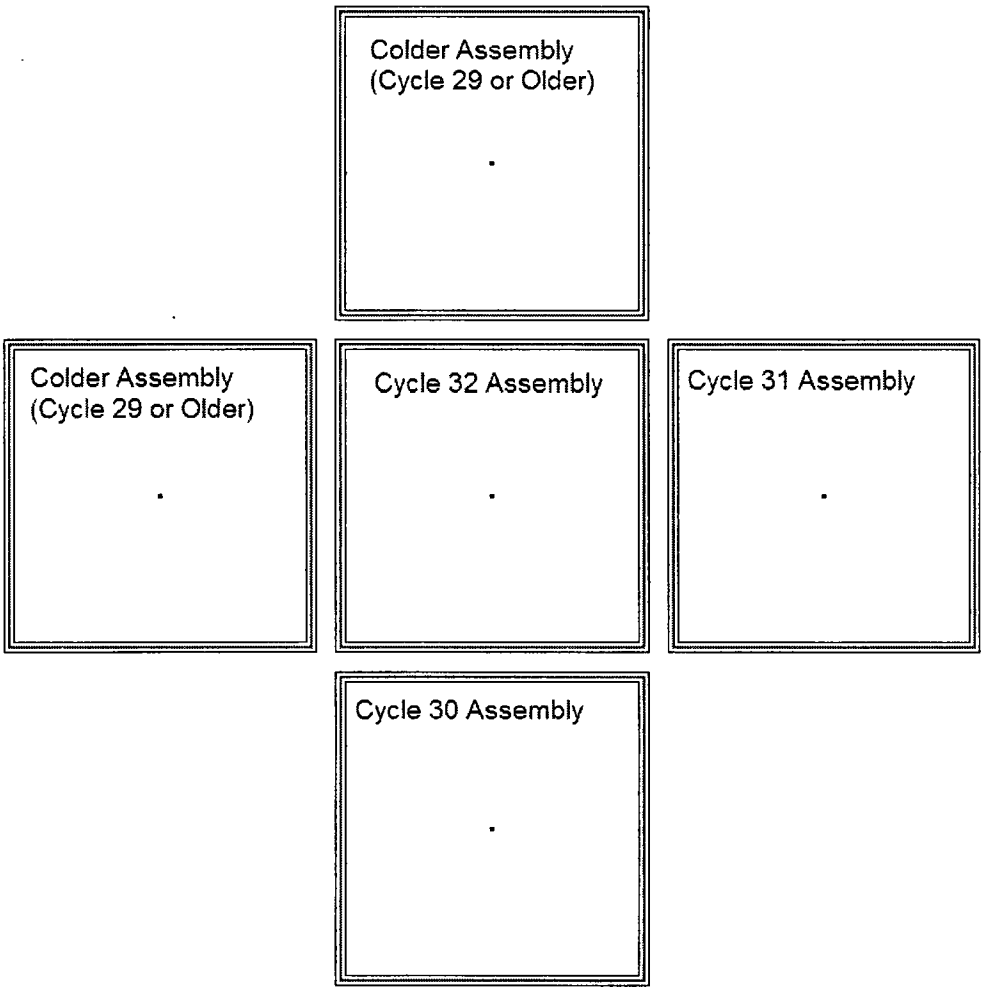

Figure 3.11: Common configuration of the worst case five assembly arrangements in the spent fuel pool.

For this analysis (and based on the limitations of COBRA) three assemblies are modeled: the "worst case" Cycle 32 assembly is between two limiting Cycle 29 assemblies. As shown in Figure 3.11 and Attachment 14, no assembly is touching more than two assemblies more recent than Cycle 29. The highest heat generation rate for any of the Cycle 29 assemblies in one of the thirteen bounding five assembly arrangements has a heat generation rate of 2300 BTU/hr in October of 2014 (Input 4.2). This heat generation rate is used for both the October 2014 model and the May 2015 model.

This heat generation rate is applied to the two adjacent assemblies in the COBRA model, as shown in Figure 3.12. This method is conservative for two key reasons. First, it assumes that there is no heat transfer to the other two adjacent assemblies. This is equivalent to modeling the other two adjacent assemblies as being also Cycle 32. Second, it assumes that the third and fourth highest heat generation assemblies touching a Cycle 32 assembly are both the worst case Cycle 29 heat assemblies. In reality the fourth adjacent assembly would have an even lower heat rate resulting in more heat transfer from the central Cycle 32 assembly.

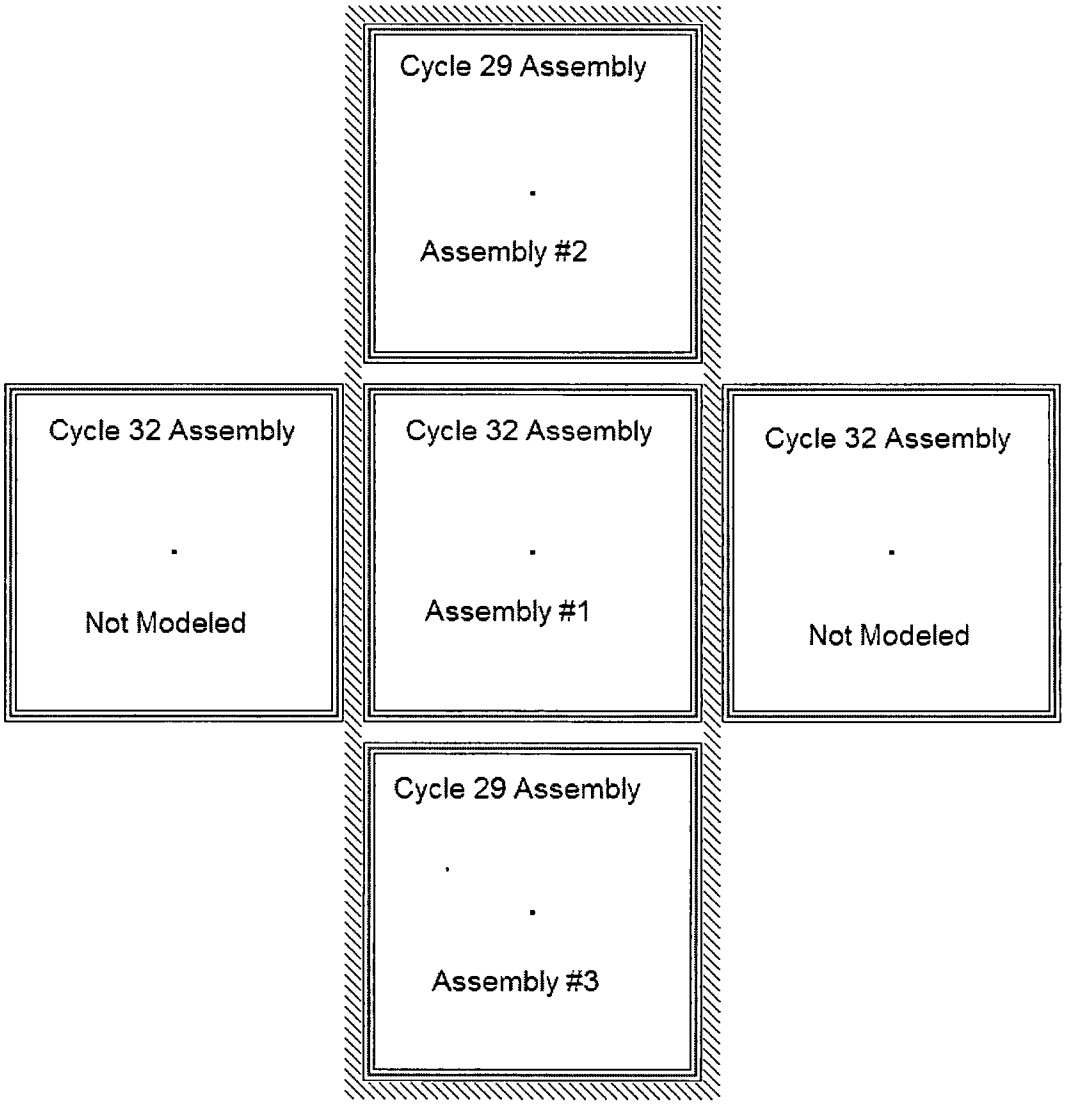

Figure 3.12: Configuration modeled in COBRA. Only the middle Cycle 32 assembly and the two Cycle 29 assemblies are modeled. The diagonal lines represent the boundary of the COBRA model and are assumed to be adiabatic.

All three assemblies are modeled with the same channel configuration in COBRA.

3.2.4 RODS Inputs

The RODS input section describes the rods in the model. The rods as modeled are the combination of the fuel and the cladding. All of the heat transfer from the rods is surface convective heat transfer (see Sections 3.2.6 and 3.2.7 below). Because the rods are configured in a 14x14 array, there are 196 total rods. Of those 196 rods, 179 are active (Input 4.2). All of the heat generating rods are modeled as being identical for simplicity.

Each rod requires a unique identification number, the diameter of the rod (including the cladding), the heat generation factor, and a list of which channels the rod is touching. The heat generation factor is

an indicator of if the rod is active (=1.0) or inactive (=0.0). It is appropriate to model all of the rods in a single assembly with a uniform heat generation rate. As stated in ETE-NAF-2013-0130 [Ref. 2.34] the maximum peaking factor for a single rod in the limiting assembly (Assembly M52 per Section 3.2.9.1) is 1.07. This means that the maximum variation among rods is ±7%. This variation is small compared to Assumption 5.1, which assumes that the heat generation rate is uniform for the full height of the rod. Per References 2.35 and 2.36, the relative power distribution in an assembly is below 80% of the assembly average for the top 5% of the rod. Even if the rod with the highest cladding temperature was also the hottest rod in the assembly, the actual heat generation rate will be less than the analyzed heat generation rate at the top of the rod where the cladding temperature is highest (80% x 1.07 < 1). Therefore the use of a uniform heat generation rate is appropriate.

The channels touching each rod are identified by the channel number and what fraction of the circumference of the rod is touching each channel. Because the rods and channels are modeled as a uniform grid, each rod touches four channels and each of those channels touches one quarter of the rod circumference.

The end of the RODS section contains material properties for the rod. The thermal conductivity, specific heat, and density of the fuel and the cladding are entered (Input 4.3), as are the fuel pellet diameter, cladding thickness, and cladding outer diameter (Input 4.2). This input is needed primarily when the user desires the temperature of the fuel pellets. This analysis does not evaluate the fuel pellet temperature, so these properties are primarily placeholders. For this reason, it is acceptable that the properties are selected at a specific temperature in the temperature range of this analysis as opposed to being entered as a function of temperature.

The final input needed in the RODS section is the gap conductance between the fuel pellet and the cladding. Similar to the fuel and cladding properties, this input is needed primarily when the user desires the temperature of the fuel pellets. This analysis does not evaluate the fuel pellet temperature, so the gap conductance is primarily a placeholder. The gap is filled with helium (Input 4.2). The thermal conductivity of helium is 0.176 Btu/hr-ft-°F (Input 4.4). The gap between the fuel pellets and the inner wall of the zirconium is on average 0.00375 inches ((Cladding ID 0.3734 – Pellet OD 0.3659) / 2). Because the gap is only ~2% of the diameter of the pellet, the gap is treated as a flat wall as opposed to concentric circles. The gap conductance is calculated to be:

$$0.176\frac{\text{BTU}}{\text{hr-ft-}^\circ\text{F}} \times \frac{1}{0.00375\ \text{in}} \times \frac{12\ \text{in}}{\text{ft}} = 563\frac{\text{BTU}}{\text{hr-ft}^2\text{-}^\circ\text{F}}\ \text{gap conductance}$$

All three assemblies shown in Figure 3.12 are modeled with the same rod configuration.

3.2.5 SLAB Inputs

The SLAB input section describes the walls of the storage cell. The walls of the storage cell are stainless steel. For this model, the walls of each assembly are modeled as 8 different slab nodes. The slabs for Assembly 1 are modeled as shown in the figure below.

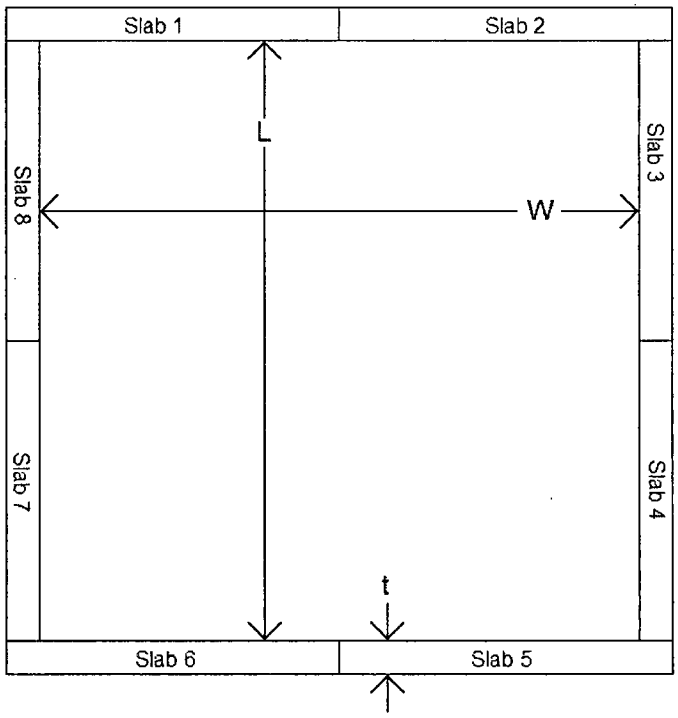

Figure 3.13: Slab Geometry for One Assembly Showing the Length, Width, and Thickness of the Storage Cell and Slab Walls

The storage cell walls between the assemblies are modeled as an infinitely thin slab (e.g Slab #21), then the "wall" (e.g. Slab #1), then another infinitely thin slab (e.g. Slab #23), as shown in Figure 3.14 below. As shown in Figure 3.15, the storage cell walls contain four sheets of stainless steel, two sheets of boron carbide, and many air gaps. Modeling this combined "wall" using three slabs allows the user to have more control over the thermal resistances used in the model.

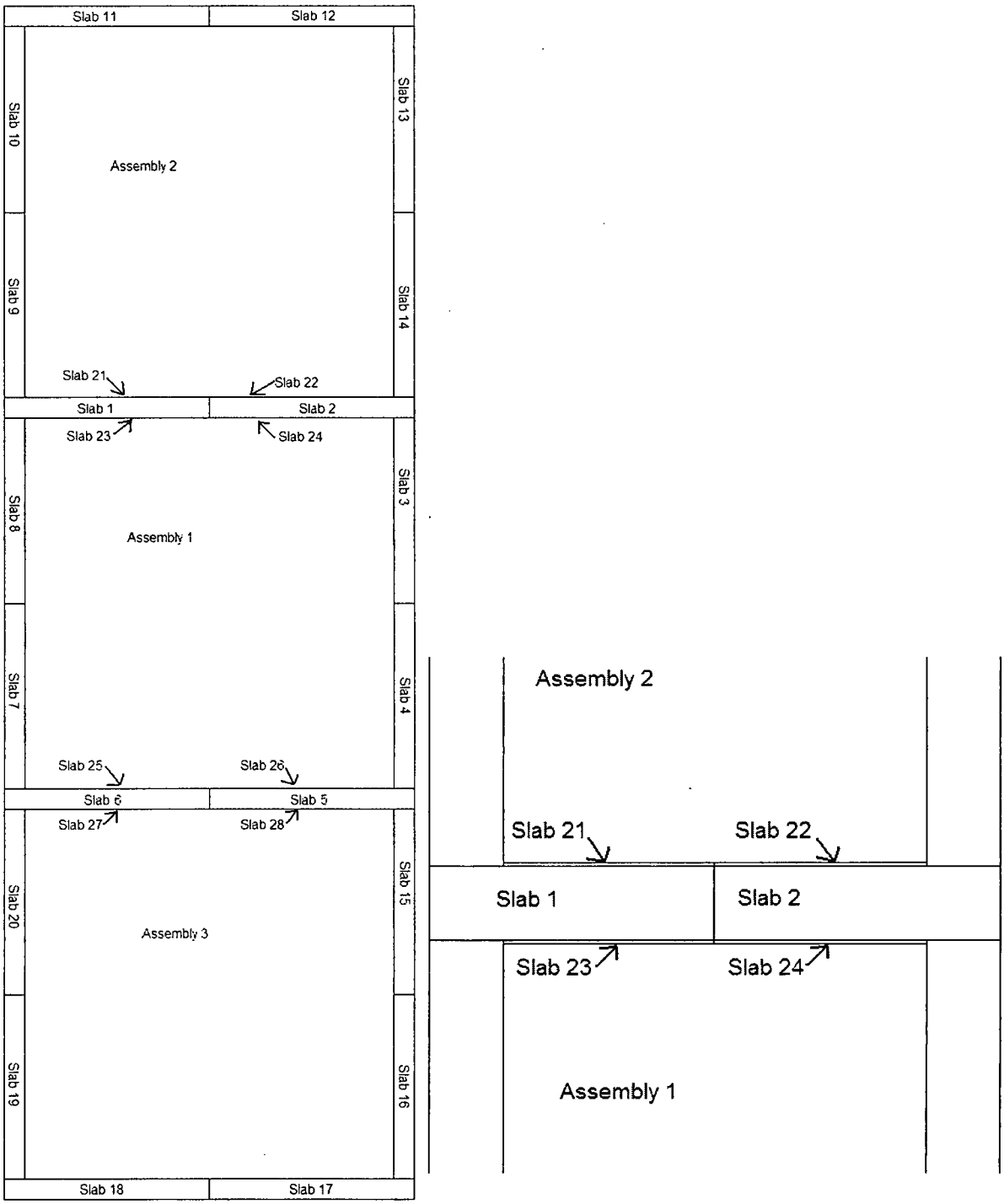

Figure 3.14: The full size and zoomed in map of the slabs modeled herein. Slabs 21-28 are infinitely thin and are used to have more control over the thermal resistance through the wall from one assembly to another.

The only thermal connections between slab nodes that are modeled are the connections between the infinitely thin slab node and the main wall slab node that it is touching (e.g. slab 23 to slab 1). To

simplify the modeling, these connections are entered with a fixed thermal resistance [Ref. 2.2.4, Section 6.2.6]. COBRA requires the thermal resistance in s-ft-°F/BTU, which is calculated using the equation below.

$$R = \frac{Wd}{Pd \times k} \qquad \textbf{Eq. 3.2-6}$$

where:

Wd = distance from the center of the solid wall node to the connection edge (in)

Pd = length of the connection between the two slabs (= W/2 = 4.15 in)

k = thermal conductivity of the wall (BTU/s-ft-°F)

The assembly walls are shown in Figure 3.15. Between the assemblies there are two sheets of 0.125 inch thick stainless steel, two sheets of 0.062 inch thick stainless steel, and two sheets of boron carbide that are each 0.21 inches thick (Input 4.2). The storage cells are on 10 inch centers and the inside wall dimension for the assemblies is 8.3 inches (Input 4.2). Therefore, there is a total of 1.7 inches of "storage cell wall" of which 0.374 inches is stainless steel and 0.42 inches is boron carbide. That leaves 0.906 inches of air between adjacent assemblies. This air is the predominant source of thermal resistance: the thermal conductivity of stainless steel is 10.9 BTU/hr-ft-°F, the thermal conductivity of boron carbide is 29 – 67 W/m-K (= 16 – 39 BTU/hr-ft-°F) (Input 4.3), and the thermal conductivity of air is on the order of 0.02 BTU/hr-ft-°F (Input 4.4). Conservatively, the thermal resistance of the "wall" between the storage cells is modeled as 0.906 inches of static air. In reality, there would likely be some air flow between the cells which would significantly increase the amount of heat transfer between storage cells. The thermal resistance is calculated using equation 3.2-6 above. The thermal resistance of air at 500°F is used as 500°F is the average temperature in the middle of the wall for the entire height (see Attachment 9 results for Slabs 1 and 2). This value is conservative: higher air temperatures have higher thermal conductivities (Input 4.4), and the regions near the top of the storage cells will have a higher temperature gradient and therefore more heat transfer.

$$R = \frac{Wd}{Pd \times k} = \frac{0.906\ in/2}{4.15\ in \times 0.0231 \frac{BTU}{hr-ft-^\circ F} \times \frac{hr}{3600\ sec}} = 17{,}011 \frac{sec-ft-^\circ F}{BTU}$$

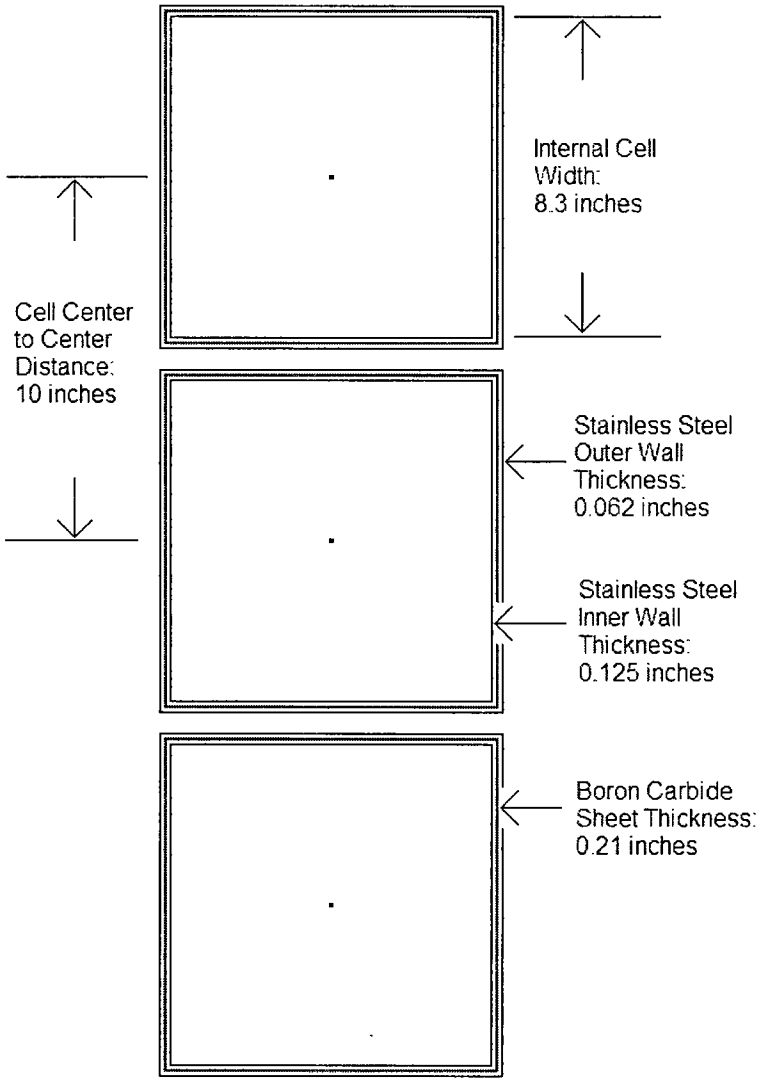

Figure 3.15: The internals of the assembly cell walls are shown.

Finally, the channels that touch each slab are identified. There are two connection types between channels and slabs. Each connection type requires the geometry factor and the connection length, as calculated below.

Connection Type	Geometry Factor	Value	
Corner	*(t/2) / C*	0.1166	**Eq. 3.2-7**
Side	*(t/2) / P*	0.1124	**Eq. 3.2-8**
Thin Slab	Thickness = 0	0.0	

(see Attachment 5 for calculations of above values)

Connection Length	Value
C	0.546
P	0.556

3.2.6 RADG Inputs

The RADG input section describes the radiative heat transfer within the assemblies used in this analysis. This model includes radiative heat transfer to all of the slabs. For each assembly, the wall nodes of the assembly must be specified. Figure 3.14 shows the wall node numbers for the assemblies. The infinitely thin slabs are used for the walls between the assemblies.

Gray body view factors are calculated using the auxiliary program RADGEN. The input manual for RADGEN is also in the COBRA User's Manual [Ref. 2.2.4]. RADGEN is a simple program. The inputs required to run the program are as follows.

- Type of geometry: For this analysis, the rods are arranged on a square pitch.
- Pitch-to-diameter ratio: From Input 4.2, the rod pitch is 0.556 inches and the rod diameter is 0.422 inches. The pitch to diameter ratio is 1.318.
- Number of rods in each row and number of rows: The rods are in a 14 x 14 grid.
- Rod outside diameter: As stated above, the rod diameter is 0.422 inches.
- Distance between the edge of the rods and the storage cell wall: From Attachment 5, the distance from the center of the last rods to the storage cell wall is 0.536 inches. Half the rod diameter is 0.211 inches. Therefore the distance from the edge of the rods to the wall is 0.325 inches.
- Rod emissivity: The default value of 0.8 is used as the emissivity of the cladding.
- Wall emissivity: The default value of 0.2 is used as the emissivity of the stainless steel.
- Number of wall surfaces: The code will only allow 8 surfaces.
- Lumping options: Rod lumping (i.e. modeling multiple rods as a single large rod) is not used in this analysis.

3.2.7 HEAT Inputs

The HEAT input section describes the heat transfer coefficients used in this analysis. The model allows a laminar and a turbulent heat transfer correlation to be used following the generic formula below.

$$H = (a_1 Re^{a_2} Pr^{a_3} + a_4)\, k/D_e$$

Eq. 3.2-9

where:

H = heat transfer coefficient (Btu/hr-ft^2-°F)
Re = Reynolds number
Pr = Prandtl number
k = thermal conductivity of air (Btu/hr-ft-°F from Input 4.4)
D_e = channel hydraulic diameter (ft)
$a_1, a_2, a_3, a_4,$ = coefficients of the correlation

The COBRA manual [Ref. 2.2.4, pg. 7.5] suggests using heat transfer correlations of:

$$H_{laminar} = \frac{k}{D_e}\left(0.83 \times Re^{0.33} \times Pr^{0.33}\right)$$ **Eq. 3.2-10**

$$H_{turbulent} = \frac{k}{D_e}\left(0.33 \times Re^{0.6} \times Pr^{0.3}\right)$$ **Eq. 3.2-11**

This analysis also models conduction, but not mixing, through the air between channels. See Attachment 6 for the code inputs used in this analysis.

3.2.8 DRAG Inputs

The DRAG input section describes the pressure losses due to wall friction and due to obstructions in the assembly.

The friction factor is specified for laminar and turbulent flow based on the equation below (see Eqns. 6.14 and 6.15 of Ref. 2.2.4).

$$f_L = a_L \times Re^{b_L} + c_L$$ **Eq. 3.2-12**

$$f_T = a \times Re^{b} + c \times Re^{d} + e$$ **Eq. 3.2-13**

In Equation 3.2-12, b_L is equal to -1 [Ref. 2.21, pg. 4-16].

The total grid spacer, entrance, and exit resistance coefficient is 30 for a flow area of 32 in^2 (Input 4.2). The flow configuration in the spent fuel pool has a flow area of 41.48 in^2 (Attachment 7). Therefore the resistance coefficient must be scaled up. The pressure drop through a form loss is proportional to the friction factor and to the velocity of the flow squared [Ref. 2.22, pg. 3-2 and Ref. 2.30, pg. 3-3]. For laminar flow, as is the case in this analysis where the Reynolds number is on the order of 100 (see Attachment 7), the friction factor is a function of the inverse of the Reynolds Number as stated above. As the Reynolds Number is a function of the velocity [Ref. 2.30, pg. 3-6], the pressure drop for laminar flow is proportional to velocity to the first power. Therefore, to account for the difference in flow area, the resistance coefficient must be scaled by the ratio of the area. The resistance coefficient for the assemblies in the spent fuel pool is therefore 39 (=30 x 41.48 / 32). Note this discussion is further supported in Reference 2.31 (see Attachment 20) which states that the pressure drop is proportional to velocity to the first power.

As stated in Section 3.2.3, COBRA is used to evaluate the heat transfer from the rods to the air and the maximum temperature of the cladding. Therefore, the total resistance is modeled as being distributed uniformly across the heated length of the rod as a resistance coefficient of 3.9 every ninth of the height of the model (ten locations of a resistance coefficient of 3.9, the first resistance is located at height 0). See Attachment 6 for the code inputs used in this analysis.

3.2.9 OPER Inputs

The OPER input section describes the boundary conditions for the model. For this model, a uniform inlet temperature and an average air mass flux are used. The uniform inlet temperature is taken from Section 7.1 of this analysis with the addition of a downcomer heat-up temperature to account for the increase in temperature as the air travels down the downcomer (see below for the calculation of this downcomer temperature increase). In addition, the heat generation rate and generation profile for the rods are entered. A uniform generation profile is used. This is conservative compared to a sine curve

generation profile as it maximizes the heat generated at the top of the rods where the air temperature is greatest.

Note: The last two numbers in the second row of OPER are multipliers on the air mass flux and heat generation rate for each of the assemblies respectively. These are used in this model to increase the number of significant digits that can be presented in the third and fourth rows of OPER.

3.2.9.1 Heat Generation Rate

The heat generation rate is applied to the entire rod diameter. The total heat generated in the rods for the worst case assembly is 11,975 BTU/hr on October 30th, 2014 and is 8,622 BTU/hr on May 18th, 2015 (Input 4.2). The worst case assembly has an assembly power factor of 1.449 [1]. The worst case five assembly arrangement, which is different from the worst assembly, has an assembly power factor of 1.386 (Input 4.2). It is appropriate to use the heat generation rates from the worst case five assembly arrangement for the following reason (taken from Reference 2.20, note that M52 is in the farthest left five assembly arrangement in Figure 3.10).

> *Note that there are several other Cycle 32 discharge assemblies with higher assembly power factors than M52. However, all of these assemblies are surrounded on all four sides by "cold" fuel discharged before Cycle 30. The heat load for the M52 configuration bounds the heat loads associated with the higher powered assemblies because the assemblies surrounding the higher power assemblies produce much less decay heat.*

The maximum heat load is scaled based on the assembly power factor of M52. This is shown in Attachment 12, Sheet 2. The total heat generated in the rods for the assembly used in this analysis (i.e. the heat generated in the Cycle 32 assembly of worst case five assembly arrangement) is 11,455 BTU/hr on October 30th, 2014 and is 8,247 BTU/hr on May 18th, 2015 (Attachment 12, Sheet 2).

The heat generated in the adjacent Cycle 29 assemblies is 2300 BTU/hr on October 30th 2014, which is also used for the May 2015 analysis (Input 4.2). This Cycle 29 heat load was selected to coincide with the worst case five assembly arrangements. Every five assembly arrangement in the spent fuel pool will have at least two assemblies with heat loads less than or equal to this Cycle 29 heat load [Ref. 2.20]. It is therefore conservative to model every assembly as being adjacent to two of these Cycle 29 assemblies and two adiabatic walls.

The heat generation rate per unit of rod volume is calculated in Attachment 6. The heat generation is entered in MBTU/hr-ft^3 for each of the three modeled assemblies. As stated in Section 3.2.9, the second row of OPER includes a multiplier for the heat generation rates. As the heat generation rates in this analysis are on the order of thousands of BTU/hr-ft^3, the multiplier in the second row (the last entry in that row) is set to 0.001. This means that the heat generation rates in the fourth row of OPER are entered in kBTU/hr-ft^3. The Cycle 32 heat load decreases much more quickly than the whole pool heat load, as shown in Figure 3.16 (see Attachment 12 for data).

[1] The "assembly power factor" is defined as the multiplier on the heat generation rate for an average assembly for a given cycle to determine the heat generation rate for a specific assembly. For example, if Cycle 30 assemblies have an average heat load of 3000 BTU/hr at a given decay date and the peak assembly power factor for a specific Cycle 30 assembly is 1.1, then the heat generation rate for that assembly would be 3300 BTU/hr.

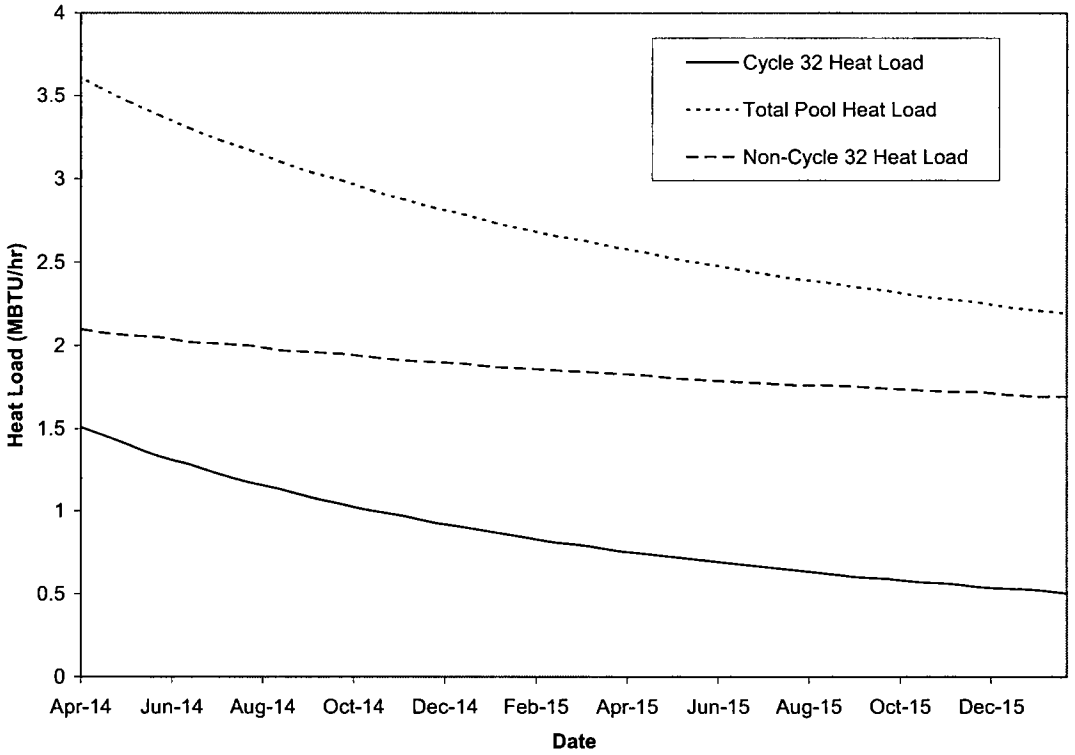

Figure 3.16: The decay rates in Cycle 32 and the rest of the pool are shown. In October 2014, Cycle 32 makes up 1/3 of the total pool heat load. In May 2015, Cycle 32 makes up approximately 1/4 of the total heat load.

3.2.9.2 Air Mass Flux

The average air mass flux (G in equations below) is calculated by equating the effective pressure increase due to the flow generated by natural circulation with the pressure drop caused by obstructions in the channel. The air flow path is shown in Figure 3.17 below. For this part of the analysis, where the goal is to determine the flow characteristics, the total height of the storage cell is used.

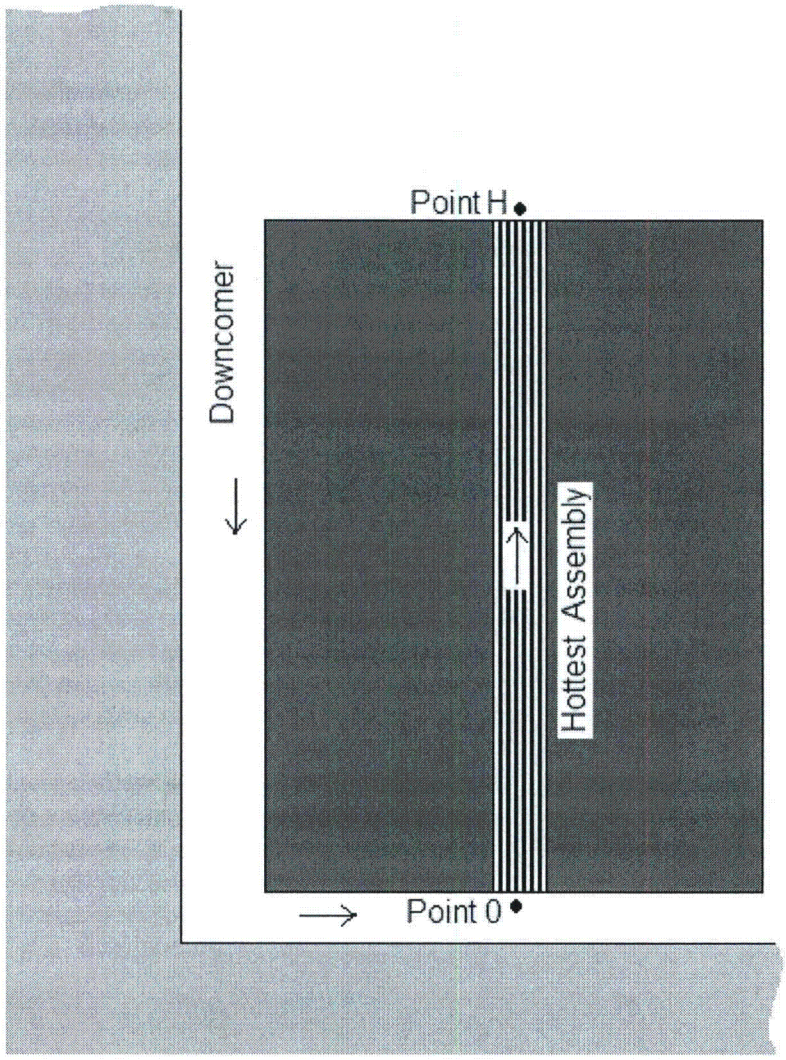

Figure 3.17: Schematic of the flow path used in this section

The pressures and flow characteristics can be calculated using the Navier-Stokes equation for momentum in the vertical direction (z) shown below.

$$\frac{\partial(\rho w)}{\partial t_t}+\frac{\partial(\rho u w)}{\partial x}+\frac{\partial(\rho v w)}{\partial y}+\frac{\partial(\rho w^2)}{\partial z}=-\frac{\partial P_r}{\partial z}+\rho g+\frac{1}{Re}\left[\frac{\partial \tau_{xz}}{\partial x}+\frac{\partial \tau_{yz}}{\partial y}+\frac{\partial \tau_{zz}}{\partial z}\right] \qquad \textbf{Eq. 3.2-14}$$

where:

ρ = density at a given point
t_t = time
x,y,z = location in horizontal, horizontal, and vertical directions respectively
u,v,w = velocity in the x, y, and z directions respectively
P_r = actual pressure

$$\frac{1}{Re}\left[\frac{\partial \tau_{xz}}{\partial x}+\frac{\partial \tau_{yz}}{\partial y}+\frac{\partial \tau_{zz}}{\partial z}\right] = \text{form and friction pressure losses as a function of distance}$$

This analysis is steady-state and the flows in the horizontal direction are zero in the storage cell and downcomer. The momentum equation is simplified as shown below.

$$\frac{\partial(\rho w^2)}{\partial z} = -\frac{\partial P_r}{\partial z} + \rho g + [form + friction\ losses] \qquad \textbf{Eq. 3.2-15}$$

The mass flux through the storage cell is defined as the mass flow rate per square foot, and is calculated as $G = \rho\ w$. The momentum equation then becomes:

$$\frac{\partial}{\partial z}\left(\frac{G^2}{\rho}\right) = -\frac{\partial P_r}{\partial z} + \rho g + [form + friction\ losses] \qquad \textbf{Eq. 3.2-16}$$

where:
G = mass flux

There are still two unknowns: the pressure rise along the storage cell and the mass flux. The two equations are the z-momentum equation through the storage cell (Point 0 to Point H in Figure 3.17) and the z-momentum equation in the downcomer (Point H back to Point 0 in Figure 3.17). Note that the horizontal flows are neglected here. This is because the form and friction losses are negligible both above and below the racks. Comparing the loss coefficients in Reference 2.22 to the analyses presented in Attachment 7 shows that the loss through a 90 degree bend is small compared to the losses in the storage cell.

Both of these equations rely on the z momentum equation above. The equations will be integrated across the height of the storage cell. The pressure increase from the volume above the pool through the downcomer to the volume under the racks is set equal to the pressure decrease from the volume under the racks up the storage cell to the volume above the pool. Figure 3.17 shows the flow path of the air modeled in this analysis.

Note that for all integration, the temperature, and therefore density, of air through the storage cell is modeled as linear through the storage cell. This is a simplification; however, it is appropriate because the fuel is modeled with a uniform heat generation rate (Assumption 5.1).

The four terms are detailed below.

The mass flux term, when integrated, becomes:

$$\left.\frac{G^2}{\rho(z)}\right|_0^H \qquad \textbf{Eq. 3.2-17}$$

through the storage cell and:

$$\left.\frac{G^2}{\rho(z)}\right|_H^0 \qquad \textbf{Eq. 3.2-18}$$

through the downcomer. Therefore, these terms will cancel out when the two equations are summed.

The pressure term, when integrated, becomes:

$$P_r\Big|_0^H \qquad \textbf{Eq. 3.2-19}$$

and: $P_r\Big|_H^0$ **Eq. 3.2-20**

through the storage cell and the downcomer respectively. Therefore, these terms will cancel out when the storage cell and downcomer equations are summed.

When the static head term, ρg, is integrated in z, it becomes:

$$\int \rho(z)\ g\ dz \qquad \textbf{Eq. 3.2-21}$$

In the downcomer (the flow path from Point H to Point 0 in Figure 3.17), the temperature is constant across the entire vertical section. The static head term therefore becomes:

$$\int_H^0 \rho(z)\ g\ dz = -\rho_{blg}\ g\ H \qquad \textbf{Eq. 3.2-22}$$

where:
H = height of the storage cells
ρ_{blg} = density of air in the Fuel Handling Area as a whole

In the storage cell, however, the density is a function of elevation. From Assumption 5.1 and above, the density is assumed to vary linearly through the storage cell from the higher density at Point 0 to the lower, heated air density at Point H. The static head integral is simplified, therefore, to be:

$$\int_0^H \rho(z)\ g\ dz = \rho_{avg}\ g\ H \qquad \textbf{Eq. 3.2-23}$$

where:
ρ_{avg} = density of average air temperature (T_{avg}) in the storage cell

The average density of air in the storage cell is calculated using the ideal gas law, as shown in the equations below.

$$\rho_{avg} = \frac{1}{H}\int_{x=0}^{H} \rho(x)dx = \frac{1}{H}\int_{x=0}^{H} \frac{P \times MW}{R \times T(x)}dx = \frac{P \times MW}{R \times H}\int_{x=0}^{H} \frac{1}{T(x)}dx$$

$$\int_{x=0}^{H} \frac{1}{T(x)} dx = \int_{x=0}^{H} \frac{1}{T_{in} + (T_{out} - T_{in})\frac{x}{H}} dx = \frac{H}{(T_{out} - T_{in})} ln\left(T_{in} + (T_{out} - T_{in})\frac{x}{H}\right)\Big|_{0}^{H}$$

$$\int_{x=0}^{H} \frac{1}{T(x)} dx = \frac{H}{(T_{out} - T_{in})}\left[ln(T_{out}) - ln(T_{in})\right] = \frac{H \times ln\left(\frac{T_{out}}{T_{in}}\right)}{(T_{out} - T_{in})}$$

$$\rho_{avg} = \frac{P \times MW \times ln\left(\frac{T_{out}}{T_{in}}\right)}{R \times (T_{out} - T_{in})}$$ **Eq. 3.2-24**

The form and friction pressure loss from Point 0 to Point H through the storage cell is calculated using the following equation (based on Ref. 2.22 pg. 3-4).

$$\Delta P_f = k\frac{G^2}{2\rho}$$ **Eq. 3.2-25**

where:
k = hydraulic resistance coefficient
P_f = form and friction pressure drop

The hydraulic resistance coefficient through the storage cell is made up of two components: the form resistance and the friction resistance. From Section 3.2.8, a form resistance coefficient of 39 is used for the fuel assembly stored within a storage cell. The friction resistance is based on correlations from NUREG/CR-6441 [Ref. 2.21] and Crane [Ref. 2.22]. From Crane, the resistance coefficient is calculated based on the friction factor as shown below:

$$k = f\frac{H}{D_h}$$ **Eq. 3.2-26**

where:
f = friction factor
D_h = hydraulic diameter = $4H_{area}/H_{perim}$ **Eq. 3.2-27**
H_{area} = hydraulic area = $W\,L - 15^2\,(\pi D^2/4)$ = 41.48 in^2 **Eq. 3.2-28**
H_{perim} = wetted perimeter = $2\,(W + L) + 15^2\,(\pi D)$ = 293.05 in **Eq. 3.2-29**

The hydraulic diameter is therefore 0.566 inches (= 4 (41.48) / 293.05).

The friction factor is calculated using the below equations from NUREG/CR-6441[Ref. 2.21, pgs. 4-16 and 4-17].

$$C_f = a + b_1(P/D - 1) + b_2(P/D - 1)^2$$ **Eq. 3.2-30**

$$f = \frac{C_f}{Re^n}$$ **Eq. 3.2-31**

where:

C_f = friction factor coefficient
a, b_1, b_2, n = parameters from Ref. 2.21, pg. 4-16 and 4-17
P = pitch (0.556 inches see Section 3.2.3)
D = cladding outer diameter (0.422 inches see Section 3.2.3)
Re = Reynolds number = $G\,D_h / \mu$ **Eq. 3.2-32**
μ = dynamic viscosity of the fluid

For a P/D ratio of 1.1 to 1.5 and laminar flow, a is 33.55, b_1 is 263.7, b_2 is -190.2, and n is 1 [Ref. 2.21, pgs. 4-16 and 4-17]. The interior flow values from Reference 2.21 are used for all the channels in order to simplify the analysis.

The form and friction losses from Point H to Point 0 through the downcomer are neglected. The hydraulic diameters of the flow paths through the downcomer and below the racks are much larger than the 0.566 inch hydraulic diameter in the assembly: the minimum downcomer gap width is 6.27 inches [Ref. 2.18]. A limitation of this analysis is that the gap between the bottom of the racks and the floor is at least 5 inches (see Limitation 1 in Section 8).

When Equations 3.2-17, 18, 19, 20, 22, 23, 25, and 26 are inserted into Equation 3.2-16 and the storage cell flow path and downcomer flow path are summed, the final equation describing the scenario is the following:

$$0 = 0 + Hg\left(\rho_{avg} - \rho_{blg}\right) + \left(\left[k_{form} + f\frac{H}{D_h}\right]\frac{G^2}{2\rho_{avg}}\right)$$ **Eq. 3.2-33**

Which simplifies to:

$$G = \sqrt{\frac{2\rho_{avg} Hg\left(\rho_{blg} - \rho_{avg}\right)}{\left[k_{form} + f\frac{H}{D_h}\right]}}$$ **Eq. 3.2-34**

Because the mass flux, G, and friction factor, f, are interrelated, the above equations must be solved iteratively. The steps of the iteration are as follows.

1. A mass flux is estimated

2. The outlet temperature is calculated using the following equation:

$$T_{out} = T_{in} + \frac{Heat_{gen}}{G \times H_{area} \times c_p}$$ **Eq. 3.2-35**

where:

T_{out} = outlet temperature at the top of the storage cell
T_{in} = temperature at the inlet of the storage cell: the Fuel Handling Area temperature

$Heat_{gen}$ = heat generated in the assembly
c_p = specific heat at the estimated average temperature

3. The average temperature is calculated assuming the temperature in the storage cell is linear. The density at the average temperature is calculated using the ideal gas law.

4. The specific heat at the average temperature is compared to the one used in step 2. If needed, steps 2 through 4 are repeated.

5. The hydraulic resistance is calculated and the mass flux is evaluated using Equation 3.2-34.

6. Steps 1 through 5 are repeated until the mass flux in step 1 is equal to the mass flux in step 5.

The spreadsheets using this procedure are shown in Attachment 7. For each date, three different cases are shown in Attachment 7: the worst case assembly, the adjacent assemblies, and an average assembly. The third case is used to determine the temperature increase of the air coming through the downcomer, as discussed in Section 3.2.9.3.

The air mass flux rate is entered in Mlb/hr-ft^2 for each of the three assemblies. As stated in Section 3.2.9, the second row of OPER includes a multiplier for the air mass flux. As the mass fluxes in this analysis are on the order of hundreds of Mlb/hr-ft^2, the multiplier in the second row (the second to last entry in that row) is set to 0.0001. This means that the mass fluxes in the third row of OPER are entered in hundreds of lb/hr-ft^2.

3.2.9.3 Downcomer Temperature Rise

The temperature increase of the air coming through the downcomer is calculated using equations from Fundamentals of Mass and Heat Transfer (Ref. 2.6, Ch. 8). In Attachment 7, using the methods presented in Section 3.2.9.2, the mass flux through an average storage cell is calculated. This is multiplied by the number of assemblies in the pool and the open area in each storage cell/assembly to calculate the mass flow rate through the downcomer. From Assumption 5.4, half of the heat generated in the fuel assemblies that are in storage cells on the edge of the racks is transferred to the air in the downcomer. The heat generation rate for these edge fuel assemblies is calculated in Attachment 12.

The temperature increase is calculated using the following equation (from Ref. 2.6, Ch. 8):

$$q = c_p \times \dot{m} \times \left(T_{bottom} - T_{top}\right) \qquad \textbf{Eq. 3.2-36}$$

$$T_{bottom} = T_{top} + \frac{q}{c_p \times \dot{m}} \qquad \textbf{Eq. 3.2-37}$$

where:
q = heat transferred (50% of the heat generated in the assemblies in edge storage cells per Assumption 5.4)
c_p = heat capacity of air
$\dot{m}$ = mass flow through the downcomer
T_{top} = temperature at the top of the downcomer, the result of the GOTHIC analysis
T_{bottom} = temperature at the bottom of the downcomer, the COBRA inlet temperature

The downcomer temperature increase, $T_{bottom} - T_{top}$, is also added to the GOTHIC analysis results for the ventilation case to determine the input temperature for the COBRA model.

3.2.9.4 Inter-Assembly Heat Transfer

Because this analysis models heat transfer among three adjacent assemblies, Sections 3.2.9.2 and 3.2.9.3 are iterated in order to match the temperatures of the outlet air in the COBRA model with the stack effect calculations shown in Attachment 7. The results from the COBRA model are used to adjust the heat applied to the air in Attachment 7. The Attachment 7 spreadsheets are then iterated to determine new air flow rates. These flow rates are then used in another COBRA run. This process is iterated until the outlet air rates match between COBRA and Attachment 7.

3.2.10 CALC Inputs

The CALC input section describes the time steps and the convergence criteria for this analysis. This analysis is a steady-state calculation. The defaults are used for the convergence criteria. The maximum number of iterations is set to 500 (the default is 20 per Reference 2.2.4). This will ensure that the steady state solution has converged.

3.2.11 OUTP Inputs

The OUTP input section describes the printed output file. For this model, the channels, rods, and slab outputs are printed. Also, the channel exit and assembly average values are printed.

The COBRA model ends with the word endd.

4. INPUT DATA

4.1 Fuel Handling Area Dimensions

The figures below provide sketches of the FHA with dimensions taken from plant structural drawings [Ref. 2.9]. These dimensions are used in Sections 3.1.1 and 3.1.2.1 to build the GOTHIC model.

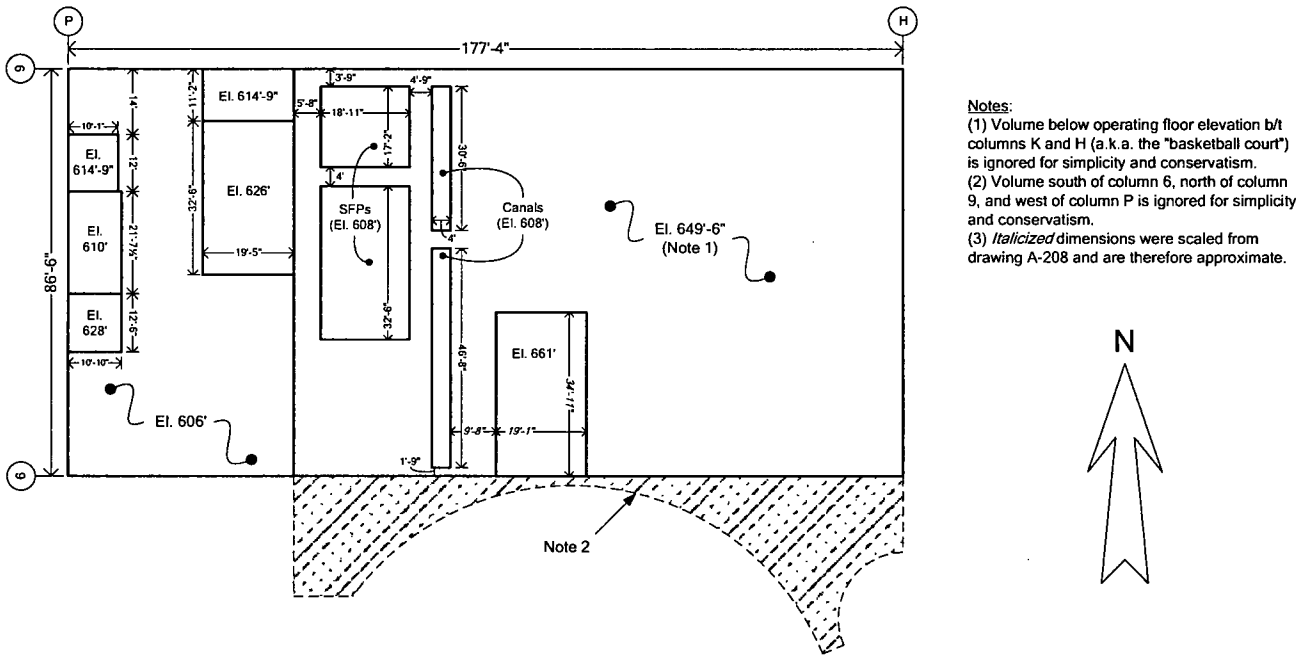

Figure 4.1: FHA Plan View

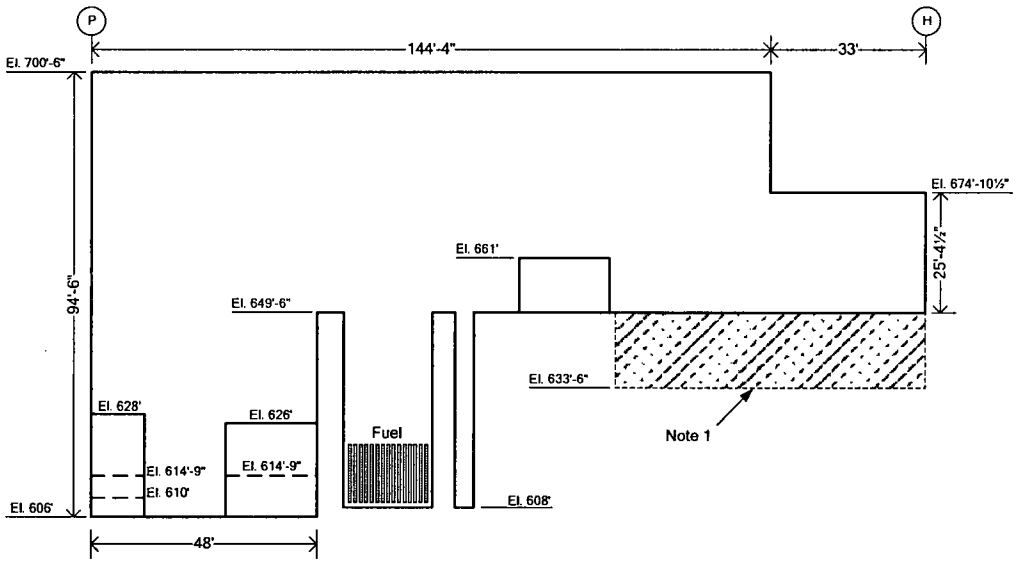

Figure 4.2: FHA Section View (looking north)

4.2 Fuel Assembly and Storage Cell Geometry

The geometry input for the fuel assembly modeled in COBRA is shown in Table 4.1 below. Per Section 3.2 of the USAR (Ref. 2.15.2), the most recent fuel in the core is Westinghouse 422V+.

Table 4.1: Fuel Assembly Geometry Inputs

Input	Value	Units	Reference
Assembly Configuration	14 x 14		Ref. 2.15.1
Assembly Height	159.775	inches	Ref. 2.15.2, Fig. 3.2-8
Storage Cell Length	8.3	inches	Ref. 2.8, Sec. 2.2
Storage Cell Width	8.3	inches	Ref. 2.8, Sec. 2.2
Storage Cell Wall Thickness	0.125	inches	Ref. 2.8, Sec. 2.2
Storage Cell Wall Material	Stainless Steel		Ref. 2.8, Sec. 2.2
Fuel Rod Spacing (Pitch)	0.556	inches	Ref. 2.15.1
Fuel Pellet Diameter	0.3659	inches	Ref. 2.15.1
Heated Rod Length	143.25	Inches	Ref. 2.15.1
Cladding Inner Diameter	0.3734	inches	Ref. 2.15.1
Cladding Outer Diameter	0.422	inches	Ref. 2.15.1
Outer Diameter of Guide Tubes (Above Dashpot)	0.526	inches	Ref. 2.15.1
Outer Diameter of Instrument Tubes	0.422	inches	Ref. 2.33
Cladding Material	ZIRLO		Ref. 2.15.1
Number of active fuel rods	179		Ref. 2.15.1
Max Assembly Heat Generation on 10/30/14	11,975	BTU/hr	Below, Ref. 2.17
Avg Assembly Heat Generation on 10/30/14 in the North/South Pools (i.e. without the Transfer Canal)	3,266	BTU/hr	Below, Ref. 2.17
Max Assembly Heat Generation on 5/18/15	8,622	BTU/hr	Below, Ref. 2.17
Avg Assembly Heat Generation on 5/18/15 in the North/South Pools (i.e. without the Transfer Canal)	2,809	BTU/hr	Below, Ref. 2.17
"Worst Five Assembly Arrangement" Cycle 29 Assembly Heat Generation on 10/30/14	2,300	BTU/hr	Att. 2 of Ref. 2.20
Worst Case Assembly Power Factor	1.449		Ref. 2.20
"Worst Five Assembly Arrangement" Power Factor for Cycle 32 Assembly	1.386		Ref. 2.20
Center to Center Assembly Pitch	10	inches	Ref. 2.8, Sec. 3.8
Stainless Steel Inner Cell Wall Sheet Thickness	0.125	inches	Ref. 2.8, Fig. 4-1
Stainless Steel Outer Cell Wall Sheet Thickness	0.062	inches	Ref. 2.8, Fig. 4-1
Boron Carbide Wall Sheet Thickness	0.21	inches	Ref. 2.8, Sec. 2.2

The assembly heat generation rate is calculated to more significant figures than were reported in the ETE [Ref. 2.17, pg. 14 of 80]. The ETE reports that the hottest fuel assembly is 0.012 MBTU/hr, and that the hottest assembly is calculated by taking the total heat load from the Cycle 32 offload (1.04 MBTU/hr), dividing by the number of assemblies in that offload (121) and multiplying by the highest assembly power fraction (1.449). The assembly heat generation rates are recalculated in Attachment 12.

The gap between the fuel pellets and the zirconium wall is filled with helium [Ref. 2.15.2, pg. 3.2-25].

The form resistance coefficient internal to the fuel assembly stored within the storage cell is the sum of the entrance and exit resistance and the resistance due to the grid spacers. Reference 2.20 states that the total form resistance coefficient is 30 given a Reynolds number of 100 and a flow area of 32 square inches [Ref. 2.20].

4.3 Solid Material Properties

The properties for the fuel, cladding, and pool rack that are modeled in COBRA are shown in Table 4.2 below.

Table 4.2: Solid Materials Property Inputs

Input	Value	Units	Reference
Maximum Allowable Zirconium Temperature(1)	565	°C	Ref. 2.1, § 3.1.3
Zirconium Thermal Conductivity	20.7	W/m-K	Ref. 2.6, pg. 908
Zirconium Specific Heat	322	J/kg-K	Ref. 2.6, pg. 908
Zirconium Density	6570	kg/m^3	Ref. 2.6, pg. 908
Uranium Dioxide Thermal Conductivity at 500°F	4.3	BTU/hr-ft-°F	Ref. 2.26, pg. 814
Uranium Dioxide Specific Heat at 500°F	0.07	BTU/lb-°F	Ref. 2.26, pg. 814
Uranium Dioxide Density	684	lb/ft^3	Ref. 2.26, pg. 814
Fuel Density	96.56%	of maximum	Ref. 2.15.1
Thermal Conductivity of Stainless Steel at 527°F	10.9(2)	BTU/hr-ft-°F	Ref. 2.3, Table A-1
Thermal Conductivity of Boron Carbide	29-67	W/m-K	Ref. 2.19

(1) Several studies are presented in NUREG/CR-6451. Brookhaven National Laboratory determined that 565°C is appropriate to be used as the critical cladding temperature. SECY-99-168 [Ref. 2.28] states that 565°C is the temperature based on the onset of clad swelling.

(2) The thermal conductivity of stainless steel is taken at 527°F. This temperature is an appropriate midpoint between the lower temperature entering the storage cell and the higher temperature of air exiting the storage cell. In addition, the thermal conductivity of the stainless steel walls does not significantly affect the results because the walls are adiabatic.

4.4 Air and Helium Properties

Air properties are taken from References 2.3 and 2.4. The relevant air properties for the COBRA models are shown in Table 4.3 and Table 4.4 below.

Table 4.3: Air Properties from Kreith [Ref. 2.3, pg. 636]

Temperature (°F)	Density (lb/ft^3)	Conductivity (Btu/hr-ft-°F)	Heat Capacity (Btu/lb-°F)	Dynamic Viscosity (lb/ft-sec)
0	0.086	0.0133	0.239	1.110E-05
100	0.071	0.0154	0.240	1.285E-05
200	0.060	0.0174	0.241	1.440E-05
300	0.052	0.0193	0.243	1.610E-05
400	0.046	0.0212	0.245	1.750E-05
500	0.0412	0.0231	0.247	1.890E-05
600	0.0373	0.0250	0.250	2.000E-05
700	0.0341	0.0268	0.253	2.14E-05
800	0.0314	0.0286	0.256	2.25E-05
900	0.0291	0.0303	0.259	2.36E-05
1000	0.0271	0.0319	0.262	2.47E-05
1500	0.0202	0.0400	0.276	3.00E-05

Table 4.4: Air Properties from Sonntag [Ref. 2.4, pg. 636]

Temperature (R)	Temperature (Converted to °F)	Enthalpy (Btu/lb)
440	-19.7	105.212
480	20.3	114.794
560	100.3	133.980
640	180.3	153.216
680	220.3	162.860
760	300.3	182.221
840	380.3	201.701
880	420.3	211.494
960	500.3	231.202
1040	580.3	251.086
1080	620.3	261.099
1160	700.3	281.273
1240	780.3	301.650
1280	820.3	311.915
1360	900.3	332.598
1440	980.3	353.483
1480	1020.3	364.000
1950	1490.3	490.928
2000	1540.3	504.755

Table 4.5: Helium Properties

Property	Value	Units	Reference
Thermal Conductivity of Helium at 800K	0.304(1)	W/m-K	Ref. 2.6, pg. 919

(1) The thermal conductivity of helium is taken at 800K (~980°F). From Reference 2.6, the conductivity of helium increases when the temperature increases. A higher conductivity is conservative because it will maximize the temperature of the cladding. A conductivity of 0.304 W/m-K converts to 0.176 Btu/h-ft-°F.

4.5 Siding Composition

References 2.9.18 through 2.9.23 show that the siding of the FHA is composed of, from inside to outside, a 1½-inch-thick layer of glass fiber insulation of density 1.58 lb/ft^3 and a 1¾-inch-thick air gap enclosed by galvanized steel panels. The thermal properties of glass fiber insulation of similar density are given in the table below. Based on this data, the following properties are used in this analysis: ρ = 1.58 lb/ft^3, c_p = 0.167 Btu/lb-°F, k = 0.0220 Btu/hr-ft-°F.

Table 4.6: Thermodynamic Properties of Glass Fiber Insulation

Density (lb/ft^3)	Specific Heat (Btu/lb-°F)	Thermal Conductivity (Btu/hr-ft-°F)	Reference
1.00	not given	0.0266	2.6, Tbl A.3
1.50	0.167	0.0220	2.29, Tbl A-3
1.75	not given	0.0220	2.6, Tbl A.3
2.50	not given	0.0202	2.6, Tbl A.3

4.6 Roof Composition

The upper roof of the FHA is composed of, from bottom to top, a 1½-inch-thick metal deck, a 2-inch-thick layer of Perlite insulation, a Trocal roof membrane, and a ¾-inch to 1½-inch-thick layer of gravel [Ref. 2.9.11]. It is assumed that the metal deck is made of plain steel (Assumption 5.6), the thermal properties of which are given in Input 4.14. The thermal properties of Perlite and gravel are also given in Input 4.14.

4.7 Thermal Radiative Properties of Various Surfaces

For computing thermal radiation heat transfer between the inside surfaces of the FHA and the surrounding vapor, an emissivity of 0.90 is used. This value is appropriate based on the following data:

- Per Reference 2.23 (Attachment 16), the walls and ceiling of the FHA are off-white. Table A.12 of Incropera & DeWitt [Ref. 2.6] provides that white paint has an emissivity of 0.90 to 0.93.
- Table A.11 of Incropera & DeWitt [Ref. 2.6] provides that concrete has an emissivity of 0.88 to 0.93.

4.8 Solar Radiation Inputs

The following data are used to determine the amount of solar radiation absorbed by the FHA walls and roof per Section 3.1.2.3b.

4.8.1 Latitude and Longitude

The latitude of the station is 44°21' and the longitude is 87°32' [Ref. 2.15.3].

4.8.2 Time Zone

The plant is in the Central Standard Time Zone.

4.8.3 Clearness Number

The clearness number for the region is 1.05, which is taken from Figure 7 in Chapter 27 of the 1993 ASHRAE Handbook of Fundamentals [Ref. 2.14].

4.8.4 Ground Reflectivity

A ground reflectivity of 0.2 is used in this analysis. This is the value recommended in Chapter 14 of ASHRAE 2009 [Ref. 2.13] for a typical mixture of ground surfaces.

4.8.5 Surface Absorptivity

Per Reference 2.23 (Attachment 16), the outside walls of the FHA are white/off-white. Table A.12 of Incropera & DeWitt [Ref. 2.6] provides that white paint absorbs between 16% and 26% of incident solar radiation. For computing the amount of solar radiation that is absorbed by the walls, the higher absorptivity value of 0.26 is used in this analysis.

The roof is covered with a layer of gravel (Input 4.6). Gravel has a solar absorptivity of 0.29 [Ref. 2.25, Table B-2].

4.9 Climate Data

The design dry-bulb temperature (2% occurrence), mean coincident wet-bulb temperature, and mean daily outside temperature range used in this analysis are tabulated below. These temperatures are taken from climatic design information published in ASHRAE 2009 [Ref. 2.13] for the Manitowac Municipal Airport weather station (WMO #726455). A review of climate data from other weather stations near the plant revealed that these values are typical for the region.

Table 4.7: Climate Data

Parameter	October	July (hottest month)
$t_{db,des}$ (°F)	69.6	86.0
t_{mcwb} (°F)	60.0	72.6
DR (°F)	14.9	16.9

The relative humidities associated with the above dry-bulb and wet-bulb temperatures are 57% for October and 53% for July [Ref. 2.13, Chapter 1, Figure 1].

4.10 Total Spent Fuel Decay Heat Loads

The total heat load from spent fuel is 2.93 x 10^6 Btu/hr on October 30, 2014 and 2.52 x 10^6 Btu/hr on May 18, 2015 [Ref. 2.17, page 10]. These heat loads are split between the north and south pits, with 24% of the heat load in the north pit and 76% in the south pit (see Attachment 12).

4.11 Electrical Equipment Heat Loads

Electrical equipment heat loads are computed in Attachment 10. A total heat load of 57.27 kW is computed. This includes the heat load from 103 lighting fixtures and 2 lighting panels. Some of these lighting fixtures may be turned off or burned out. However, this reduction is not credited. Underwater lighting is not included (see Limitation 2 in Section 8).

4.12 Ventilation

ETE-KW-2013-0025 [Ref. 2.23] provides that the following ventilation flow rates exist in the postulated scenario. These flow rates are based on an off-design alignment of the ventilation system that requires operator action (see Limitation 3 in Section 8). The total flow rate exhausted from the FHA is 34,875 cfm, which equates to an air exchange rate of 2.3 turnovers/hr. These flows are illustrated in Figure 3.7.

- Supply air is drawn through the open garage doors and exhausted from the FHA. There are two garage doors: one on the ground floor at the southwest corner of the FHA, and one on the ground floor at the northwest corner of the FHA [Ref. 2.9.10]. The doors are 17 ft. wide by 22 ft. high [Ref. 2.9.10].

- 12,128 cfm of the total flow is exhausted from the FHA through Stairwell K, which is located south of the SFPs and is open to the FHA [Ref. 2.9.15].
- 13,747 cfm of the total flow travels west to east across the "basketball court" (see Figure 4.1) and is exhausted from the FHA through doors or ductwork to Zone SV.
- 9,000 cfm of the total flow is exhausted through the twelve SFP exhaust registers on the west side of the SFPs [Ref. 2.23]. The registers are 36 in. wide by 8 in. high [Ref. 2.10.1]. The midpoint elevation of the registers is approximately 3.7 ft above the operating floor [Ref. 2.10.1, Section A-A].

4.13 Volume of Equipment in Spent Fuel Pools

Table 5.5.1 of Holtec Report HI-992208 [Ref. 2.7] provides the following input data:

Table 4.8: SFP Net Water Volume [Ref. 2.7]

North SFP Surface Area	329 ft^2
South SFP Surface Area	623 ft^2
Transfer Canal SFP Surface Area	120 ft^2
Minimum Pool Water Depth	37 ft
SFPs Net Water Volume	34,080 ft^3

Based on this data, the volume occupied by equipment in the SFPs is 5584 ft^3 ((329 + 623 + 120) x 37 – 34080). Approximating that the equipment is evenly distributed between the three pits gives:

Table 4.9: Volume of Equipment in Spent Fuel Pools

North SFP	1,714 ft^3
South SFP	3,245 ft^3
Transfer Canal SFP	625 ft^3

The effect of equipment is accounted for in the north and south SFPs only (see Section 3.1.1). The effect of equipment on the transfer canal is ignored, which is acceptable because it is offset by the conservatisms listed in Notes 1 and 2 of Figure 4.1.

4.14 Thermal Properties of Various Materials

Thermodynamic properties of various materials are given in the table below.

Table 4.10: Thermal Properties of Various Materials

Material	Density (lb/ft^3)	Specific Heat (Btu/lb-°F)	Thermal Conductivity (Btu/hr-ft-°F)	Reference
Concrete	145	0.156	0.92	2.27
Plain Steel	490	0.12	27.0	2.27
Perlite	6.6	0.1*	0.032	2.6, Tbl A.3
Gravel	116	0.1*	0.22	2.12, Tbl 4.4.3

* The specific heat of these materials could not be found in numerous references. Therefore, a conservatively low value of 0.1 Btu/lb-°F is used in this analysis. Using a low value is conservative because it minimizes the amount of energy that can be absorbed. This parameter has a negligible impact on the results of this analysis.

5. ASSUMPTIONS

5.1 The heat generation rate is assumed to be distributed uniformly along the heated length of the rod (144 inches per Input 4.2). It is conservative to assume a uniform heat generation rate compared to a sine distribution because the heat generation will be greater at the top of the fuel rod for the uniform heat generation rate. This will maximize the heat generation, and therefore temperature of the cladding, at the top of the hottest rods. This assumption applies to the COBRA model.

5.2 The bulk pressure in the Fuel Handling Area is assumed to be 14.7 psia. This is appropriate because the FHA is not air tight. The slight negative pressure developed in the FHA due to ventilation is ignored. The atmospheric pressure does not significantly affect the results.

5.3 For the purposes of calculating the mass flux of air in the storage cell, the temperature of air in the storage cell is assumed to vary linearly. This approximation is appropriate because the heat generation rate in the rod is modeled as being uniform (Assumption 5.1) and because the enthalpy of air is linear through the range of temperatures in this analysis (Input 4.4).

5.4 The heat transfer to the downcomer is assumed to be 50% of the heat generated by the assemblies in the storage cells on the edge of the racks. This heat transfer is used to calculate the temperature increase of the air going through the downcomer. This assumption is conservative because most of the heat will be removed by the air going through the storage cell of those assemblies, as opposed to being transferred through the stainless steel sides of the storage cells and into the downcomer.

5.5 It is assumed that the fuel handling crane is not being operated at any time during the event. Thus, heat loads associated with crane equipment are not included in the GOTHIC model.

5.6 It is assumed that the 1½-inch-thick metal deck referred to in Input 4.6 is plain steel.

5.7 Based on a review of Drawing A-208 [Ref. 2.9.15], one quarter of the Shield Building's circumference is estimated to be inside the FHA and the wall is estimated to be 2.5 feet thick. These inputs to the GOTHIC model have a negligible impact on the results of this analysis; therefore, estimations are acceptable.

6. COMPUTER PROGRAMS

6.1 GOTHIC

GOTHIC (Generation of Thermal-Hydraulic Information for Containments) [Ref. 2.2.1] is a general purpose thermal-hydraulics software package for the analysis of nuclear power plant containments, confinement buildings, and system components. GOTHIC has been verified and validated under S&L's Quality Assurance (QA) program. All runs are performed on S&L PC Nos. EAW16 & EAW17 with the Windows XP Professional operating system. The audit trail for GOTHIC is provided in Attachment 2.

6.2 COBRA

COBRA-SFS [Ref. 2.2.3] is a computer program that performs thermal-hydraulic analysis of assembly spent fuel storage or transportation systems. RADGEN is an auxiliary program included in COBRA that generates gray body view factors to be used in COBRA. COBRA has been verified and validated under S&L's Quality Assurance (QA) program. RADGEN was verified and validated as part of the validation of COBRA. All runs are performed on an MS-DOS v6.22 virtual PC running on VMware Player v2.02.

6.3 UHSSIM, Surface Solar Module

The Surface Solar module of the UHSSIM (Ultimate Heat Sink Simulator) computer program [Ref. 2.2.5] is a software package for determining the time-dependent heat transfer rates to walls from solar and sky radiation. UHSSIM has been verified and validated under S&L's QA program. All runs are performed on S&L PC No. ZL7786 with the Windows XP Professional operating system via controlled folder \\SNLVS5\sys3\Ops$\UHS87010\.

7. RESULTS

7.1 Maximum Air Temperature Between the Storage Racks and the SFP Walls

7.1.1 October 2014 Case

Figure 7.1 shows the maximum air temperatures computed by GOTHIC in the space between the storage racks and the SFP walls in both pits using predicted conditions for October 30, 2014. The maximum temperature is below 180°F (82°C). This temperature data is taken from the GOTHIC output files provided in Attachment 13.

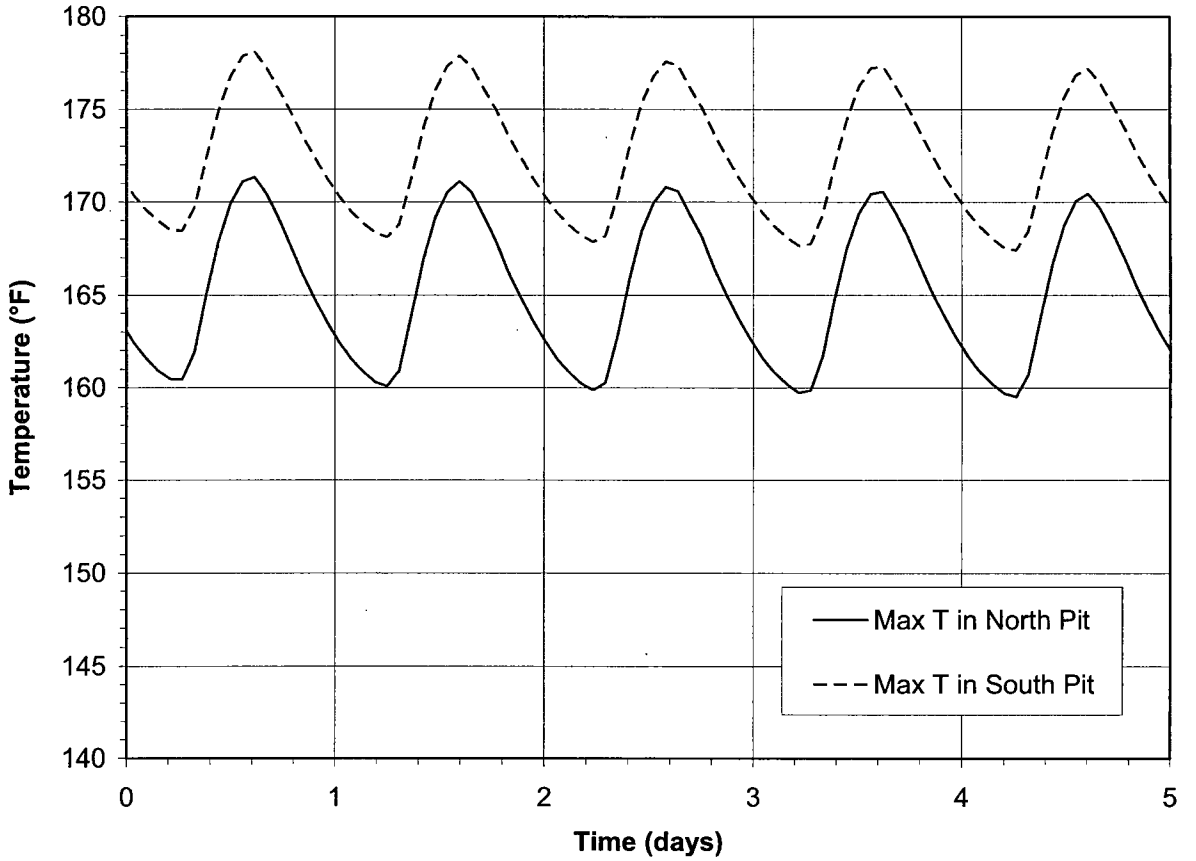

Figure 7.1: Maximum Air Temperatures Between the Storage Racks and the SFP Walls (October 30, 2014)

7.1.2 May 2015 Case

Figure 7.2 shows the maximum air temperatures computed by GOTHIC in the space between the storage racks and the SFP walls in both pits using predicted conditions for May 2015. The maximum temperature is below 195°F (91°C). This temperature data is taken from the GOTHIC output files provided in Attachment 13.

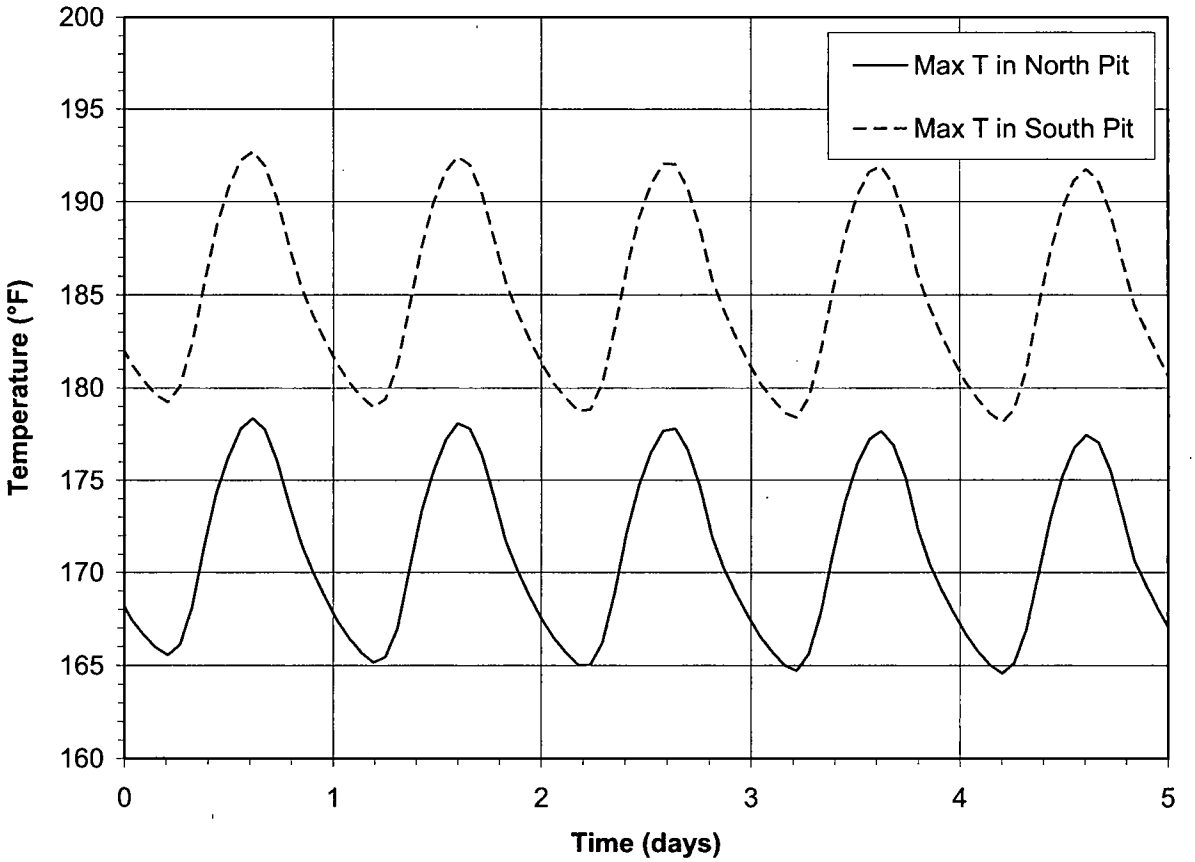

Figure 7.2: Maximum Air Temperatures Between the Storage Racks and the SFP Walls (May 2015)

7.2 Maximum Cladding Surface Temperature

7.2.1 Downcomer Temperature Rise

A temperature of 180°F (82°C) is used as the temperature at the top of the downcomer for the October 2014 case. A temperature of 195°F (91°C) is used as the temperature at the top of the downcomer for the May 2015 case. Based on the results in Attachment 7, the temperature increase for air in the downcomer is 20°F (11°C) for the October 2014 case and 22°F (12°C) for the May 2015 case. Therefore, the inlet temperature for the fuel assemblies for the October 2014 case is 200°F (93°C) and the inlet temperature for the fuel assemblies for the May 2015 case is 217°F (103°C).

7.2.2 Cladding Temperature

The input deck for the COBRA analysis is shown in Attachment 8. The input files for the October 2014 case and May 2015 case are called koct.i and kmay.i respectively. Selected portions of the output deck are shown in Attachment 9. The output files are called koctselected.o and kmayselected.o respectively.

The results of the COBRA analysis show that the maximum cladding temperature for the October 2014 case is 1022°F (550°C). The maximum cladding temperature for the May 2015 case is 876°F (469°C). For both cases, the limiting rod is Rod #105 of the Cycle 32 assembly (see Figure 3.9 for rod numbers).

7.2.3 Adjacent Assembly Heat Transfer

The average air exit temperature at the exit of the Cycle 32 assembly for the October 2014 case is 994°F (534°C). Based on the specific heat capacity of air for the range of temperatures evaluated in this model, approximately 540 BTU/hr is transferred to each of the adjacent Cycle 29 assemblies (see Attachment 7). As the initial heat load of the center Cycle 32 assembly is 11,455 BTU/hr, roughly 5% of the heat load is transferred to each adjacent assembly, or a total of 10%. This heat transfer is evaluated again in Attachment 15 to ensure that the results of the COBRA model are interpreted correctly.

An additional check is used to ensure that the temperatures in the COBRA model match the temperatures used in Attachment 7 to determine the air flow rates through the assemblies. This check also verifies that the energy put into the system by the rods matches the energy removed from the system by the air. For the October 2014 case, the COBRA results show that the outlet temperature is 994°F (534°C) for the hot assembly and 493°F (256°C) for the adjacent assemblies. This matches very closely with the Attachment 7 values of 995°F and 494°F respectively. For the May 2015 case, the COBRA results show that the outlet temperature is 852°F (456°C) for the hot assembly and 512°F (267°C) for the adjacent assemblies. This matches very closely with the Attachment 7 values of 852°F and 513°F respectively.

7.3 Summary of Results

The results discussed above are summarized below.

Case	Maximum Cladding Temperature
October 30, 2014	1022°F / 550°C
May 2015	876°F / 469°C

8. CONCLUSIONS

The results of this analysis show that the surface temperature of the cladding in the spent fuel pools will not exceed the critical temperature for zirconium following a total loss of water from the pools on or after October 30, 2014. The cladding remains below the critical temperature due to adequate FHA ventilation and heat rejection to the outside through the FHA walls and roof.

There are several conservatisms in this calculation. The primary conservatisms are listed below in order of judged significance.

- The heat transfer is only modeled from the hottest assembly in a group of five to two of the four adjacent assemblies. From Figure 3.10 and Figure 3.11, the worst case configurations are a Cycle 32 assembly adjacent to a Cycle 31, Cycle 30, and two Cycle 29 assemblies. From the results section, the heat transferred from the hottest assembly to each of two adjacent Cycle 29 assemblies is roughly 540 BTU/hr, or 5% of the Cycle 32 heat load of 11,455 BTU/hr. The other two adjacent assemblies (Cycle 30 and Cycle 31) would each remove some of the heat from the hot assembly. Even if each assembly only provided an additional 2% of heat removal (~220 BTU/hr) the temperature reduction would be significant. The total temperature increase of the air is roughly 800°F. An additional 4% heat removal would result in a reduction in outlet air temperature by around 30°F (= 800°F x 4%). This is a significant conservatism.

- The resistance coefficient for the assembly as calculated in ETE-NAF-2013-0077 [Ref. 2.17] was conservatively rounded up. A higher resistance coefficient through the assembly results in a lower air flow rate through the assembly and therefore lower heat removal.

- Some large heat sinks are not included in the GOTHIC model. Namely, the floor of the truck bay, the floor of the "basketball court", the Control Complex wall, and the walls and ceilings of the various rooms east of the "basketball court" on elevation 633'-6".

- The outside of the Shield Building wall is conservatively modeled as adiabatic in the GOTHIC model. The Shield Building is not normally ventilated [Ref. 2.24].

- Shading from the Shield Building and other structures is conservatively ignored in the GOTHIC model.

Finally, the acceptance criterion for this analysis—that the cladding surface temperature is maintained below 565°C (1049°F)—is also conservative. Per NUREG/CR-6451 [Ref. 2.1, see Input 4.3], 565°C (1049°F) is the lowest temperature where incipient cladding failure might occur with an expected failure at 671°C (1240°F). Per SECY-99-168 [Ref. 2.28], 800°C (1472°F) is the lowest temperature where self-sustained oxidation would occur and 565°C is the minimum temperature where clad swelling might occur. NUREG-1738 [Ref. 2.5, pg. 3-7] states that runaway oxidation of zirconium occurs at 900°C and 565°C is associated with the 10 hour creep rupture time. For this analysis, 565°C (1049°F) is conservatively used as the critical temperature for the zirconium cladding.

Limitations:

1. The gap between the floor of the spent fuel pool and the bottom of the assembly racks is at least 5 inches.

2. The heat load due to underwater lighting is not included in the GOTHIC model. These lights are normally off and would likely burn out in the event that the SFP is drained. Nevertheless, the operator should take action to verify that the lights are off. The results of the adiabatic fuel heat-up analysis [Ref. 2.32] indicate that the operator must complete this action within 6 hours of the initiating event.

3. The ventilation flow rates used in this analysis (see Input 4.12) are based on an off-design alignment of the ventilation system that requires operator action. Specifically, the operator must shut off the Auxiliary Building supply fans, verify that at least one of two Auxiliary Building exhaust fans and one of two SFP exhaust fans are operating, and open various doors, including the garage doors. The results of the adiabatic fuel heat-up analysis [Ref. 2.32] indicate that the operator must complete these actions within 6 hours of the initiating event.

9. RECOMMENDATIONS

There are no specific recommendations for this analysis.

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Control Volume Parameters

Vol #	Description	Vol (ft3)	Elev (ft)	Ht (ft)	Hyd. D. (ft)	L/V IA (ft2)
1s	SFPs	100.	2.	92.5	100.	DEFAULT
2s	FHA	100.	0.	94.5	100.	DEFAULT
3	Outside	100000.	0.	94.5	100.	DEFAULT

Control Volume Options

Vol #	S Wave Damper	Pool HMT Mult	Pool Opt	Pool Pres. Correction	Gas Tracking	Burn Opt	ICIP Drag
1s	1.	DEFAULT	LOCAL	ON	ON	NONE	ON
2s	1.	DEFAULT	LOCAL	ON	ON	NONE	ON
3	1.	DEFAULT	LOCAL	ON	ON	NONE	ON

Laminar Leakage

Vol #	Lk Rate Factor (%/hr)	Ref Press (psia)	Ref Temp (F)	Ref Humid (%)	Sink or Src	Model Option	Rep Wall	Subvol Option	Leak Area (ft2)
1s	0.					CNST T		UNIFORM	DEFAULT
2s	0.					CNST T		UNIFORM	DEFAULT
3	0.					CNST T		UNIFORM	DEFAULT

Turbulent Leakage

Vol #	Lk Rate Factor (%/hr)	Ref Press (psia)	Ref Temp (F)	Ref Humid (%)	Sink or Src	Model Option	Rep Wall	Subvol Option	Leak Area (ft2)	fL/D
1s	0.					CNST T		UNIFORM	DEFAULT	
2s	0.					CNST T		UNIFORM	DEFAULT	
3	0.					CNST T		UNIFORM	DEFAULT	

X-Direction Noding
Volume 1s

Cell Plane	Distance (ft)	Width (ft)
1	0.	6.67
2	6.67	8.455
3	15.125	8.455
4	23.58	4.

Y-Direction Noding
Volume 1s

Cell Plane	Distance (ft)	Depth (ft)
1	0.	30.08

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Y-Direction Noding (cont.)
Volume 1s

Cell Plane	Distance (ft)	Depth (ft)
2	30.08	18.92
3	49.	11.58
4	60.58	3.
5	63.58	3.
6	66.58	7.585
7	74.165	7.585
8	81.75	4.75

Z-Direction Noding
Volume 1s

Cell Plane	Distance (ft)	Height (ft)
1	0.	1.
2	1.	13.31
3	14.31	13.595
4	27.905	13.595
5	41.5	17.
6	58.5	17.
7	75.5	17.

Cell Blockages - Table 1
Volume 1s

Blockage No.	Description	Type			
1	North Wall	BLK	B	I	N
2	West Wall of Pits	BLK	B	I	N
3	South Wall of Pits	BLK	B	I	N
4	East Wall of Pits	BLK	B	I	N
5	Pit Dividing Wall	BLK	B	I	N
6	N Racks N Wall	BLK	B	I	N
7	N Racks E Wall	BLK	B	I	N
8	N Racks S Wall 1	BLK	B	I	N
9	N Racks S Wall 2	BLK	B	I	N
10	N Racks W Wall 1	BLK	B	I	N
11	N Racks W Wall 2	BLK	B	I	N
12	S Racks N Wall	BLK	B	I	N
13	S Racks E Wall	BLK	B	I	N
14	S Racks S Wall	BLK	B	I	N
15	S Racks W Wall	BLK	B	I	N

Cell Blockages - Table 2
Volume 1s

Blockage No.	Coordinates & Dimensions (ft) X1	Y1	Z1	X2	Y2	Z2	X3	Y3	Z3	L	Curb Height
1	0.	82.75	0.	27.58	86.5	41.5					0.

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Cell Blockages - Table 2 (cont.)
Volume 1s

Blockage No.	Coordinates & Dimensions (ft) X1	Y1	Z1	X2	Y2	Z2	X3	Y3	Z3	L	Curb Height
2	0.	0.	0.	5.67	86.5	41.5					0.
3	5.67	0.	0.	24.58	29.08	41.5					0.
4	24.58	0.	0.	27.58	82.75	41.5					0.
5	5.67	61.58	0.	24.58	65.58	41.5					0.
6	6.67	81.75	1.	23.58	81.75	14.31					0.
7	23.58	81.75	1.	23.58	66.58	14.31					0.
8	15.125	66.58	1.	23.58	66.58	14.31					0.
9	6.67	74.165	1.	15.125	74.165	14.31					0.
10	15.125	66.58	1.	15.125	74.165	14.31					0.
11	6.67	74.165	1.	6.67	81.75	14.31					0.
12	6.67	60.58	1.	23.58	60.58	14.31					0.
13	23.58	30.08	1.	23.58	60.58	14.31					0.
14	6.67	30.08	1.	23.58	30.08	14.31					0.
15	6.669	30.08	1.	6.67	60.58	14.31					0.

X-Direction Cell Face Variations
Volume 1s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.		1000000.	0.	0.
1s38	0	0.		1000000.	0.	0.
1s39	0	0.		1000000.	0.	0.
1s42	0	0.		1000000.	0.	0.
1s43	0	0.		1000000.	0.	0.
1s54	0	0.		1000000.	0.	0.
1s55	0	0.		1000000.	0.	0.
1s57	0	0.		1000000.	0.	0.
1s58	0	0.		1000000.	0.	0.
1s59	0	0.		1000000.	0.	0.
1s29	1	0.210938		4.00781	0.	0.
1s30	1	0.210938		4.00781	0.	0.
1s31	1	0.210938		4.00781	0.	0.
1s32	1	0.210938		4.00781	0.	0.
1s61	1	0.210938		4.00781	0.	0.
1s62	1	0.210938		4.00781	0.	0.
1s63	1	0.210938		4.00781	0.	0.
1s64	1	0.210938		4.00781	0.	0.
1s93	1	0.210938		4.00781	0.	0.
1s94	1	0.210938		4.00781	0.	0.
1s95	1	0.210938		4.00781	0.	0.
1s96	1	0.210938		4.00781	0.	0.
1s125	1	0.210938		4.00781	0.	0.
1s126	1	0.210938		4.00781	0.	0.
1s127	1	0.210938		4.00781	0.	0.
1s128	1	0.210938		4.00781	0.	0.
1s157	1	1.		86.069	0.	0.
1s158	1	1.		86.069	0.	0.
1s159	1	1.		86.069	0.	0.
1s160	1	1.		86.069	0.	0.
1s1	3	0.033203		3.995	0.	0.
1s2	3	0.033203		3.995	0.	0.
1s3	3	0.033203		3.995	0.	0.
1s33	3	0.033203		3.995	0.	0.

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X-Direction Cell Face Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
1s34	3	0.033203		3.995	0.	0.
1s35	3	0.033203		3.995	0.	0.
1s65	3	0.033203		3.995	0.	0.
1s66	3	0.033203		3.995	0.	0.
1s67	3	0.033203		3.995	0.	0.
1s97	3	0.033203		3.995	0.	0.
1s98	3	0.033203		3.995	0.	0.
1s99	3	0.033203		3.995	0.	0.
1s129	3	1.		70.3515	0.	0.
1s130	3	1.		70.3515	0.	0.
1s131	3	1.		70.3515	0.	0.
1s4	4	0.		1e-006	0.	0.
1s8	4	0.		1e-006	0.	0.
1s12	4	0.		1e-006	0.	0.
1s16	4	0.		1e-006	0.	0.
1s20	4	0.		1e-006	0.	0.
1s24	4	0.		1e-006	0.	0.
1s28	4	0.		1e-006	0.	0.
1s32	4	0.789063		14.9922	0.	0.
1s36	4	0.		1e-006	0.	0.
1s40	4	0.		1e-006	0.	0.
1s44	4	0.		1e-006	0.	0.
1s48	4	0.		1e-006	0.	0.
1s52	4	0.		1e-006	0.	0.
1s56	4	0.		1e-006	0.	0.
1s60	4	0.		1e-006	0.	0.
1s64	4	0.789063		14.9922	0.	0.
1s68	4	0.		1e-006	0.	0.
1s72	4	0.		1e-006	0.	0.
1s76	4	0.		1e-006	0.	0.
1s80	4	0.		1e-006	0.	0.
1s84	4	0.		1e-006	0.	0.
1s88	4	0.		1e-006	0.	0.
1s92	4	0.		1e-006	0.	0.
1s96	4	0.789063		14.9922	0.	0.
1s100	4	0.		1e-006	0.	0.
1s104	4	0.		1e-006	0.	0.
1s108	4	0.		1e-006	0.	0.
1s112	4	0.		1e-006	0.	0.
1s116	4	0.		1e-006	0.	0.
1s120	4	0.		1e-006	0.	0.
1s124	4	0.		1e-006	0.	0.
1s128	4	0.789063		14.9922	0.	0.
1s132	4	1.		68.	0.	0.
1s136	4	1.		68.	0.	0.
1s140	4	1.		68.	0.	0.
1s144	4	1.		68.	0.	0.
1s148	4	1.		68.	0.	0.
1s152	4	1.		68.	0.	0.
1s156	4	1.		68.	0.	0.
1s160	4	1.		323.039	0.	0.
1s13	5	0.332031		3.98438	0.	0.
1s14	5	0.332031		3.98438	0.	0.
1s15	5	0.332031		3.98438	0.	0.
1s17	5	0.332031		3.98438	0.	0.
1s18	5	0.332031		3.98438	0.	0.
1s19	5	0.332031		3.98438	0.	0.

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X-Direction Cell Face Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
1s45	5	0.335938		4.03125	0.	0.
1s46	5	0.335938		4.03125	0.	0.
1s47	5	0.335938		4.03125	0.	0.
1s49	5	0.335938		4.03125	0.	0.
1s50	5	0.335938		4.03125	0.	0.
1s51	5	0.335938		4.03125	0.	0.
1s77	5	0.335938		4.03125	0.	0.
1s78	5	0.335938		4.03125	0.	0.
1s79	5	0.335938		4.03125	0.	0.
1s81	5	0.335938		4.03125	0.	0.
1s82	5	0.335938		4.03125	0.	0.
1s83	5	0.335938		4.03125	0.	0.
1s109	5	0.335938		4.03125	0.	0.
1s110	5	0.335938		4.03125	0.	0.
1s111	5	0.335938		4.03125	0.	0.
1s113	5	0.335938		4.03125	0.	0.
1s114	5	0.335938		4.03125	0.	0.
1s115	5	0.335938		4.03125	0.	0.
1s141	5	1.		101.947	0.	0.
1s142	5	1.		101.947	0.	0.
1s143	5	1.		101.947	0.	0.
1s145	5	1.		101.947	0.	0.
1s146	5	1.		101.947	0.	0.
1s147	5	1.		101.947	0.	0.
1s57	6	1.		30.34	0.	0.
1s58	6	1.		30.34	0.	0.
1s59	6	1.		30.34	0.	0.
1s61	6	1.		19.	0.	0.
1s62	6	1.		19.	0.	0.
1s63	6	1.		19.	0.	0.
1s23	7	1.		4.	0.	0.
1s27	7	1.		4.	0.	0.
1s51	7	1.		12.	0.	0.
1s55	7	0.		1e-006	0.	0.
1s59	7	0.		1e-006	0.	0.
1s63	7	1.		19.	0.	0.
1s87	7	1.		54.38	0.	0.
1s91	7	1.		54.38	0.	0.
1s50	8	1.		12.	0.	0.
1s51	8	1.		12.	0.	0.
1s54	8	1.		30.34	0.	0.
1s55	8	1.		30.34	0.	0.
1s53	9	1.		30.34	0.	0.
1s54	9	1.		30.34	0.	0.
1s57	9	1.		30.34	0.	0.
1s58	9	1.		30.34	0.	0.
1s22	10	1.		4.	0.	0.
1s50	10	1.		12.	0.	0.
1s54	10	0.		1e-006	0.	0.
1s58	10	1.		30.34	0.	0.
1s86	10	1.		54.38	0.	0.
1s25	11	1.		4.	0.	0.
1s53	11	1.		30.34	0.	0.
1s57	11	0.		1e-006	0.	0.
1s61	11	1.		19.	0.	0.
1s89	11	1.		54.38	0.	0.
1s41	12	1.		46.32	0.	0.

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X-Direction Cell Face Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
1s42	12	1.		46.32	0.	0.
1s43	12	1.		46.32	0.	0.
1s45	12	1.		12.	0.	0.
1s46	12	1.		12.	0.	0.
1s47	12	1.		12.	0.	0.
1s7	13	1.		4.	0.	0.
1s11	13	1.		4.	0.	0.
1s35	13	1.		120.32	0.	0.
1s39	13	0.		1e-006	0.	0.
1s43	13	0.		1e-006	0.	0.
1s47	13	1.		12.	0.	0.
1s71	13	1.		54.38	0.	0.
1s75	13	1.		54.38	0.	0.
1s33	14	1.		120.32	0.	0.
1s34	14	1.		120.32	0.	0.
1s35	14	1.		120.32	0.	0.
1s37	14	1.		75.68	0.	0.
1s38	14	1.		75.68	0.	0.
1s39	14	1.		75.68	0.	0.
1s5	15	1.		4.	0.	0.
1s9	15	1.		4.	0.	0.
1s33	15	1.		120.32	0.	0.
1s37	15	0.		1e-006	0.	0.
1s41	15	0.		1e-006	0.	0.
1s45	15	1.		12.	0.	0.
1s69	15	1.		54.38	0.	0.
1s73	15	1.		54.38	0.	0.

Y-Direction Cell Face Variations
Volume 1s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.		1000000.	0.	0.
1s38	0	0.		1000000.	0.	0.
1s39	0	0.		1000000.	0.	0.
1s42	0	0.		1000000.	0.	0.
1s43	0	0.		1000000.	0.	0.
1s51	0	0.		1000000.	0.	0.
1s54	0	0.		1000000.	0.	0.
1s55	0	0.		1000000.	0.	0.
1s58	0	0.		1000000.	0.	0.
1s59	0	0.		1000000.	0.	0.
1s29	1	0.		1e-006	0.	0.
1s30	1	0.		1e-006	0.	0.
1s31	1	0.		1e-006	0.	0.
1s32	1	0.		1e-006	0.	0.
1s61	1	0.		1e-006	0.	0.
1s62	1	0.		1e-006	0.	0.
1s63	1	0.		1e-006	0.	0.
1s64	1	0.		1e-006	0.	0.
1s93	1	0.		1e-006	0.	0.
1s94	1	0.		1e-006	0.	0.
1s95	1	0.		1e-006	0.	0.

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Y-Direction Cell Face Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
1s96	1	0.		1e-006	0.	0.
1s125	1	0.		1e-006	0.	0.
1s126	1	0.		1e-006	0.	0.
1s127	1	0.		1e-006	0.	0.
1s128	1	0.		1e-006	0.	0.
1s157	1	1.		68.	0.	0.
1s158	1	1.		68.	0.	0.
1s159	1	1.		68.	0.	0.
1s160	1	1.		68.	0.	0.
1s1	2	0.150391		4.01242	0.	0.
1s5	2	0.150391		4.01242	0.	0.
1s9	2	0.150391		4.01242	0.	0.
1s13	2	0.150391		4.01242	0.	0.
1s17	2	0.150391		4.01242	0.	0.
1s21	2	0.150391		4.01242	0.	0.
1s25	2	0.150391		4.01242	0.	0.
1s29	2	0.150391		4.01242	0.	0.
1s33	2	0.148437		3.96031	0.	0.
1s37	2	0.148437		3.96031	0.	0.
1s41	2	0.148437		3.96031	0.	0.
1s45	2	0.148437		3.96031	0.	0.
1s49	2	0.148437		3.96031	0.	0.
1s53	2	0.148437		3.96031	0.	0.
1s57	2	0.148437		3.96031	0.	0.
1s61	2	0.148437		3.96031	0.	0.
1s65	2	0.148437		3.96031	0.	0.
1s69	2	0.148437		3.96031	0.	0.
1s73	2	0.148437		3.96031	0.	0.
1s77	2	0.148437		3.96031	0.	0.
1s81	2	0.148437		3.96031	0.	0.
1s85	2	0.148437		3.96031	0.	0.
1s89	2	0.148437		3.96031	0.	0.
1s93	2	0.148437		3.96031	0.	0.
1s97	2	0.148437		3.96031	0.	0.
1s101	2	0.148437		3.96031	0.	0.
1s105	2	0.148437		3.96031	0.	0.
1s109	2	0.148437		3.96031	0.	0.
1s113	2	0.148437		3.96031	0.	0.
1s117	2	0.148437		3.96031	0.	0.
1s121	2	0.148437		3.96031	0.	0.
1s125	2	0.148437		3.96031	0.	0.
1s129	2	1.		79.9879	0.	0.
1s133	2	1.		79.9879	0.	0.
1s137	2	1.		79.9879	0.	0.
1s141	2	1.		79.9879	0.	0.
1s145	2	1.		79.9879	0.	0.
1s149	2	1.		79.9879	0.	0.
1s153	2	1.		79.9879	0.	0.
1s157	2	1.		79.9879	0.	0.
1s4	4	0.25		4.	0.	0.
1s8	4	0.25		4.	0.	0.
1s12	4	0.25		4.	0.	0.
1s16	4	0.25		4.	0.	0.
1s20	4	0.25		4.	0.	0.
1s24	4	0.25		4.	0.	0.
1s28	4	0.25		4.	0.	0.
1s36	4	0.25		4.	0.	0.

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Y-Direction Cell Face Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
1s40	4	0.25		4.	0.	0.
1s44	4	0.25		4.	0.	0.
1s48	4	0.25		4.	0.	0.
1s52	4	0.25		4.	0.	0.
1s56	4	0.25		4.	0.	0.
1s60	4	0.25		4.	0.	0.
1s68	4	0.25		4.	0.	0.
1s72	4	0.25		4.	0.	0.
1s76	4	0.25		4.	0.	0.
1s80	4	0.25		4.	0.	0.
1s84	4	0.25		4.	0.	0.
1s88	4	0.25		4.	0.	0.
1s92	4	0.25		4.	0.	0.
1s100	4	0.25		4.	0.	0.
1s104	4	0.25		4.	0.	0.
1s108	4	0.25		4.	0.	0.
1s112	4	0.25		4.	0.	0.
1s116	4	0.25		4.	0.	0.
1s120	4	0.25		4.	0.	0.
1s124	4	0.25		4.	0.	0.
1s132	4	1.		90.5332	0.	0.
1s136	4	1.		90.5332	0.	0.
1s140	4	1.		90.5332	0.	0.
1s144	4	1.		90.5332	0.	0.
1s148	4	1.		90.5332	0.	0.
1s152	4	1.		90.5332	0.	0.
1s156	4	1.		90.5332	0.	0.
1s13	5	0.849609		22.6676	0.	0.
1s14	5	0.		1e-006	0.	0.
1s15	5	0.		1e-006	0.	0.
1s16	5	0.75		12.	0.	0.
1s45	5	0.851562		22.7197	0.	0.
1s46	5	0.		1e-006	0.	0.
1s47	5	0.		1e-006	0.	0.
1s48	5	0.75		12.	0.	0.
1s77	5	0.851562		22.7197	0.	0.
1s78	5	0.		1e-006	0.	0.
1s79	5	0.		1e-006	0.	0.
1s80	5	0.75		12.	0.	0.
1s109	5	0.851562		22.7197	0.	0.
1s110	5	0.		1e-006	0.	0.
1s111	5	0.		1e-006	0.	0.
1s112	5	0.75		12.	0.	0.
1s141	5	1.		453.246	0.	0.
1s142	5	1.		68.	0.	0.
1s143	5	1.		68.	0.	0.
1s144	5	1.		270.802	0.	0.
1s26	6	1.		4.	0.	0.
1s27	6	1.		4.	0.	0.
1s57	6	1.		26.68	0.	0.
1s58	6	0.		1e-006	0.	0.
1s59	6	0.		1e-006	0.	0.
1s60	6	1.		16.	0.	0.
1s90	6	1.		54.38	0.	0.
1s91	6	1.		54.38	0.	0.
1s51	7	1.		33.82	0.	0.
1s52	7	1.		16.	0.	0.

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Y-Direction Cell Face Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
1s55	7	1.		33.82	0.	0.
1s56	7	1.		16.	0.	0.
1s59	7	1.		33.82	0.	0.
1s60	7	1.		16.	0.	0.
1s19	8	1.		4.	0.	0.
1s50	8	1.		33.82	0.	0.
1s51	8	0.		1e-006	0.	0.
1s52	8	1.		16.	0.	0.
1s83	8	1.		54.38	0.	0.
1s22	9	1.		4.	0.	0.
1s53	9	1.		26.68	0.	0.
1s54	9	0.		1e-006	0.	0.
1s55	9	1.		33.82	0.	0.
1s86	9	1.		54.38	0.	0.
1s50	10	1.		33.82	0.	0.
1s51	10	1.		33.82	0.	0.
1s54	10	1.		33.82	0.	0.
1s55	10	1.		33.82	0.	0.
1s54	11	1.		33.82	0.	0.
1s58	11	1.		33.82	0.	0.
1s10	12	1.		4.	0.	0.
1s11	12	1.		4.	0.	0.
1s41	12	1.		26.68	0.	0.
1s42	12	0.		1e-006	0.	0.
1s43	12	0.		1e-006	0.	0.
1s44	12	1.		16.	0.	0.
1s74	12	1.		54.38	0.	0.
1s75	12	1.		54.38	0.	0.
1s35	13	1.		33.82	0.	0.
1s36	13	1.		16.	0.	0.
1s39	13	1.		33.82	0.	0.
1s40	13	1.		16.	0.	0.
1s43	13	1.		33.82	0.	0.
1s44	13	1.		16.	0.	0.
1s2	14	1.		4.	0.	0.
1s3	14	1.		4.	0.	0.
1s33	14	1.		26.68	0.	0.
1s34	14	0.		1e-006	0.	0.
1s35	14	0.		1e-006	0.	0.
1s36	14	1.		16.	0.	0.
1s66	14	1.		54.38	0.	0.
1s67	14	1.		54.38	0.	0.
1s33	15	1.		26.68	0.	0.
1s34	15	1.		33.82	0.	0.
1s37	15	1.		26.68	0.	0.
1s38	15	1.		33.82	0.	0.
1s41	15	1.		26.68	0.	0.
1s42	15	1.		33.82	0.	0.

Z-Direction Cell Face Variations
Volume 1s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor	Curb Ht (ft)
def	0	1.		1000000.	0.	0.	

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Z-Direction Cell Face Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor	Curb Ht (ft)
1s38	0	0.417		0.0472	39.	0.	0.
1s39	0	0.417		0.0472	39.	0.	0.
1s42	0	0.417		0.0472	39.	0.	0.
1s43	0	0.417		0.0472	39.	0.	0.
1s55	0	0.407		0.0472	39.	0.	0.
1s58	0	0.555		0.0472	39.	0.	0.
1s59	0	0.407		0.0472	39.	0.	0.
1s29	1	0.21051		3.99969	0.	0.	0.
1s30	1	0.21051		3.99969	0.	0.	0.
1s31	1	0.21051		3.99969	0.	0.	0.
1s32	1	0.21051		3.99969	0.	0.	0.
1s61	1	0.21051		3.99969	0.	0.	0.
1s62	1	0.21051		3.99969	0.	0.	0.
1s63	1	0.21051		3.99969	0.	0.	0.
1s64	1	0.21051		3.99969	0.	0.	0.
1s93	1	0.21051		3.99969	0.	0.	0.
1s94	1	0.21051		3.99969	0.	0.	0.
1s95	1	0.21051		3.99969	0.	0.	0.
1s96	1	0.21051		3.99969	0.	0.	0.
1s125	1	0.21051		3.99969	0.	0.	0.
1s126	1	0.21051		3.99969	0.	0.	0.
1s127	1	0.21051		3.99969	0.	0.	0.
1s128	1	0.21051		3.99969	0.	0.	0.
1s1	2	0.148437		3.96031	0.	0.	0.
1s5	2	0.148438		3.96031	0.	0.	0.
1s9	2	0.148438		3.96031	0.	0.	0.
1s13	2	0.148437		3.96031	0.	0.	0.
1s17	2	0.148437		3.96031	0.	0.	0.
1s21	2	0.148438		3.96031	0.	0.	0.
1s25	2	0.148438		3.96031	0.	0.	0.
1s29	2	0.148438		3.96031	0.	0.	0.
1s33	2	0.148437		3.96031	0.	0.	0.
1s37	2	0.148438		3.96031	0.	0.	0.
1s41	2	0.148438		3.96031	0.	0.	0.
1s45	2	0.148437		3.96031	0.	0.	0.
1s49	2	0.148437		3.96031	0.	0.	0.
1s53	2	0.148438		3.96031	0.	0.	0.
1s57	2	0.148438		3.96031	0.	0.	0.
1s61	2	0.148438		3.96031	0.	0.	0.
1s65	2	0.148437		3.96031	0.	0.	0.
1s69	2	0.148438		3.96031	0.	0.	0.
1s73	2	0.148438		3.96031	0.	0.	0.
1s77	2	0.148437		3.96031	0.	0.	0.
1s81	2	0.148437		3.96031	0.	0.	0.
1s85	2	0.148438		3.96031	0.	0.	0.
1s89	2	0.148438		3.96031	0.	0.	0.
1s93	2	0.148438		3.96031	0.	0.	0.
1s97	2	0.148437		3.96031	0.	0.	0.
1s101	2	0.148438		3.96031	0.	0.	0.
1s105	2	0.148438		3.96031	0.	0.	0.
1s109	2	0.148437		3.96031	0.	0.	0.
1s113	2	0.148437		3.96031	0.	0.	0.
1s117	2	0.148438		3.96031	0.	0.	0.
1s121	2	0.148438		3.96031	0.	0.	0.
1s125	2	0.148438		3.96031	0.	0.	0.
1s1	3	0.848938		22.6791	0.	0.	0.
1s2	3	0.033233		3.99867	0.	0.	0.

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Z-Direction Cell Face Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor	Curb Ht (ft)
1s3	3	0.033233		3.99867	0.	0.	0.
1s4	3	0.758301		12.1337	0.	0.	0.
1s33	3	0.848938		22.6791	0.	0.	0.
1s34	3	0.033233		3.99867	0.	0.	0.
1s35	3	0.033233		3.99867	0.	0.	0.
1s36	3	0.758301		12.1337	0.	0.	0.
1s65	3	0.848938		22.6791	0.	0.	0.
1s66	3	0.033233		3.99867	0.	0.	0.
1s67	3	0.033233		3.99867	0.	0.	0.
1s68	3	0.758301		12.1337	0.	0.	0.
1s97	3	0.848938		22.6791	0.	0.	0.
1s98	3	0.033233		3.99867	0.	0.	0.
1s99	3	0.033233		3.99867	0.	0.	0.
1s100	3	0.758301		12.1337	0.	0.	0.
1s4	4	0.25		4.	0.	0.	0.
1s8	4	0.25		4.	0.	0.	0.
1s12	4	0.25		4.	0.	0.	0.
1s16	4	0.25		4.	0.	0.	0.
1s20	4	0.25		4.	0.	0.	0.
1s24	4	0.25		4.	0.	0.	0.
1s28	4	0.25		4.	0.	0.	0.
1s32	4	0.841797		15.9905	0.	0.	0.
1s36	4	0.25		4.	0.	0.	0.
1s40	4	0.25		4.	0.	0.	0.
1s44	4	0.25		4.	0.	0.	0.
1s48	4	0.25		4.	0.	0.	0.
1s52	4	0.25		4.	0.	0.	0.
1s56	4	0.25		4.	0.	0.	0.
1s60	4	0.25		4.	0.	0.	0.
1s64	4	0.841797		15.9905	0.	0.	0.
1s68	4	0.25		4.	0.	0.	0.
1s72	4	0.25		4.	0.	0.	0.
1s76	4	0.25		4.	0.	0.	0.
1s80	4	0.25		4.	0.	0.	0.
1s84	4	0.25		4.	0.	0.	0.
1s88	4	0.25		4.	0.	0.	0.
1s92	4	0.25		4.	0.	0.	0.
1s96	4	0.841797		15.9905	0.	0.	0.
1s100	4	0.25		4.	0.	0.	0.
1s104	4	0.25		4.	0.	0.	0.
1s108	4	0.25		4.	0.	0.	0.
1s112	4	0.25		4.	0.	0.	0.
1s116	4	0.25		4.	0.	0.	0.
1s120	4	0.25		4.	0.	0.	0.
1s124	4	0.25		4.	0.	0.	0.
1s128	4	0.841797		15.9905	0.	0.	0.
1s13	5	0.901428		24.0837	0.	0.	0.
1s14	5	0.333313		3.99976	0.	0.	0.
1s15	5	0.333313		3.99976	0.	0.	0.
1s16	5	0.833984		13.3456	0.	0.	0.
1s17	5	0.901428		24.0837	0.	0.	0.
1s18	5	0.333313		3.99976	0.	0.	0.
1s19	5	0.333313		3.99976	0.	0.	0.
1s20	5	0.833984		13.3456	0.	0.	0.
1s45	5	0.901428		24.0837	0.	0.	0.
1s46	5	0.333313		3.99976	0.	0.	0.
1s47	5	0.333313		3.99976	0.	0.	0.

Z-Direction Cell Face Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor	Curb Ht (ft)
1s48	5	0.833984		13.3456	0.	0.	0.
1s49	5	0.901428		24.0837	0.	0.	0.
1s50	5	0.333313		3.99976	0.	0.	0.
1s51	5	0.333313		3.99976	0.	0.	0.
1s52	5	0.833984		13.3456	0.	0.	0.
1s77	5	0.901428		24.0837	0.	0.	0.
1s78	5	0.333313		3.99976	0.	0.	0.
1s79	5	0.333313		3.99976	0.	0.	0.
1s80	5	0.833984		13.3456	0.	0.	0.
1s81	5	0.901428		24.0837	0.	0.	0.
1s82	5	0.333313		3.99976	0.	0.	0.
1s83	5	0.333313		3.99976	0.	0.	0.
1s84	5	0.833984		13.3456	0.	0.	0.
1s109	5	0.901428		24.0837	0.	0.	0.
1s110	5	0.333313		3.99976	0.	0.	0.
1s111	5	0.333313		3.99976	0.	0.	0.
1s112	5	0.833984		13.3456	0.	0.	0.
1s113	5	0.901428		24.0837	0.	0.	0.
1s114	5	0.333313		3.99976	0.	0.	0.
1s115	5	0.333313		3.99976	0.	0.	0.
1s116	5	0.833984		13.3456	0.	0.	0.
1s26	6	1.		30.34	0.	0.	0.
1s27	6	1.		30.34	0.	0.	0.
1s30	6	1.		19.	0.	0.	0.
1s31	6	1.		19.	0.	0.	0.
1s58	6	1.		30.34	0.	0.	0.
1s59	6	1.		30.34	0.	0.	0.
1s62	6	1.		19.	0.	0.	0.
1s63	6	1.		19.	0.	0.	0.
1s23	7	1.		33.82	0.	0.	0.
1s24	7	1.		16.	0.	0.	0.
1s27	7	1.		33.82	0.	0.	0.
1s28	7	1.		16.	0.	0.	0.
1s55	7	1.		33.82	0.	0.	0.
1s56	7	1.		16.	0.	0.	0.
1s59	7	1.		33.82	0.	0.	0.
1s60	7	1.		16.	0.	0.	0.
1s19	8	1.		12.	0.	0.	0.
1s23	8	1.		30.34	0.	0.	0.
1s51	8	1.		12.	0.	0.	0.
1s55	8	1.		30.34	0.	0.	0.
1s22	9	1.		30.34	0.	0.	0.
1s26	9	1.		30.34	0.	0.	0.
1s54	9	1.		30.34	0.	0.	0.
1s58	9	1.		30.34	0.	0.	0.
1s22	10	1.		33.82	0.	0.	0.
1s23	10	1.		33.82	0.	0.	0.
1s54	10	1.		33.82	0.	0.	0.
1s55	10	1.		33.82	0.	0.	0.
1s26	11	1.		33.82	0.	0.	0.
1s58	11	1.		33.82	0.	0.	0.
1s14	12	1.		12.	0.	0.	0.
1s15	12	1.		12.	0.	0.	0.
1s46	12	1.		12.	0.	0.	0.
1s47	12	1.		12.	0.	0.	0.
1s7	13	1.		33.82	0.	0.	0.
1s8	13	1.		16.	0.	0.	0.

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Z-Direction Cell Face Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor	Curb Ht (ft)
1s11	13	1.		33.82	0.	0.	0.
1s12	13	1.		16.	0.	0.	0.
1s39	13	1.		33.82	0.	0.	0.
1s40	13	1.		16.	0.	0.	0.
1s43	13	1.		33.82	0.	0.	0.
1s44	13	1.		16.	0.	0.	0.
1s2	14	1.		120.32	0.	0.	0.
1s3	14	1.		120.32	0.	0.	0.
1s6	14	1.		75.68	0.	0.	0.
1s7	14	1.		75.68	0.	0.	0.
1s34	14	1.		120.32	0.	0.	0.
1s35	14	1.		120.32	0.	0.	0.
1s38	14	1.		75.68	0.	0.	0.
1s39	14	1.		75.68	0.	0.	0.
1s5	15	1.		26.68	0.	0.	0.
1s6	15	1.		33.82	0.	0.	0.
1s9	15	1.		26.68	0.	0.	0.
1s10	15	1.		33.82	0.	0.	0.
1s37	15	1.		26.68	0.	0.	0.
1s38	15	1.		33.82	0.	0.	0.
1s41	15	1.		26.68	0.	0.	0.
1s42	15	1.		33.82	0.	0.	0.

Volume Variations
Volume 1s

Cell No.	Blockage No.	Volume Porosity	FF	Hyd. Dia. (ft)
def	0	1.		1000000.
1s1	0	0.		1000000.
1s4	0	0.		1000000.
1s13	0	0.		1000000.
1s16	0	0.		1000000.
1s17	0	0.		1000000.
1s20	0	0.		1000000.
1s29	0	0.		1000000.
1s32	0	0.		1000000.
1s38	0	0.527		0.0472
1s39	0	0.527		0.0472
1s42	0	0.527		0.0472
1s43	0	0.527		0.0472
1s55	0	0.331		0.0472
1s58	0	0.331		0.0472
1s59	0	0.331		0.0472
1s97	0	0.		1000000.
1s100	0	0.		1000000.
1s29	1	0.210938		4.00781
1s30	1	0.210938		4.00781
1s31	1	0.210938		4.00781
1s32	1	0.210938		4.00781
1s61	1	0.210938		4.00781
1s62	1	0.210937		4.00781
1s63	1	0.210937		4.00781
1s64	1	0.210938		4.00781

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Volume Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Volume Porosity	FF	Hyd. Dia. (ft)
1s93	1	0.210938		4.00781
1s94	1	0.210938		4.00781
1s95	1	0.210938		4.00781
1s96	1	0.210938		4.00781
1s125	1	0.210938		4.00781
1s126	1	0.210938		4.00781
1s127	1	0.210938		4.00781
1s128	1	0.210938		4.00781
1s157	1	1.		86.1425
1s158	1	1.		86.1425
1s159	1	1.		86.1425
1s160	1	1.		86.1425
1s1	2	0.150391		4.01242
1s5	2	0.150391		4.01242
1s9	2	0.150391		4.01242
1s13	2	0.150391		4.01242
1s17	2	0.150391		4.01242
1s21	2	0.150391		4.01242
1s25	2	0.150391		4.01242
1s29	2	0.150391		4.01242
1s33	2	0.150391		4.01242
1s37	2	0.150391		4.01242
1s41	2	0.150391		4.01242
1s45	2	0.150391		4.01242
1s49	2	0.150391		4.01242
1s53	2	0.150391		4.01242
1s57	2	0.150391		4.01242
1s61	2	0.150391		4.01242
1s65	2	0.148438		3.96031
1s69	2	0.148438		3.96031
1s73	2	0.148438		3.96031
1s77	2	0.148438		3.96031
1s81	2	0.148438		3.96031
1s85	2	0.148438		3.96031
1s89	2	0.148438		3.96031
1s93	2	0.148438		3.96031
1s97	2	0.148438		3.96031
1s101	2	0.148438		3.96031
1s105	2	0.148438		3.96031
1s109	2	0.148438		3.96031
1s113	2	0.148438		3.96031
1s117	2	0.148438		3.96031
1s121	2	0.148438		3.96031
1s125	2	0.148438		3.96031
1s129	2	1.		80.0133
1s133	2	1.		80.0133
1s137	2	1.		80.0133
1s141	2	1.		80.0133
1s145	2	1.		80.0133
1s149	2	1.		80.0133
1s153	2	1.		80.0133
1s157	2	1.		80.0133
1s1	3	0.856491		22.8574
1s2	3	0.033203		3.995
1s3	3	0.033203		3.995
1s4	3	0.758301		12.133
1s33	3	0.856491		22.8574

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Volume Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Volume Porosity	FF	Hyd. Dia. (ft)
1s34	3	0.033203		3.995
1s35	3	0.033203		3.995
1s36	3	0.758301		12.133
1s65	3	0.856491		22.8574
1s66	3	0.033203		3.995
1s67	3	0.033203		3.995
1s68	3	0.758301		12.133
1s97	3	0.856491		22.8574
1s98	3	0.033203		3.995
1s99	3	0.033203		3.995
1s100	3	0.758301		12.133
1s129	3	1.		467.75
1s130	3	1.		70.3441
1s131	3	1.		70.3441
1s132	3	1.		276.601
1s4	4	0.25		4.
1s8	4	0.25		4.
1s12	4	0.25		4.
1s16	4	0.25		4.
1s20	4	0.25		4.
1s24	4	0.25		4.
1s28	4	0.25		4.
1s32	4	0.841797		15.9932
1s36	4	0.25		4.
1s40	4	0.25		4.
1s44	4	0.25		4.
1s48	4	0.25		4.
1s52	4	0.25		4.
1s56	4	0.25		4.
1s60	4	0.25		4.
1s64	4	0.841797		15.9932
1s68	4	0.25		4.
1s72	4	0.25		4.
1s76	4	0.25		4.
1s80	4	0.25		4.
1s84	4	0.25		4.
1s88	4	0.25		4.
1s92	4	0.25		4.
1s96	4	0.841797		15.9932
1s100	4	0.25		4.
1s104	4	0.25		4.
1s108	4	0.25		4.
1s112	4	0.25		4.
1s116	4	0.25		4.
1s120	4	0.25		4.
1s124	4	0.25		4.
1s128	4	0.841797		15.9932
1s132	4	1.		90.6236
1s136	4	1.		90.6236
1s140	4	1.		90.6236
1s144	4	1.		90.6236
1s148	4	1.		90.6236
1s152	4	1.		90.6236
1s156	4	1.		90.6236
1s160	4	1.		429.77
1s13	5	0.899544		24.0188
1s14	5	0.333008		3.99609

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Volume Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Volume Porosity	FF	Hyd. Dia. (ft)
1s15	5	0.333008		3.99609
1s16	5	0.833496		13.3362
1s17	5	0.899544		24.0188
1s18	5	0.333008		3.99609
1s19	5	0.333008		3.99609
1s20	5	0.833496		13.3362
1s45	5	0.899544		24.0188
1s46	5	0.332031		3.98438
1s47	5	0.332031		3.98438
1s48	5	0.833496		13.3362
1s49	5	0.899544		24.0188
1s50	5	0.332031		3.98438
1s51	5	0.332031		3.98438
1s52	5	0.833496		13.3362
1s77	5	0.899544		24.0188
1s78	5	0.332031		3.98438
1s79	5	0.332031		3.98438
1s80	5	0.833496		13.3362
1s81	5	0.899544		24.0188
1s82	5	0.332031		3.98438
1s83	5	0.332031		3.98438
1s84	5	0.833496		13.3362
1s109	5	0.899544		24.0188
1s110	5	0.332031		3.98438
1s111	5	0.332031		3.98438
1s112	5	0.833496		13.3362
1s113	5	0.899544		24.0188
1s114	5	0.332031		3.98438
1s115	5	0.332031		3.98438
1s116	5	0.833496		13.3362
1s141	5	1.		682.848
1s142	5	1.		101.984
1s143	5	1.		101.984
1s144	5	1.		404.785
1s145	5	1.		682.848
1s146	5	1.		101.984
1s147	5	1.		101.984
1s148	5	1.		404.785
1s58	6	1.		30.34
1s59	6	1.		30.34
1s62	6	1.		19.
1s63	6	1.		19.
1s55	7	1.		33.82
1s56	7	1.		16.
1s59	7	1.		33.82
1s60	7	1.		16.
1s51	8	1.		12.
1s55	8	1.		30.34
1s54	9	1.		30.34
1s58	9	1.		30.34
1s54	10	1.		33.82
1s55	10	1.		33.82
1s58	11	1.		33.82
1s46	12	1.		12.
1s47	12	1.		12.
1s39	13	1.		33.82
1s40	13	1.		16.

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Volume Variations (cont.)
Volume 1s

Cell No.	Blockage No.	Volume Porosity	FF	Hyd. Dia. (ft)
1s43	13	1.		33.82
1s44	13	1.		16.
1s38	14	1.		75.68
1s39	14	1.		75.68
1s37	15	1.		26.68
1s38	15	1.		33.82
1s41	15	1.		26.68
1s42	15	1.		33.82

Boundary Slip Conditions
Volume 1s

North	South	East	West	Top	Bottom
NO SLIP	NO SLIP	SLIP	SLIP	NO SLIP	NO SLIP

X-Direction Noding
Volume 2s

Cell Plane	Distance (ft)	Width (ft)
1	0.	24.
2	24.	24.
3	48.	27.58
4	75.58	14.42
5	90.	19.955
6	109.955	34.375
7	144.33	33.

Y-Direction Noding
Volume 2s

Cell Plane	Distance (ft)	Depth (ft)
1	0.	30.08
2	30.08	18.92
3	49.	14.58
4	63.58	22.92

Z-Direction Noding
Volume 2s

Cell Plane	Distance (ft)	Height (ft)
1	0.	22.
2	22.	21.5

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Z-Direction Noding (cont.)
Volume 2s

Cell Plane	Distance (ft)	Height (ft)
3	43.5	17.
4	60.5	17.
5	77.5	17.

Cell Blockages - Table 1
Volume 2s

Blockage No.	Description	Type			
1	Operating Floor	BLK	B	I	N
2	Lower Roof	BLK	B	I	N
3	Health Physics Lab	BLK	B	I	N
4	Shipping Platform	BLK	B	I	N
5	Elevator C	BLK	B	I	N
6	Monitor Room	BLK	B	I	N
7	Decontamination Area	BLK	B	I	N
8	CV1 Blockage	BLK	B	I	S
9	Air Lock	BLK	B	I	N
10	West Canal Wall	BLK	B	I	N
11	North Canal Wall	BLK	B	I	N
12	South Canal Wall	BLK	B	I	N
13	Canal Dividing Wall	BLK	B	I	N
14	Canal Floor	BLK	B	I	N

Cell Blockages - Table 2
Volume 2s

Blockage	Coordinates & Dimensions (ft)										Curb
No.	X1	Y1	Z1	X2	Y2	Z2	X3	Y3	Z3	L	Height
1	81.33	0.	0.	177.33	86.5	43.5					0.
2	144.33	0.	68.875	177.33	86.5	94.5					0.
3	0.	60.5	0.	10.083	72.5	8.75					0.
4	0.	38.875	0.	10.833	60.5	4.					0.
5	0.	26.375	0.	10.833	38.875	22.					0.
6	28.583	75.333	0.	48.	86.5	8.75					0.
7	28.583	42.833	0.	48.	75.333	20.					0.
8	48.	0.	0.	75.58	86.5	94.5					0.
9	91.	0.	43.5	110.08	34.92	55.					0.
10	75.58	0.	0.	77.33	86.5	43.5					0.
11	77.33	82.75	2.	81.33	86.5	43.5					0.
12	77.33	0.	2.	81.33	1.75	43.5					0.
13	77.33	48.42	2.	81.33	52.25	43.5					0.
14	77.33	0.	0.	81.33	86.5	2.					0.

X-Direction Cell Face Variations
Volume 2s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.		1000000.	0.	0.

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X-Direction Cell Face Variations (cont.)
Volume 2s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
2s4	1	0.		1e-006	0.	0.
2s5	1	0.		1e-006	0.	0.
2s6	1	0.		1e-006	0.	0.
2s7	1	0.		1e-006	0.	0.
2s11	1	0.		1e-006	0.	0.
2s12	1	0.		1e-006	0.	0.
2s13	1	0.		1e-006	0.	0.
2s14	1	0.		1e-006	0.	0.
2s18	1	0.		1e-006	0.	0.
2s19	1	0.		1e-006	0.	0.
2s20	1	0.		1e-006	0.	0.
2s21	1	0.		1e-006	0.	0.
2s25	1	0.		1e-006	0.	0.
2s26	1	0.		1e-006	0.	0.
2s27	1	0.		1e-006	0.	0.
2s28	1	0.		1e-006	0.	0.
2s32	1	0.		1e-006	0.	0.
2s33	1	0.		1e-006	0.	0.
2s34	1	0.		1e-006	0.	0.
2s35	1	0.		1e-006	0.	0.
2s39	1	0.		1e-006	0.	0.
2s40	1	0.		1e-006	0.	0.
2s41	1	0.		1e-006	0.	0.
2s42	1	0.		1e-006	0.	0.
2s46	1	0.		1e-006	0.	0.
2s47	1	0.		1e-006	0.	0.
2s48	1	0.		1e-006	0.	0.
2s49	1	0.		1e-006	0.	0.
2s53	1	0.		1e-006	0.	0.
2s54	1	0.		1e-006	0.	0.
2s55	1	0.		1e-006	0.	0.
2s56	1	0.		1e-006	0.	0.
2s60	1	1.		68.	0.	0.
2s61	1	1.		68.	0.	0.
2s62	1	1.		68.	0.	0.
2s63	1	1.		68.	0.	0.
2s67	1	1.		68.	0.	0.
2s68	1	1.		68.	0.	0.
2s69	1	1.		68.	0.	0.
2s70	1	1.		68.	0.	0.
2s74	1	1.		68.	0.	0.
2s75	1	1.		68.	0.	0.
2s76	1	1.		68.	0.	0.
2s77	1	1.		68.	0.	0.
2s81	1	1.		68.	0.	0.
2s82	1	1.		68.	0.	0.
2s83	1	1.		68.	0.	0.
2s84	1	1.		68.	0.	0.
2s90	2	0.492645		33.4999	0.	0.
2s91	2	0.492645		33.4999	0.	0.
2s97	2	0.492645		33.4999	0.	0.
2s98	2	0.492645		33.4999	0.	0.
2s104	2	0.492645		33.4999	0.	0.
2s105	2	0.492645		33.4999	0.	0.
2s111	2	0.492645		33.4999	0.	0.
2s112	2	0.492645		33.4999	0.	0.
2s118	2	0.		1e-006	0.	0.

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X-Direction Cell Face Variations (cont.)
Volume 2s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
2s119	2	0.		1e-006	0.	0.
2s125	2	0.		1e-006	0.	0.
2s126	2	0.		1e-006	0.	0.
2s132	2	0.		1e-006	0.	0.
2s133	2	0.		1e-006	0.	0.
2s139	2	0.		1e-006	0.	0.
2s140	2	0.		1e-006	0.	0.
2s23	6	0.80545		81.7673	0.	0.
2s9	7	0.701355		44.7142	0.	0.
2s16	7	0.090911		8.00024	0.	0.
2s23	7	0.536255		34.0914	0.	0.
2s2	8	0.		1000000.	0.	0.
2s3	8	0.		1e-006	0.	0.
2s9	8	0.		1000000.	0.	0.
2s10	8	0.		1e-006	0.	0.
2s16	8	0.		1000000.	0.	0.
2s17	8	0.		1e-006	0.	0.
2s23	8	0.		1000000.	0.	0.
2s24	8	0.		1e-006	0.	0.
2s30	8	0.		1000000.	0.	0.
2s31	8	0.		1e-006	0.	0.
2s37	8	0.		1000000.	0.	0.
2s38	8	0.		1e-006	0.	0.
2s44	8	0.		1000000.	0.	0.
2s45	8	0.		1e-006	0.	0.
2s51	8	0.		1000000.	0.	0.
2s52	8	0.		1e-006	0.	0.
2s58	8	0.		1000000.	0.	0.
2s59	8	0.		1e-006	0.	0.
2s65	8	0.		1000000.	0.	0.
2s66	8	0.		1e-006	0.	0.
2s72	8	0.		1000000.	0.	0.
2s73	8	0.		1e-006	0.	0.
2s79	8	0.		1000000.	0.	0.
2s80	8	0.		1e-006	0.	0.
2s86	8	0.		1000000.	0.	0.
2s87	8	0.		1e-006	0.	0.
2s93	8	0.		1000000.	0.	0.
2s94	8	0.		1e-006	0.	0.
2s100	8	0.		1000000.	0.	0.
2s101	8	0.		1e-006	0.	0.
2s107	8	0.		1000000.	0.	0.
2s108	8	0.		1e-006	0.	0.
2s114	8	0.		1000000.	0.	0.
2s115	8	0.		1e-006	0.	0.
2s121	8	0.		1000000.	0.	0.
2s122	8	0.		1e-006	0.	0.
2s128	8	0.		1000000.	0.	0.
2s129	8	0.		1e-006	0.	0.
2s135	8	0.		1000000.	0.	0.
2s136	8	0.		1e-006	0.	0.
2s33	9	1.		86.	0.	0.
2s40	9	1.		336.755	0.	0.
2s61	9	0.323517		21.9991	0.	0.
2s68	9	0.827423		65.2798	0.	0.
2s3	10	0.		1e-006	0.	0.
2s10	10	0.		1e-006	0.	0.

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X-Direction Cell Face Variations (cont.)
Volume 2s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
2s17	10	0.		1e-006	0.	0.
2s24	10	0.		1e-006	0.	0.
2s31	10	0.		1e-006	0.	0.
2s38	10	0.		1e-006	0.	0.
2s45	10	0.		1e-006	0.	0.
2s52	10	0.		1e-006	0.	0.
2s59	10	1.		68.	0.	0.
2s66	10	1.		68.	0.	0.
2s73	10	1.		68.	0.	0.
2s80	10	1.		68.	0.	0.

Y-Direction Cell Face Variations
Volume 2s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.		1000000.	0.	0.
2s4	1	0.398437		22.9819	0.	0.
2s5	1	0.		1e-006	0.	0.
2s6	1	0.		1e-006	0.	0.
2s7	1	0.		1e-006	0.	0.
2s11	1	0.398437		22.9819	0.	0.
2s12	1	0.		1e-006	0.	0.
2s13	1	0.		1e-006	0.	0.
2s14	1	0.		1e-006	0.	0.
2s18	1	0.398437		22.9819	0.	0.
2s19	1	0.		1e-006	0.	0.
2s20	1	0.		1e-006	0.	0.
2s21	1	0.		1e-006	0.	0.
2s25	1	0.398437		22.9819	0.	0.
2s26	1	0.		1e-006	0.	0.
2s27	1	0.		1e-006	0.	0.
2s28	1	0.		1e-006	0.	0.
2s32	1	0.398438		22.9819	0.	0.
2s33	1	0.		1e-006	0.	0.
2s34	1	0.		1e-006	0.	0.
2s35	1	0.		1e-006	0.	0.
2s39	1	0.398438		22.9819	0.	0.
2s40	1	0.		1e-006	0.	0.
2s41	1	0.		1e-006	0.	0.
2s42	1	0.		1e-006	0.	0.
2s46	1	0.398438		22.9819	0.	0.
2s47	1	0.		1e-006	0.	0.
2s48	1	0.		1e-006	0.	0.
2s49	1	0.		1e-006	0.	0.
2s53	1	0.398438		22.9819	0.	0.
2s54	1	0.		1e-006	0.	0.
2s55	1	0.		1e-006	0.	0.
2s56	1	0.		1e-006	0.	0.
2s60	1	1.		113.13	0.	0.
2s61	1	1.		68.	0.	0.
2s62	1	1.		68.	0.	0.
2s63	1	1.		68.	0.	0.
2s67	1	1.		113.13	0.	0.

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Y-Direction Cell Face Variations (cont.)
Volume 2s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
2s68	1	1.		68.	0.	0.
2s69	1	1.		68.	0.	0.
2s70	1	1.		68.	0.	0.
2s74	1	1.		113.13	0.	0.
2s75	1	1.		68.	0.	0.
2s76	1	1.		68.	0.	0.
2s77	1	1.		68.	0.	0.
2s81	1	1.		113.13	0.	0.
2s82	1	1.		68.	0.	0.
2s83	1	1.		68.	0.	0.
2s84	1	1.		68.	0.	0.
2s90	2	1.		271.021	0.	0.
2s91	2	0.492645		33.4999	0.	0.
2s97	2	1.		271.021	0.	0.
2s98	2	0.492645		33.4999	0.	0.
2s104	2	1.		271.021	0.	0.
2s105	2	0.492645		33.4999	0.	0.
2s111	2	1.		271.021	0.	0.
2s112	2	0.492645		33.4999	0.	0.
2s118	2	1.		137.5	0.	0.
2s119	2	0.		1e-006	0.	0.
2s125	2	1.		137.5	0.	0.
2s126	2	0.		1e-006	0.	0.
2s132	2	1.		137.5	0.	0.
2s133	2	0.		1e-006	0.	0.
2s139	2	1.		137.5	0.	0.
2s140	2	0.		1e-006	0.	0.
2s15	3	0.831909		93.4842	0.	0.
2s8	4	0.918579		130.998	0.	0.
2s1	5	0.546875		52.5	0.	0.
2s29	5	1.		190.493	0.	0.
2s23	6	0.677826		50.8347	0.	0.
2s24	6	1.		277.217	0.	0.
2s9	7	0.267212		14.3245	0.	0.
2s10	7	1.		121.403	0.	0.
2s16	7	0.267212		14.3245	0.	0.
2s17	7	1.		121.403	0.	0.
2s3	8	0.		1e-006	0.	0.
2s10	8	0.		1e-006	0.	0.
2s17	8	0.		1e-006	0.	0.
2s24	8	0.		1e-006	0.	0.
2s31	8	0.		1e-006	0.	0.
2s38	8	0.		1e-006	0.	0.
2s45	8	0.		1e-006	0.	0.
2s52	8	0.		1e-006	0.	0.
2s59	8	0.		1e-006	0.	0.
2s66	8	0.		1e-006	0.	0.
2s73	8	0.		1e-006	0.	0.
2s80	8	0.		1e-006	0.	0.
2s87	8	0.		1e-006	0.	0.
2s94	8	0.		1e-006	0.	0.
2s101	8	0.		1e-006	0.	0.
2s108	8	0.		1e-006	0.	0.
2s115	8	0.		1e-006	0.	0.
2s122	8	0.		1e-006	0.	0.
2s129	8	0.		1e-006	0.	0.
2s136	8	0.		1e-006	0.	0.

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Y-Direction Cell Face Variations (cont.)
Volume 2s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
2s33	9	1.		90.5535	0.	0.
2s61	9	0.354828		15.8175	0.	0.
2s62	9	1.		202.062	0.	0.
2s3	10	1.		110.32	0.	0.
2s4	10	0.875		50.47	0.	0.
2s10	10	1.		110.32	0.	0.
2s11	10	0.875		50.47	0.	0.
2s17	10	1.		110.32	0.	0.
2s18	10	0.875		50.47	0.	0.
2s24	10	1.		110.32	0.	0.
2s25	10	0.875		50.47	0.	0.
2s31	10	1.		110.32	0.	0.
2s32	10	0.875		50.47	0.	0.
2s38	10	1.		110.32	0.	0.
2s39	10	0.875		50.47	0.	0.
2s45	10	1.		110.32	0.	0.
2s46	10	0.875		50.47	0.	0.
2s52	10	1.		110.32	0.	0.
2s53	10	0.875		50.47	0.	0.
2s60	10	1.		559.25	0.	0.
2s67	10	1.		559.25	0.	0.
2s74	10	1.		559.25	0.	0.
2s81	10	1.		559.25	0.	0.
2s25	11	0.751129		21.685	0.	0.
2s53	11	0.726562		20.9541	0.	0.
2s81	11	1.		245.103	0.	0.
2s11	13	0.751129		21.685	0.	0.
2s39	13	0.726562		20.9541	0.	0.
2s67	13	1.		245.103	0.	0.
2s4	14	0.975433		155.111	0.	0.
2s11	14	0.975433		155.111	0.	0.
2s18	14	0.975433		155.111	0.	0.
2s25	14	0.975433		155.111	0.	0.

Z-Direction Cell Face Variations
Volume 2s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor	Curb Ht (ft)
def	0	1.		1000000.	0.	0.	
2s4	1	0.398437		22.9819	0.	0.	0.
2s5	1	0.		1e-006	0.	0.	0.
2s6	1	0.		1e-006	0.	0.	0.
2s7	1	0.		1e-006	0.	0.	0.
2s11	1	0.398437		22.9819	0.	0.	0.
2s12	1	0.		1e-006	0.	0.	0.
2s13	1	0.		1e-006	0.	0.	0.
2s14	1	0.		1e-006	0.	0.	0.
2s18	1	0.398437		22.9819	0.	0.	0.
2s19	1	0.		1e-006	0.	0.	0.
2s20	1	0.		1e-006	0.	0.	0.
2s21	1	0.		1e-006	0.	0.	0.
2s25	1	0.398438		22.9819	0.	0.	0.
2s26	1	0.		1e-006	0.	0.	0.

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Z-Direction Cell Face Variations (cont.)
Volume 2s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor	Curb Ht (ft)
2s27	1	0.		1e-006	0.	0.	0.
2s28	1	0.		1e-006	0.	0.	0.
2s32	1	0.398437		22.9819	0.	0.	0.
2s33	1	0.		1e-006	0.	0.	0.
2s34	1	0.		1e-006	0.	0.	0.
2s35	1	0.		1e-006	0.	0.	0.
2s39	1	0.398437		22.9819	0.	0.	0.
2s40	1	0.		1e-006	0.	0.	0.
2s41	1	0.		1e-006	0.	0.	0.
2s42	1	0.		1e-006	0.	0.	0.
2s46	1	0.398437		22.9819	0.	0.	0.
2s47	1	0.		1e-006	0.	0.	0.
2s48	1	0.		1e-006	0.	0.	0.
2s49	1	0.		1e-006	0.	0.	0.
2s53	1	0.398438		22.9819	0.	0.	0.
2s54	1	0.		1e-006	0.	0.	0.
2s55	1	0.		1e-006	0.	0.	0.
2s56	1	0.		1e-006	0.	0.	0.
2s90	2	1.		137.5	0.	0.	0.
2s91	2	0.		1e-006	0.	0.	0.
2s97	2	1.		137.5	0.	0.	0.
2s98	2	0.		1e-006	0.	0.	0.
2s104	2	1.		137.5	0.	0.	0.
2s105	2	0.		1e-006	0.	0.	0.
2s111	2	1.		137.5	0.	0.	0.
2s112	2	0.		1e-006	0.	0.	0.
2s118	2	1.		137.5	0.	0.	0.
2s119	2	0.		1e-006	0.	0.	0.
2s125	2	1.		137.5	0.	0.	0.
2s126	2	0.		1e-006	0.	0.	0.
2s132	2	1.		137.5	0.	0.	0.
2s133	2	0.		1e-006	0.	0.	0.
2s139	2	1.		137.5	0.	0.	0.
2s140	2	0.		1e-006	0.	0.	0.
2s1	5	0.943359		187.921	0.	0.	0.
2s8	5	0.787598		72.9838	0.	0.	0.
2s3	8	0.		1e-006	0.	0.	0.
2s10	8	0.		1e-006	0.	0.	0.
2s17	8	0.		1e-006	0.	0.	0.
2s24	8	0.		1e-006	0.	0.	0.
2s31	8	0.		1e-006	0.	0.	0.
2s38	8	0.		1e-006	0.	0.	0.
2s45	8	0.		1e-006	0.	0.	0.
2s52	8	0.		1e-006	0.	0.	0.
2s59	8	0.		1e-006	0.	0.	0.
2s66	8	0.		1e-006	0.	0.	0.
2s73	8	0.		1e-006	0.	0.	0.
2s80	8	0.		1e-006	0.	0.	0.
2s87	8	0.		1e-006	0.	0.	0.
2s94	8	0.		1e-006	0.	0.	0.
2s101	8	0.		1e-006	0.	0.	0.
2s108	8	0.		1e-006	0.	0.	0.
2s115	8	0.		1e-006	0.	0.	0.
2s122	8	0.		1e-006	0.	0.	0.
2s129	8	0.		1e-006	0.	0.	0.
2s136	8	0.		1e-006	0.	0.	0.
2s33	9	0.050781		4.05336	0.	0.	0.

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Z-Direction Cell Face Variations (cont.)
Volume 2s

Cell No.	Blockage No.	Area Porosity	FF	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor	Curb Ht (ft)
2s34	9	1.		137.5	0.	0.	0.
2s40	9	0.75528		47.9769	0.	0.	0.
2s41	9	1.		531.81	0.	0.	0.
2s3	10	1.		110.32	0.	0.	0.
2s4	10	0.875		50.47	0.	0.	0.
2s10	10	1.		110.32	0.	0.	0.
2s11	10	0.875		50.47	0.	0.	0.
2s17	10	1.		110.32	0.	0.	0.
2s18	10	0.875		50.47	0.	0.	0.
2s24	10	1.		110.32	0.	0.	0.
2s25	10	0.875		50.47	0.	0.	0.
2s31	10	1.		110.32	0.	0.	0.
2s32	10	0.875		50.47	0.	0.	0.
2s38	10	1.		110.32	0.	0.	0.
2s39	10	0.875		50.47	0.	0.	0.
2s45	10	1.		110.32	0.	0.	0.
2s46	10	0.875		50.47	0.	0.	0.
2s52	10	1.		110.32	0.	0.	0.
2s53	10	0.875		50.47	0.	0.	0.
2s25	11	0.955139		110.126	0.	0.	0.
2s53	11	0.955139		110.126	0.	0.	0.
2s4	12	0.983978		228.726	0.	0.	0.
2s32	12	0.983978		228.726	0.	0.	0.
2s11	13	1.		213.321	0.	0.	0.
2s18	13	0.939117		75.2672	0.	0.	0.
2s39	13	1.		213.321	0.	0.	0.
2s46	13	0.939117		75.2672	0.	0.	0.

Volume Variations
Volume 2s

Cell No.	Blockage No.	Volume Porosity	FF	Hyd. Dia. (ft)
def	0	1.		1000000.
2s4	1	0.398437		22.9819
2s5	1	0.		1e-006
2s6	1	0.		1e-006
2s7	1	0.		1e-006
2s11	1	0.398437		22.9819
2s12	1	0.		1e-006
2s13	1	0.		1e-006
2s14	1	0.		1e-006
2s18	1	0.398437		22.9819
2s19	1	0.		1e-006
2s20	1	0.		1e-006
2s21	1	0.		1e-006
2s25	1	0.398438		22.9819
2s26	1	0.		1e-006
2s27	1	0.		1e-006
2s28	1	0.		1e-006
2s32	1	0.398438		22.9819
2s33	1	0.		1e-006
2s34	1	0.		1e-006
2s35	1	0.		1e-006

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Volume Variations (cont.)
Volume 2s

Cell No.	Blockage No.	Volume Porosity	FF	Hyd. Dia. (ft)
2s39	1	0.398438		22.9819
2s40	1	0.		1e-006
2s41	1	0.		1e-006
2s42	1	0.		1e-006
2s46	1	0.398438		22.9819
2s47	1	0.		1e-006
2s48	1	0.		1e-006
2s49	1	0.		1e-006
2s53	1	0.398438		22.9819
2s54	1	0.		1e-006
2s55	1	0.		1e-006
2s56	1	0.		1e-006
2s60	1	1.		113.107
2s61	1	1.		68.
2s62	1	1.		68.
2s63	1	1.		68.
2s67	1	1.		113.107
2s68	1	1.		68.
2s69	1	1.		68.
2s70	1	1.		68.
2s74	1	1.		113.107
2s75	1	1.		68.
2s76	1	1.		68.
2s77	1	1.		68.
2s81	1	1.		113.107
2s82	1	1.		68.
2s83	1	1.		68.
2s84	1	1.		68.
2s90	2	1.		270.898
2s91	2	0.492187		33.4687
2s97	2	1.		270.898
2s98	2	0.492187		33.4688
2s104	2	1.		270.898
2s105	2	0.492188		33.4687
2s111	2	1.		270.898
2s112	2	0.492187		33.4688
2s118	2	1.		137.5
2s119	2	0.		1e-006
2s125	2	1.		137.5
2s126	2	0.		1e-006
2s132	2	1.		137.5
2s133	2	0.		1e-006
2s139	2	1.		137.5
2s140	2	0.		1e-006
2s15	3	0.963951		205.524
2s22	3	0.935627		179.317
2s8	4	0.954865		199.304
2s15	4	0.933624		136.044
2s1	5	0.944485		187.654
2s8	5	0.790276		73.1347
2s29	5	1.		1536.26
2s36	5	1.		408.434
2s23	6	0.846268		85.0406
2s24	6	1.		569.197
2s9	7	0.758392		48.361
2s10	7	1.		372.964
2s16	7	0.265633		14.2363

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Volume Variations (cont.)
Volume 2s

Cell No.	Blockage No.	Volume Porosity	FF	Hyd. Dia. (ft)
2s17	7	1.		121.355
2s23	7	0.620331		35.4021
2s24	7	1.		236.592
2s3	8	0.		1e-006
2s10	8	0.		1e-006
2s17	8	0.		1e-006
2s24	8	0.		1e-006
2s31	8	0.		1e-006
2s38	8	0.		1e-006
2s45	8	0.		1e-006
2s52	8	0.		1e-006
2s59	8	0.		1e-006
2s66	8	0.		1e-006
2s73	8	0.		1e-006
2s80	8	0.		1e-006
2s87	8	0.		1e-006
2s94	8	0.		1e-006
2s101	8	0.		1e-006
2s108	8	0.		1e-006
2s115	8	0.		1e-006
2s122	8	0.		1e-006
2s129	8	0.		1e-006
2s136	8	0.		1e-006
2s33	9	1.		90.5413
2s40	9	1.		354.952
2s61	9	0.358536		15.9795
2s62	9	1.		201.245
2s68	9	0.839905		59.4235
2s69	9	1.		785.825
2s3	10	1.		110.32
2s4	10	0.878906		50.6953
2s10	10	1.		110.32
2s11	10	0.878906		50.6953
2s17	10	1.		110.32
2s18	10	0.878906		50.6953
2s24	10	1.		110.32
2s25	10	0.878906		50.6953
2s31	10	1.		110.32
2s32	10	0.878906		50.6953
2s38	10	1.		110.32
2s39	10	0.878906		50.6953
2s45	10	1.		110.32
2s46	10	0.878906		50.6953
2s52	10	1.		110.32
2s53	10	0.878906		50.6953
2s60	10	1.		559.73
2s67	10	1.		559.73
2s74	10	1.		559.73
2s81	10	1.		559.73
2s25	11	0.960175		115.593
2s53	11	0.954498		109.9
2s81	11	1.		1502.83
2s4	12	0.986061		243.933
2s32	12	0.983749		228.14
2s11	13	1.		235.061
2s18	13	0.944244		78.9118
2s39	13	1.		212.322

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Volume Variations (cont.)
Volume 2s

Cell No.	Blockage No.	Volume Porosity	FF	Hyd. Dia. (ft)
2s46	13	0.938248		75.1841
2s74	13	1.		1095.1
2s4	14	0.974541		154.925
2s11	14	0.974541		154.925
2s18	14	0.974541		154.925
2s25	14	0.974541		154.925

Boundary Slip Conditions
Volume 2s

North	South	East	West	Top	Bottom
NO SLIP	NO SLIP	NO SLIP	NO SLIP	NO SLIP	NO SLIP

Turbulence Parameters

Vol #	Molec. Diff.	Turb. Model	Liquid Mix.L. (ft)	Vapor Mix.L (ft)	Liquid Pr/Sc No.	Vapor Pr/Sc No.	Phase Option
1s	YES	ke-STD			1.	1.	VAPOR
2s	YES	ke-STD			1.	1.	VAPOR
3	NO	NO			1.	1.	VAPOR

Turbulence Sources

Vol #	Type	Phase	Kinetic Energy (ft2/s2) [*lbm/s]	FF	Dissipation (ft2/s3) [*lbm/s]	FF

Pipe Parameters

Vol #	Relative Rough-ness	OD (in)	ID (in)	Modulus of Elasticity (psi)	Stiffness Factor
1s					
2s					
3					

Discrete Burn Parameters

Vol #	Min H2 Frac	Min O2 Frac	Max H2O Frac	Burn Length (ft)	Flame Speed (ft/s)	Burn Rate FF	Un Burn Frac	Burn Opt
1s	0.07	0.05	0.55	DEFAULT	DEFAULT		DEFAULT	FBR

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Discrete Burn Parameters (cont.)

Vol #	Min H2 Frac	Min O2 Frac	Max H2O Frac	Burn Length (ft)	Flame Speed (ft/s)	Burn Rate FF	Un Burn Frac	Burn Opt
2s	0.07	0.05	0.55	DEFAULT	DEFAULT		DEFAULT	FBR
3	0.07	0.05	0.55	DEFAULT	DEFAULT		DEFAULT	FBR

Continuous Burn Parameters

Vol Vol #	Min H2 Flow (lbm/s)	Min O2 Frac	Max H2O Frac	Max H2O/H2 Ratio	Burn Frac
1s	0.	0.05	0.55	1000.	1.
2s	0.	0.05	0.55	1000.	1.
3	0.	0.05	0.55	1000.	1.

Mechanistic Burn Rate Parameters

Vol #	Min H2 Frac	Min O2 Frac	Max H2O Frac	Da No.	Lam Burn Rate (lbm/ft3-s)	FF	Burn Temp Limit (F)	FF	Turb Burn Opt	Turb Burn FF
1s	0.	0.	1.	1.	DEFAULT		350.		EDIS	
2s	0.	0.	1.	1.	DEFAULT		350.		EDIS	
3	0.	0.	1.	1.	DEFAULT		350.		EDIS	

Mechanistic Burn Propagation Parameters

Vol #	Unburned H2 Frac	FF	Burned H2 Frac	FF	CC Flow Vel (ft/s)	FF	Flame Thick (ft)	FF	Ig Min H2 Frac	Ig Min O2 Frac	Ig Max Steam Frac	Auto Ig Temp (F)	FF
1s	0.04		0.001		DEFAULT		0.164		0.04	0.05	0.55	DEFAULT	
2s	0.04		0.001		DEFAULT		0.164		0.04	0.05	0.55	DEFAULT	
3	0.04		0.001		DEFAULT		0.164		0.04	0.05	0.55	DEFAULT	

Fluid Boundary Conditions - Table 1

BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	S P	J O	ON Trip	OFF Trip	Elev. (ft)
1F	Flow-thru in	14.7		1	2T	v50000		N	N			0.
2P	Flow-thru out	14.7		1	2T			N	N			0.
3F	SFP Exhaust	14.7		1	2T	v-150		N	N			0.
4F	Str K Exhaust	14.7		1	2T	v-202.1		N	N			43.5
5F	BBall Ct Exhaust	14.7		1	2T	v-229.1		N	N			43.5

Fluid Boundary Conditions - Table 2

BC#	Liq. V. Frac.	FF	Stm. V. Frac.	FF	Drop D. (in)	FF	Drop GSD	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF	Outlet Quality	FF
1F			h57		NONE		1.						DEFAULT	

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Fluid Boundary Conditions - Table 2 (cont.)

BC#	Liq. V. Frac.	FF	Stm. V. Frac.	FF	Drop D. (in)	FF	Drop GSD	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF	Outlet Quality	FF
2P			h57		NONE		1.						DEFAULT	
3F					NONE		1.						DEFAULT	
4F					NONE		1.						DEFAULT	
5F					NONE		1.						DEFAULT	

Fluid Boundary Conditions - Table 3
Volume Fractions

BC#	Air Gas 1	FF	Gas 2	FF	Gas 3	FF	Gas 4	FF
1F	1.							
2P	1.							
3F	1.							
4F	1.							
5F	1.							

Fluid Boundary Conditions - Table 4
Volume Fractions

BC#	Gas 5	FF	Gas 6	FF	Gas 7	FF	Unused	--
1F								
2P								
3F								
4F								
5F								

Flow Paths - Table 1

F.P. #	Description	Vol A	Elev (ft)	Ht (ft)	Vol B	Elev (ft)	Ht (ft)
1	Flow-thru in	3	0.	1.	1F	0.	1.
2	Flow-thru out	3	0.	1.	2P	0.	1.
3	S Door Top	2s1	11.	11.	3	11.	11.
4	S Door Bott	2s1	0.	11.	3	0.	11.
5	N Door Top	2s22	11.	11.	3	11.	11.
6	N Door Bott	2s22	0.	11.	3	0.	11.
7	Str K Exhaust	1s129	43.5	17.	4F	43.5	17.
8	BBall Ct Exhaust	2s70	43.5	17.	5F	43.5	17.

Flow Paths - Table 2

Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Relative Rough-ness	Dep Bend (deg)	Mom Trn Opt	Strat Flow Opt
1	1000.	10.	10.				-	NONE

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Flow Paths - Table 2 (cont.)

Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Relative Rough-ness	Dep Bend (deg)	Mom Trn Opt	Strat Flow Opt
2	1000.	10.	10.				-	NONE
3	187.	4.8	10.				-	NONE
4	187.	4.8	10.				-	NONE
5	187.	4.8	10.				-	NONE
6	187.	4.8	10.				-	NONE
7	113.4	9.6	10.				-	NONE
8	321.6	17.9	10.				-	NONE

Flow Paths - Table 3

Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.	Critical Flow Model	Exit Loss Coeff.	Drop Breakup Model	Homog. Flow Opt.
1			OFF	OFF	0.	OFF	OFF
2			OFF	OFF	0.	OFF	OFF
3	2.78	2.78	OFF	OFF	0.	OFF	OFF
4	2.78	2.78	OFF	OFF	0.	OFF	OFF
5	2.78	2.78	OFF	OFF	0.	OFF	OFF
6	2.78	2.78	OFF	OFF	0.	OFF	OFF
7			OFF	OFF	0.	OFF	OFF
8			OFF	OFF	0.	OFF	OFF

Flow Paths - Table 4

Flow Path #	Forward Min H2 Frac	Forward Min O2 Frac	Forward Max H2O Frac	Reverse Min H2 Frac	Reverse Min O2 Frac	Reverse Max H2O Frac	Burn Time Frac	Prop With Zero Flow	Prop Opt
1	0.06	0.05	0.55	0.06	0.05	0.55	0.5	NO	COFLOW
2	0.06	0.05	0.55	0.06	0.05	0.55	0.5	NO	COFLOW
3	0.06	0.05	0.55	0.06	0.05	0.55	0.5	NO	COFLOW
4	0.06	0.05	0.55	0.06	0.05	0.55	0.5	NO	COFLOW
5	0.06	0.05	0.55	0.06	0.05	0.55	0.5	NO	COFLOW
6	0.06	0.05	0.55	0.06	0.05	0.55	0.5	NO	COFLOW
7	0.06	0.05	0.55	0.06	0.05	0.55	0.5	NO	COFLOW
8	0.06	0.05	0.55	0.06	0.05	0.55	0.5	NO	COFLOW

3D Connectors

Connector No.	Description	Volume A	Volume B	Fwd. Loss Coeff.	Rev. Loss Coeff.	LP Vol Momentum
1	West Connection	1s129-221	2s58-135			CONSERVE
2	East Connection	1s132-224	2s60-137			CONSERVE

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Network Nodes

Node #	Description	Elev (ft)	Heating Rate (Btu/s)	Heat FF	ON Trip	OFF Trip
1n	Joint	47.2	0.			

Network Links - Table 1

Link #	Description	Vol A	Elev (ft)	Vol B	Elev (ft)
1L	SFP Exh 1	1s133	47.2	1n	47.2
2L	SFP Exh 2	1s133	47.2	1n	47.2
3L	SFP Exh 3	1s133	47.2	1n	47.2
4L	SFP Exh 4	1s133	47.2	1n	47.2
5L	SFP Exh 5	1s137	47.2	1n	47.2
6L	SFP Exh 6	1s137	47.2	1n	47.2
7L	SFP Exh 7	1s137	47.2	1n	47.2
8L	SFP Exh 8	1s137	47.2	1n	47.2
9L	SFP Exh 9	1s145	47.2	1n	47.2
10L	SFP Exh 10	1s149	47.2	1n	47.2
11L	SFP Exh 11	1s149	47.2	1n	47.2
12L	SFP Exh 12	1s153	47.2	1n	47.2
13L	Duct	1n	47.2	3F	0.

Network Links - Table 2

Link #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Relative Rough-ness	Fwd. Loss Coeff.	Rev. Loss Coeff.
1L	2.	1.1	10.			1.	1.
2L	2.	1.1	10.			1.	1.
3L	2.	1.1	10.			1.	1.
4L	2.	1.1	10.			1.	1.
5L	2.	1.1	10.			1.	1.
6L	2.	1.1	10.			1.	1.
7L	2.	1.1	10.			1.	1.
8L	2.	1.1	10.			1.	1.
9L	2.	1.1	10.			1.	1.
10L	2.	1.1	10.			1.	1.
11L	2.	1.1	10.			1.	1.
12L	2.	1.1	10.			1.	1.
13L	2.	1.1	10.				

Thermal Conductors

Cond #	Description	Vol A	Srf Opt	Vol B	Srf Opt	Cond Type	S. A. (ft2)	Init. T.(F)	Or	Grp #
1s	N Pit N Wall	1s29-1	1	1s29-1	4	6	785.	160.	I	1
2s	N Pit W Wall	1s17-1	1	2s23	1	4	712.	160.	X	1
3s	Dividing Wall	1s17-1	1	1s13-1	1	2	717.	160.	X	1
4s	N Pit E Wall	1s20-1	1	2s25	1	3	644.	160.	X	1
5s	N Pit Floor	1s29-2	3	1s29-2	10	7	325.	160.	I	1

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Thermal Conductors (cont.)

Cond #	Description	Vol A	Srf Opt	Vol B	Srf Opt	Cond Type	S. A. (ft2)	Init. T.(F)	Or	Grp #
6s	S Pit W Wall	1s1-10	1	2s9	1	4	1349.	160.	X	1
7s	S Pit S Wall	1s1-10	1	1s1-10	9	2	785.	160.	I	1
8s	S Pit NE Wall	1s12-1	1	2s18	1	3	387.	160.	X	1
9s	S Pit SE Wall	1s4-10	1	2s11	1	3	734.	160.	X	1
10s	S Pit Floor	1s1-16	3	1s1-16	10	7	615.	160.	I	1
11s	N Canal N Wall	2s25-5	1	2s25-5	4	6	166.	160.	I	1
12s	N Canal E Bott	2s18-5	1	2s18-5	9	5	778.	160.	I	1
13s	N Canal E Top	2s46-5	1	2s76-8	1	5	488.	160.	X	1
14s	N Canal Floor	2s26-1	3	2s26-1	10	7	122.	160.	I	1
15s	S Canal W Wall	2s4-32	1	2s4-32	9	3	1134.	160.	I	1
16s	S Canal E Bott	2s4-39	1	2s4-39	9	5	1190.	160.	I	1
17s	S Canal E Top	2s32-3	1	2s62-6	1	5	747.	160.	X	1
18s	S Canal Floor	2s4-11	3	2s4-11	10	7	187.	160.	I	1
19s	Truck Bay N	2s22-1	1	2s22-1	4	8	3849.	160.	I	2
20s	Truck Bay W	2s1-13	1	2s1-13	4	11	7484.	160.	I	2
21s	Truck Bay S	2s2-11	1	2s2-11	4	10	3922.	160.	I	2
22s	Shield Wall	2s60-1	1	2s60-1	11	1	4807.	160.	I	2
23s	Op Fl N Wall 1	1s157-	1	1s157-	4	8	1407.	160.	I	2
24s	Op Fl N Wall 2	2s81-1	1	2s81-1	4	8	3453.	160.	I	2
25s	Op Fl E Wall	2s90-1	1	2s90-1	4	9	2206.	160.	I	2
26s	Roof over CV1	1s193-	2	1s193-	4	12	2386.	160.	I	3
27s	Roof over CV2	2s113-	2	2s113-	4	12	10099.	160.	I	3
28s	Lower Roof	2s91-1	2	2s91-1	5	12	2855.	160.	I	3
29	N Pit Decay 1	1s58	8	1s58	11	13	1.	160.	I	4
30s	N Pit Decay 2	1s55-5	8	1s55-5	11	14	1.	160.	I	4
31s	S Pit Decay Ht	1s38-4	8	1s38-4	11	15	1.	160.	I	4

Thermal Conductors - Radiation Parameters

Cond #	Therm. Rad. Side A	Emiss. Side A	Therm. Rad. Side B	Emiss. Side B
1s	No		No	
2s	No		No	
3s	No		No	
4s	No		No	
5s	No		No	
6s	No		No	
7s	No		No	
8s	No		No	
9s	No		No	
10s	No		No	
11s	No		No	
12s	No		No	
13s	No		No	
14s	No		No	
15s	No		No	
16s	No		No	
17s	No		No	
18s	No		No	
19s	No		No	
20s	No		No	
21s	No		No	
22s	No		No	
23s	No		No	
24s	No		No	

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Thermal Conductors - Radiation Parameters (cont.)

Cond #	Therm. Rad. Side A	Emiss. Side A	Therm. Rad. Side B	Emiss. Side B
25s	No		No	
26s	No		No	
27s	No		No	
28s	No		No	
29	No		No	
30s	No		No	
31s	No		No	

Conductor Surface Options - Table 1

Type #	Description	Heat Transfer Option	Nominal Value	FF	Cnd/ Cnv Opt	Cnd Opt	Sp Cnv HTC	Nat Cnv Opt	For Cnv Opt
1	Wall HTC	Direct			ADD	DLM		VERT SURF	OFF
2	Ceiling HTC	Direct			ADD	DLM		FACE DOWN	OFF
3	Floor HTC	Direct			ADD	DLM		FACE UP	OFF
4	Outside Wall HTC	Sp Ambie	1.	2T			5		
5	h=4	Sp Conv	4.						
6	h=1.46	Sp Conv	1.46						
7	h=1.08	Sp Conv	1.08						
8	h=1e9	Sp Conv	1e+009						
9	T-exh temp wall	Sp Ambie	1.	9C			6		
10	T-exh temp floor	Sp Ambie	1.	9C			7		
11	Adiabatic	Sp Heat	0.						

Conductor Surface Options - Table 2

Type #	Phase Opt	Min Liq Fract	Max Liq Fract	Convection Bulk Temp Model	FF	Condensation Bulk Temp Model	FF	Rad to Steam Emissivity Dry	Wet
1	VAP			Tg-Tf		Tb-Tw		0.9	DEFAULT
2	VAP			Tg-Tf		Tb-Tw		0.9	DEFAULT
3	VAP			Tg-Tf		Tb-Tw		0.9	DEFAULT
4									
5	VAP			Tg-Tw				0.	0.
6	VAP			Tg-Tw				0.	0.
7	VAP			Tg-Tw				0.	0.
8	VAP			Tg-Tw				0.	0.
9									
10									
11									

Conductor Surface Options - Table 3

Type #	Char. Length (ft)	Nat Conv Coef FF	Nat Conv Exp FF	For Conv Coef FF	For Conv Exp FF	Nom Vel (ft/s)	Vel FF	Minimum Conv HTC (B/h-f2-F)	Char. Height (ft)	Cond. Length (ft)
1								DEFAULT	DEFAUL	DEFAUL
2								DEFAULT	DEFAUL	DEFAUL

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Conductor Surface Options - Table 3 (cont.)

Type #	Char. Length (ft)	Nat Conv Coef FF	Nat Conv Exp FF	For Conv Coef FF	For Conv Exp FF	Nom Vel (ft/s)	Vel FF	Minimum Conv HTC (B/h-f2-F)	Char. Height (ft)	Cond. Length (ft)
3								DEFAULT	DEFAUL	DEFAUL
4									DEFAUL	DEFAUL
5								DEFAULT	DEFAUL	DEFAUL
6								DEFAULT	DEFAUL	DEFAUL
7								DEFAULT	DEFAUL	DEFAUL
8								DEFAULT	DEFAUL	DEFAUL
9									DEFAUL	DEFAUL
10									DEFAUL	DEFAUL
11									DEFAUL	DEFAUL

Conductor Surface Options - Table 4

Type #	Const CT	Total Heat (Btu)	Peak Time (sec)	Exp XT	Initial Value (B/h-f2-F)	BD Exp yt	Post-BD Exp xt	Post-BD Direct FF
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								

Thermal Conductor Types

Type #	Description	Geom	Thick. (in)	O.D. (in)	Regions	Heat (Btu/ft3-s)	Heat FF
1	2.5' Concrete	WALL	30.	0.	5	0.	
2	4' Concrete	WALL	48.	0.	17	0.	
3	4.75' Concrete	WALL	57.	0.	18	0.	
4	5.67' Concrete	WALL	68.	0.	18	0.	
5	6' Concrete	WALL	72.	0.	18	0.	
6	6' Conc w Solar	WALL	72.	0.	18	0.26	3T
7	7' Concrete	WALL	84.	0.	18	0.	
8	Ins Siding N	WALL	3.25	0.	26	0.26	3T
9	Ins Siding E	WALL	3.25	0.	26	0.26	4T
10	Ins Siding S	WALL	3.25	0.	26	0.26	5T
11	Ins Siding W	WALL	3.25	0.	26	0.26	6T
12	Upper Roof	WALL	5.5	0.	39	0.29	7T
13	N Decay Heat 1	WALL	12.	0.	1	65.1	
14	N Decay Heat 2	WALL	12.	0.	1	130.2	
15	S Decay Heat	WALL	12.	0.	1	618.6	

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Thermal Conductor Type
1
2.5' Concrete

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	1	0.	1.104	1	0.
2	1	1.104	2.208	1	0.
3	1	3.312	4.416	1	0.
4	1	7.728	11.136	1	0.
5	1	18.864	11.136	1	0.

Thermal Conductor Type
2
4' Concrete

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	1	0.	0.1104	1	0.
2	1	0.1104	0.2208	1	0.
3	1	0.3312	0.4416	1	0.
4	1	0.7728	0.8832	1	0.
5	1	1.656	1.7664	1	0.
6	1	3.4224	3.5328	1	0.
7	1	6.9552	7.0656	1	0.
8	1	14.0208	8.4948	1	0.
9	1	22.5156	8.4948	1	0.
10	1	31.0104	5.0172	1	0.
11	1	36.0276	5.0172	1	0.
12	1	41.0448	3.5328	1	0.
13	1	44.5776	1.7664	1	0.
14	1	46.344	0.8832	1	0.
15	1	47.2272	0.4416	1	0.
16	1	47.6688	0.2208	1	0.
17	1	47.8896	0.1104	1	0.

Thermal Conductor Type
3
4.75' Concrete

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	1	0.	0.1104	1	0.
2	1	0.1104	0.2208	1	0.
3	1	0.3312	0.4416	1	0.
4	1	0.7728	0.8832	1	0.
5	1	1.656	1.7664	1	0.
6	1	3.4224	3.5328	1	0.
7	1	6.9552	7.0656	1	0.
8	1	14.0208	14.1312	1	0.
9	1	28.152	7.212	1	0.
10	1	35.364	7.212	1	0.
11	1	42.576	3.7344	1	0.
12	1	46.3104	3.7344	1	0.
13	1	50.0448	3.5328	1	0.
14	1	53.5776	1.7664	1	0.

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Thermal Conductor Type (cont.)
3
4.75' Concrete

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
15	1	55.344	0.8832	1	0.
16	1	56.2272	0.4416	1	0.
17	1	56.6688	0.2208	1	0.
18	1	56.8896	0.1104	1	0.

Thermal Conductor Type
4
5.67' Concrete

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	1	0.	0.1104	1	0.
2	1	0.1104	0.2208	1	0.
3	1	0.3312	0.4416	1	0.
4	1	0.7728	0.8832	1	0.
5	1	1.656	1.7664	1	0.
6	1	3.4224	3.5328	1	0.
7	1	6.9552	7.0656	1	0.
8	1	14.0208	14.1312	1	0.
9	1	28.152	9.962	1	0.
10	1	38.114	9.962	1	0.
11	1	48.076	6.4844	1	0.
12	1	54.5604	6.4844	1	0.
13	1	61.0448	3.5328	1	0.
14	1	64.5776	1.7664	1	0.
15	1	66.344	0.8832	1	0.
16	1	67.2272	0.4416	1	0.
17	1	67.6688	0.2208	1	0.
18	1	67.8896	0.1104	1	0.

Thermal Conductor Type
5
6' Concrete

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	1	0.	0.1104	1	0.
2	1	0.1104	0.2208	1	0.
3	1	0.3312	0.4416	1	0.
4	1	0.7728	0.8832	1	0.
5	1	1.656	1.7664	1	0.
6	1	3.4224	3.5328	1	0.
7	1	6.9552	7.0656	1	0.
8	1	14.0208	14.1312	1	0.
9	1	28.152	10.962	1	0.
10	1	39.114	10.962	1	0.
11	1	50.076	7.4844	1	0.
12	1	57.5604	7.4844	1	0.
13	1	65.0448	3.5328	1	0.
14	1	68.5776	1.7664	1	0.

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Thermal Conductor Type (cont.)
5
6' Concrete

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
15	1	70.344	0.8832	1	0.
16	1	71.2272	0.4416	1	0.
17	1	71.6688	0.2208	1	0.
18	1	71.8896	0.1104	1	0.

Thermal Conductor Type
6
6' Conc w Solar

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	1	0.	0.1104	1	0.
2	1	0.1104	0.2208	1	0.
3	1	0.3312	0.4416	1	0.
4	1	0.7728	0.8832	1	0.
5	1	1.656	1.7664	1	0.
6	1	3.4224	3.5328	1	0.
7	1	6.9552	7.0656	1	0.
8	1	14.0208	14.1312	1	0.
9	1	28.152	10.962	1	0.
10	1	39.114	10.962	1	0.
11	1	50.076	7.4844	1	0.
12	1	57.5604	7.4844	1	0.
13	1	65.0448	3.5328	1	0.
14	1	68.5776	1.7664	1	0.
15	1	70.344	0.8832	1	0.
16	1	71.2272	0.4416	1	0.
17	1	71.6688	0.2208	1	0.
18	1	71.8896	0.1104	1	108.7

Thermal Conductor Type
7
7' Concrete

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	1	0.	0.1104	1	0.
2	1	0.1104	0.2208	1	0.
3	1	0.3312	0.4416	1	0.
4	1	0.7728	0.8832	1	0.
5	1	1.656	1.7664	1	0.
6	1	3.4224	3.5328	1	0.
7	1	6.9552	7.0656	1	0.
8	1	14.0208	14.1312	1	0.
9	1	28.152	13.962	1	0.
10	1	42.114	13.962	1	0.
11	1	56.076	10.4844	1	0.
12	1	66.5604	10.4844	1	0.
13	1	77.0448	3.5328	1	0.
14	1	80.5776	1.7664	1	0.

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Thermal Conductor Type (cont.)
7
7' Concrete

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
15	1	82.344	0.8832	1	0.
16	1	83.2272	0.4416	1	0.
17	1	83.6688	0.2208	1	0.
18	1	83.8896	0.1104	1	0.

Thermal Conductor Type
8
Ins Siding N

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	6	0.	0.00264	1	0.
2	6	0.00264	0.00528	1	0.
3	6	0.00792	0.01056	1	0.
4	6	0.01848	0.02112	1	0.
5	6	0.0396	0.04224	1	0.
6	6	0.08184	0.08448	1	0.
7	6	0.16632	0.16896	1	0.
8	6	0.33528	0.33792	1	0.
9	6	0.6732	0.2067	1	0.
10	6	0.8799	0.2067	1	0.
11	6	1.0866	0.2067	1	0.
12	6	1.2933	0.2067	1	0.
13	7	1.5	0.090681	1	0.
14	7	1.590682	0.181363	1	0.
15	7	1.772045	0.362727	1	0.
16	7	2.134773	0.278806	1	0.
17	7	2.41358	0.278806	1	0.
18	7	2.692386	0.177460	1	0.
19	7	2.869847	0.177460	1	0.
20	7	3.047308	0.102144	1	0.
21	7	3.149452	0.051072	1	0.
22	7	3.200524	0.025536	1	0.
23	7	3.22606	0.012768	1	0.
24	7	3.238828	0.006384	1	0.
25	7	3.245212	0.003192	1	0.
26	7	3.248404	0.001595	1	7519.

Thermal Conductor Type
9
Ins Siding E

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	6	0.	0.00264	1	0.
2	6	0.00264	0.00528	1	0.
3	6	0.00792	0.01056	1	0.
4	6	0.01848	0.02112	1	0.
5	6	0.0396	0.04224	1	0.
6	6	0.08184	0.08448	1	0.

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Thermal Conductor Type (cont.)
9
Ins Siding E

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
7	6	0.16632	0.16896	1	0.
8	6	0.33528	0.33792	1	0.
9	6	0.6732	0.2067	1	0.
10	6	0.8799	0.2067	1	0.
11	6	1.0866	0.2067	1	0.
12	6	1.2933	0.2067	1	0.
13	7	1.5	0.090681	1	0.
14	7	1.590682	0.181363	1	0.
15	7	1.772045	0.362727	1	0.
16	7	2.134773	0.278806	1	0.
17	7	2.41358	0.278806	1	0.
18	7	2.692386	0.177460	1	0.
19	7	2.869847	0.177460	1	0.
20	7	3.047308	0.102144	1	0.
21	7	3.149452	0.051072	1	0.
22	7	3.200524	0.025536	1	0.
23	7	3.22606	0.012768	1	0.
24	7	3.238828	0.006384	1	0.
25	7	3.245212	0.003192	1	0.
26	7	3.248404	0.001595	1	7519.

Thermal Conductor Type
10
Ins Siding S

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	6	0.	0.00264	1	0.
2	6	0.00264	0.00528	1	0.
3	6	0.00792	0.01056	1	0.
4	6	0.01848	0.02112	1	0.
5	6	0.0396	0.04224	1	0.
6	6	0.08184	0.08448	1	0.
7	6	0.16632	0.16896	1	0.
8	6	0.33528	0.33792	1	0.
9	6	0.6732	0.2067	1	0.
10	6	0.8799	0.2067	1	0.
11	6	1.0866	0.2067	1	0.
12	6	1.2933	0.2067	1	0.
13	7	1.5	0.090681	1	0.
14	7	1.590682	0.181363	1	0.
15	7	1.772045	0.362727	1	0.
16	7	2.134773	0.278806	1	0.
17	7	2.41358	0.278806	1	0.
18	7	2.692386	0.177460	1	0.
19	7	2.869847	0.177460	1	0.
20	7	3.047308	0.102144	1	0.
21	7	3.149452	0.051072	1	0.
22	7	3.200524	0.025536	1	0.
23	7	3.22606	0.012768	1	0.
24	7	3.238828	0.006384	1	0.
25	7	3.245212	0.003192	1	0.
26	7	3.248404	0.001595	1	7519.

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Thermal Conductor Type
11
Ins Siding W

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	6	0.	0.00264	1	0.
2	6	0.00264	0.00528	1	0.
3	6	0.00792	0.01056	1	0.
4	6	0.01848	0.02112	1	0.
5	6	0.0396	0.04224	1	0.
6	6	0.08184	0.08448	1	0.
7	6	0.16632	0.16896	1	0.
8	6	0.33528	0.33792	1	0.
9	6	0.6732	0.2067	1	0.
10	6	0.8799	0.2067	1	0.
11	6	1.0866	0.2067	1	0.
12	6	1.2933	0.2067	1	0.
13	7	1.5	0.090681	1	0.
14	7	1.590682	0.181363	1	0.
15	7	1.772045	0.362727	1	0.
16	7	2.134773	0.278806	1	0.
17	7	2.41358	0.278806	1	0.
18	7	2.692386	0.177460	1	0.
19	7	2.869847	0.177460	1	0.
20	7	3.047308	0.102144	1	0.
21	7	3.149452	0.051072	1	0.
22	7	3.200524	0.025536	1	0.
23	7	3.22606	0.012768	1	0.
24	7	3.238828	0.006384	1	0.
25	7	3.245212	0.003192	1	0.
26	7	3.248404	0.001595	1	7519.

Thermal Conductor Type
12
Upper Roof

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	2	0.	1.5	1	0.
2	7	1.5	7.4e-005	1	0.
3	7	1.500074	1.5e-004	1	0.
4	7	1.500222	3e-004	1	0.
5	7	1.500517	5.9e-004	1	0.
6	7	1.501108	0.001182	1	0.
7	7	1.502291	0.002364	1	0.
8	7	1.504655	0.004728	1	0.
9	7	1.509384	0.009457	1	0.
10	7	1.518842	0.018915	1	0.
11	7	1.537757	0.037831	1	0.
12	7	1.575588	0.087205	1	0.
13	7	1.662794	0.043602	1	0.
14	7	1.706397	0.043602	1	0.
15	3	1.75	0.060150	1	0.
16	3	1.81015	0.120300	1	0.
17	3	1.930451	0.240601	1	0.
18	3	2.171053	0.481203	1	0.
19	3	2.652256	0.274436	1	0.
20	3	2.926692	0.274436	1	0.

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Thermal Conductor Type (cont.)
12
Upper Roof

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
21	3	3.201128	0.184210	1	0.
22	3	3.385338	0.184210	1	0.
23	3	3.569549	0.120300	1	0.
24	3	3.68985	0.060150	1	0.
25	7	3.75	0.083125	1	0.
26	7	3.833125	0.041718	1	0.
27	7	3.874844	0.041718	1	0.
28	7	3.916562	0.028116	1	0.
29	7	3.944679	0.028116	1	0.
30	7	3.972796	0.018136	1	0.
31	7	3.990932	0.009068	1	0.
32	4	4.	0.413533	1	0.
33	4	4.413534	0.271616	1	0.
34	4	4.68515	0.271616	1	0.
35	4	4.956767	0.179216	1	0.
36	4	5.135984	0.179216	1	0.
37	4	5.3152	0.1056	1	0.
38	4	5.4208	0.0528	1	0.
39	4	5.4736	0.0264	1	454.5

Thermal Conductor Type
13
N Decay Heat 1

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	5	0.	12.	1	1.

Thermal Conductor Type
14
N Decay Heat 2

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	5	0.	12.	1	1.

Thermal Conductor Type
15
S Decay Heat

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	5	0.	12.	1	1.

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Cooler/Heater

Heater Cooler #	Description	Vol. #	On Trip #	Off Trip #	Flow Rate (CFM)	Flow Rate FF	Heat Rate (Btu/s)	Heat Rate FF	Phs Opt	Ctrlr Loc
1H	1000A-AB0	2s113					1.32689		VTI	2s113
2H	1000A-BC0	2s113					1.32689		VTI	2s113
3H	1000A-BC0	2s120					1.32689		VTI	2s120
4H	1000A-AC0	2s127					1.32689		VTI	2s127
5H	1000A-AC0	2s134					1.32689		VTI	2s134
6H	1000A-AB0	2s120					1.32689		VTI	2s120
7H	1000A-AB0	2s127					1.32689		VTI	2s127
8H	1000A-AB0	2s134					1.32689		VTI	2s134
9H	1000AA-2	2s114					0.94777		VTI	2s114
10H	1000AA-2	2s121					0.94777		VTI	2s121
11H	1000AA-18	2s121					0.94777		VTI	2s121
12H	1000AA-18	2s128					0.94777		VTI	2s128
13H	1000AA-20	2s135					0.94777		VTI	2s135
14H	500E-5 (2x)	1s161					0.94777		VTI	1s141
15H	500E-5	1s162					0.47388		VTI	1s142
16H	50CA-2	1s193					0.05686		VTI	1s169
17H	50CA-2	1s221					0.05686		VTI	1s193
18H	1000AA-2	1s194					0.94777		VTI	1s170
19H	1000AA-2	1s198					0.94777		VTI	1s174
20H	1000AA-3	1s198					0.94777		VTI	1s174
21H	1000AA-1	1s202					0.94777		VTI	1s178
22H	1000AA-1	1s218					0.94777		VTI	1s190
23H	50CA-2	1s195					0.05686		VTI	1s171
24H	1000AA-4	1s195					0.94777		VTI	1s171
25H	1000AA-4	1s199					0.94777		VTI	1s175
26H	1000AA-3	1s199					0.94777		VTI	1s175
27H	1000AA-3	1s203					0.94777		VTI	1s179
28H	1000AA-1	1s219					0.94777		VTI	1s191
29H	1000AA-19	2s116					0.94777		VTI	2s116
30H	50CA-2	2s116					0.05686		VTI	2s116
31H	50CA-2	2s137					0.05686		VTI	2s137
32H	1000AA-4	2s116					0.94777		VTI	2s116
33H	1000AA-4	2s123					0.94777		VTI	2s123
34H	1000AA-5	2s123					0.94777		VTI	2s123
35H	1000AA-3	2s130					0.94777		VTI	2s130
36H	1000AA-5	2s137					0.94777		VTI	2s137
37H	RPB13	2s60					0.47388		VTI	2s60
38H	RPB15	2s60					0.47388		VTI	2s60
39H	50CA-2	2s124					0.05686		VTI	2s124
40H	1000A-AB0	2s125					1.32689		VTI	2s125
41H	1000A-AB0	2s139					1.32689		VTI	2s139
42H	1000A-AB0	2s118					1.32689		VTI	2s118
43H	1000A-AC0	2s118					1.32689		VTI	2s118
44H	1000A-AC0	2s125					1.32689		VTI	2s125
45H	1000A-AC0	2s139					1.32689		VTI	2s139
46H	50CA-6	2s118					0.05686		VTI	2s118
47H	1000A-BC0	2s118					1.32689		VTI	2s118
48H	50CA-2	2s139					0.05686		VTI	2s139
49H	400B-AB0	2s63					0.37911		VTI	2s63
50H	1000A-BC0	2s105					1.32689		VTI	2s105
51H	1000A-BC0	2s112					1.32689		VTI	2s112
52H	200T-9	2s112					0.22746		VTI	2s112
53H	400B-AC0	2s91					0.37911		VTI	2s91
54H	400B-AB0	2s98					0.37911		VTI	2s98
55H	100P-6	2s105					0.11373		VTI	2s105
56H	50CA-6	2s105					0.05686		VTI	2s105
57H	100P-6	2s98					0.11373		VTI	2s98

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Cooler/Heater (cont.)

Heater Cooler #	Description	Vol. #	On Trip #	Off Trip #	Flow Rate (CFM)	Flow Rate FF	Heat Rate (Btu/s)	Heat Rate FF	Phs Opt	Ctrlr Loc
58H	100P-6	2s98					0.11373		VTI	2s98
59H	100P-6	2s105					0.11373		VTI	2s105
60H	100P-4/6 (6x)	2s69					0.6824		VTI	2s69
61H	100P-4/6 (5x)	2s76					0.56866		VTI	2s76
62H	50CA-2	2s76					0.05686		VTI	2s76
63H	200C-8 (4x)	2s83					0.75822		VTI	2s83
64H	25DA-8	2s1					0.02843		VTI	2s1
65H	50CA-1	2s8					0.05686		VTI	2s8
66H	100P-6 (2x)	2s22					0.22746		VTI	2s22
67H	200C-AE-6	2s22					0.18955		VTI	2s22
68H	50CA-1	2s22					0.05686		VTI	2s22
69H	300D (6x)	2s30					1.706		VTI	2s30
70H	300D (3x)	2s37					0.853		VTI	2s37
71H	50CA-1	2s9					0.05686		VTI	2s9
72H	50CA-1	2s23					0.05686		VTI	2s23
73H	200I-13a	2s9					0.18955		VTI	2s9
74H	200I-13a (2x)	2s16					0.37911		VTI	2s16
75H	200I-13a (3x)	2s23					0.56866		VTI	2s23
76H	100P (6x)	2s23					0.6824		VTI	2s23

Volume Initial Conditions

Vol #	Total Pressure (psia)	Vapor Temp. (F)	Liquid Temp. F	Relative Humidity (%)	Liquid Volume Fract.	Unused	Unused
def	14.7	80.	80.	60.	0.	0.	0.

Initial Volume Fractions

Vol #	Air Gas 1	Gas 2	Gas 3	Gas 4	Gas 5	Gas 6	Gas 7	Liq Comp
def	1.	0.	0.	0.	0.	0.	0.	0.

Noncondensing Gases

Gas No.	Description	Symbol	Type	Mol. Weight	Lennard-Jones Diameter (Ang)	Parameters e/K (K)
1	Air	Air	POLY	28.97	3.617	97.

Noncondensing Gases - Cp/Visc. Equations

Gas No.	Cp Tmin (R)	Equation Tmax (R)	(Required) Cp (Btu/lbm-R)	Visc. Tmin (R)	Equation Tmax (R)	(Optional) Viscosity (lbm/ft-hr)
1	360.	2880.	0.238534-6.2006			

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Materials		
Type #	Description	Gap
1	Concrete	NO
2	Plain Steel	NO
3	Perlite	NO
4	Gravel	NO
5	Ideal Conductor	NO
6	Glass Fiber Insulation	NO
7	Air	NO

Material Type
1
Concrete

Temp. (F)	Density (lbm/ft3)	Cond. (Btu/hr-ft-F)	Sp. Heat (Btu/lbm-F)
100.	145.	0.92	0.156

Material Type
2
Plain Steel

Temp. (F)	Density (lbm/ft3)	Cond. (Btu/hr-ft-F)	Sp. Heat (Btu/lbm-F)
100.	490.	27.	0.12

Material Type
3
Perlite

Temp. (F)	Density (lbm/ft3)	Cond. (Btu/hr-ft-F)	Sp. Heat (Btu/lbm-F)
100.	6.6	0.032	0.1

Material Type
4
Gravel

Temp. (F)	Density (lbm/ft3)	Cond. (Btu/hr-ft-F)	Sp. Heat (Btu/lbm-F)
100.	116.	0.22	0.1

Material Type
5
Ideal Conductor

Temp. (F)	Density (lbm/ft3)	Cond. (Btu/hr-ft-F)	Sp. Heat (Btu/lbm-F)
100.	0.1	1000.	0.1

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Material Type
6
Glass Fiber Insulation

Temp. (F)	Density (lbm/ft3)	Cond. (Btu/hr-ft-F)	Sp. Heat (Btu/lbm-F)
100.	1.58	0.022	0.167

Material Type
7
Air

Temp. (F)	Density (lbm/ft3)	Cond. (Btu/hr-ft-F)	Sp. Heat (Btu/lbm-F)
0.	0.086	0.0133	0.239
100.	0.071	0.0154	0.24
200.	0.06	0.0174	0.241
300.	0.052	0.0193	0.243
400.	0.046	0.0212	0.245

Forcing Function Tables

FF#	Description	Ind. Var.	Dep. Var.	Points
0	Constant	-	-	0
1T	Time of Day	Elapsed Ti	Time of Da	400
2T	Outside Temp	cv1C	Temperatur	25
3T	North Solar Flu	cv1C	Solar Flux	25
4T	East Solar Flux	cv1C	Solar Flux	25
5T	South Solar Flu	cv1C	Solar Flux	25
6T	West Solar Flux	cv1C	Solar Flux	25
7T	Roof Solar Flux	cv1C	Solar Flux	25
8T	Ramp Up	Ind. Var.	Dep. Var.	3

Function
1T
Time of Day
Ind. Var.: Elapsed Time (s)
Dep. Var.: Time of Day (s)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	86400.	86400.
86400.01	0.	172800.	86400.
172800.01	0.	259200.	86400.
259200.01	0.	345600.	86400.
345600.01	0.	432000.	86400.
432000.01	0.	518400.	86400.
518400.01	0.	604800.	86400.
604800.01	0.	691200.	86400.
691200.01	0.	777600.	86400.
777600.01	0.	864000.	86400.
864000.01	0.	950400.	86400.
950400.01	0.	1036800.	86400.
1036800.01	0.	1123200.	86400.

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Function (cont.)
1T
Time of Day
Ind. Var.: Elapsed Time (s)
Dep. Var.: Time of Day (s)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
1123200.01	0.	1209600.	86400.
1209600.01	0.	1296000.	86400.
1296000.01	0.	1382400.	86400.
1382400.01	0.	1468800.	86400.
1468800.01	0.	1555200.	86400.
1555200.01	0.	1641600.	86400.
1641600.01	0.	1728000.	86400.
1728000.01	0.	1814400.	86400.
1814400.01	0.	1900800.	86400.
1900800.01	0.	1987200.	86400.
1987200.01	0.	2073600.	86400.
2073600.01	0.	2160000.	86400.
2160000.01	0.	2246400.	86400.
2246400.01	0.	2332800.	86400.
2332800.01	0.	2419200.	86400.
2419200.01	0.	2505600.	86400.
2505600.01	0.	2592000.	86400.
2592000.01	0.	2678400.	86400.
2678400.01	0.	2764800.	86400.
2764800.01	0.	2851200.	86400.
2851200.01	0.	2937600.	86400.
2937600.01	0.	3024000.	86400.
3024000.01	0.	3110400.	86400.
3110400.01	0.	3196800.	86400.
3196800.01	0.	3283200.	86400.
3283200.01	0.	3369600.	86400.
3369600.01	0.	3456000.	86400.
3456000.01	0.	3542400.	86400.
3542400.01	0.	3628800.	86400.
3628800.01	0.	3715200.	86400.
3715200.01	0.	3801600.	86400.
3801600.01	0.	3888000.	86400.
3888000.01	0.	3974400.	86400.
3974400.01	0.	4060800.	86400.
4060800.01	0.	4147200.	86400.
4147200.01	0.	4233600.	86400.
4233600.01	0.	4320000.	86400.
4320000.01	0.	4406400.	86400.
4406400.01	0.	4492800.	86400.
4492800.01	0.	4579200.	86400.
4579200.01	0.	4665600.	86400.
4665600.01	0.	4752000.	86400.
4752000.01	0.	4838400.	86400.
4838400.01	0.	4924800.	86400.
4924800.01	0.	5011200.	86400.
5011200.01	0.	5097600.	86400.
5097600.01	0.	5184000.	86400.
5184000.01	0.	5270400.	86400.
5270400.01	0.	5356800.	86400.
5356800.01	0.	5443200.	86400.
5443200.01	0.	5529600.	86400.
5529600.01	0.	5616000.	86400.
5616000.01	0.	5702400.	86400.
5702400.01	0.	5788800.	86400.
5788800.01	0.	5875200.	86400.

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Function (cont.)
1T
Time of Day
Ind. Var.: Elapsed Time (s)
Dep. Var.: Time of Day (s)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
5875200.01	0.	5961600.	86400.
5961600.01	0.	6048000.	86400.
6048000.01	0.	6134400.	86400.
6134400.01	0.	6220800.	86400.
6220800.01	0.	6307200.	86400.
6307200.01	0.	6393600.	86400.
6393600.01	0.	6480000.	86400.
6480000.01	0.	6566400.	86400.
6566400.01	0.	6652800.	86400.
6652800.01	0.	6739200.	86400.
6739200.01	0.	6825600.	86400.
6825600.01	0.	6912000.	86400.
6912000.01	0.	6998400.	86400.
6998400.01	0.	7084800.	86400.
7084800.01	0.	7171200.	86400.
7171200.01	0.	7257600.	86400.
7257600.01	0.	7344000.	86400.
7344000.01	0.	7430400.	86400.
7430400.01	0.	7516800.	86400.
7516800.01	0.	7603200.	86400.
7603200.01	0.	7689600.	86400.
7689600.01	0.	7776000.	86400.
7776000.01	0.	7862400.	86400.
7862400.01	0.	7948800.	86400.
7948800.01	0.	8035200.	86400.
8035200.01	0.	8121600.	86400.
8121600.01	0.	8208000.	86400.
8208000.01	0.	8294400.	86400.
8294400.01	0.	8380800.	86400.
8380800.01	0.	8467200.	86400.
8467200.01	0.	8553600.	86400.
8553600.01	0.	8640000.	86400.
8640000.01	0.	8726400.	86400.
8726400.01	0.	8812800.	86400.
8812800.01	0.	8899200.	86400.
8899200.01	0.	8985600.	86400.
8985600.01	0.	9072000.	86400.
9072000.01	0.	9158400.	86400.
9158400.01	0.	9244800.	86400.
9244800.01	0.	9331200.	86400.
9331200.01	0.	9417600.	86400.
9417600.01	0.	9504000.	86400.
9504000.01	0.	9590400.	86400.
9590400.01	0.	9676800.	86400.
9676800.01	0.	9763200.	86400.
9763200.01	0.	9849600.	86400.
9849600.01	0.	9936000.	86400.
9936000.01	0.	10022400.	86400.
10022400.	0.	10108800.	86400.
10108800.	0.	10195200.	86400.
10195200.	0.	10281600.	86400.
10281600.	0.	10368000.	86400.
10368000.	0.	10454400.	86400.
10454400.	0.	10540800.	86400.
10540800.	0.	10627200.	86400.

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Function (cont.)
1T
Time of Day
Ind. Var.: Elapsed Time (s)
Dep. Var.: Time of Day (s)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
10627200.	0.	10713600.	86400.
10713600.	0.	10800000.	86400.
10800000.	0.	10886400.	86400.
10886400.	0.	10972800.	86400.
10972800.	0.	11059200.	86400.
11059200.	0.	11145600.	86400.
11145600.	0.	11232000.	86400.
11232000.	0.	11318400.	86400.
11318400.	0.	11404800.	86400.
11404800.	0.	11491200.	86400.
11491200.	0.	11577600.	86400.
11577600.	0.	11664000.	86400.
11664000.	0.	11750400.	86400.
11750400.	0.	11836800.	86400.
11836800.	0.	11923200.	86400.
11923200.	0.	12009600.	86400.
12009600.	0.	12096000.	86400.
12096000.	0.	12182400.	86400.
12182400.	0.	12268800.	86400.
12268800.	0.	12355200.	86400.
12355200.	0.	12441600.	86400.
12441600.	0.	12528000.	86400.
12528000.	0.	12614400.	86400.
12614400.	0.	12700800.	86400.
12700800.	0.	12787200.	86400.
12787200.	0.	12873600.	86400.
12873600.	0.	12960000.	86400.
12960000.	0.	13046400.	86400.
13046400.	0.	13132800.	86400.
13132800.	0.	13219200.	86400.
13219200.	0.	13305600.	86400.
13305600.	0.	13392000.	86400.
13392000.	0.	13478400.	86400.
13478400.	0.	13564800.	86400.
13564800.	0.	13651200.	86400.
13651200.	0.	13737600.	86400.
13737600.	0.	13824000.	86400.
13824000.	0.	13910400.	86400.
13910400.	0.	13996800.	86400.
13996800.	0.	14083200.	86400.
14083200.	0.	14169600.	86400.
14169600.	0.	14256000.	86400.
14256000.	0.	14342400.	86400.
14342400.	0.	14428800.	86400.
14428800.	0.	14515200.	86400.
14515200.	0.	14601600.	86400.
14601600.	0.	14688000.	86400.
14688000.	0.	14774400.	86400.
14774400.	0.	14860800.	86400.
14860800.	0.	14947200.	86400.
14947200.	0.	15033600.	86400.
15033600.	0.	15120000.	86400.
15120000.	0.	15206400.	86400.
15206400.	0.	15292800.	86400.
15292800.	0.	15379200.	86400.

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Function (cont.)
1T
Time of Day
Ind. Var.: Elapsed Time (s)
Dep. Var.: Time of Day (s)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
15379200.	0.	15465600.	86400.
15465600.	0.	15552000.	86400.
15552000.	0.	15638400.	86400.
15638400.	0.	15724800.	86400.
15724800.	0.	15811200.	86400.
15811200.	0.	15897600.	86400.
15897600.	0.	15984000.	86400.
15984000.	0.	16070400.	86400.
16070400.	0.	16156800.	86400.
16156800.	0.	16243200.	86400.
16243200.	0.	16329600.	86400.
16329600.	0.	16416000.	86400.
16416000.	0.	16502400.	86400.
16502400.	0.	16588800.	86400.
16588800.	0.	16675200.	86400.
16675200.	0.	16761600.	86400.
16761600.	0.	16848000.	86400.
16848000.	0.	16934400.	86400.
16934400.	0.	17020800.	86400.
17020800.	0.	17107200.	86400.
17107200.	0.	17193600.	86400.
17193600.	0.	17280000.	86400.

Function
2T
Outside Temp
Ind. Var.: Time of Day (s)
Dep. Var.: Temperature (F)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	57.4	3600.	56.5
7200.	55.9	10800.	55.4
14400.	55.	18000.	54.7
21600.	55.	25200.	56.
28800.	58.6	32400.	61.4
36000.	63.9	39600.	66.2
43200.	67.7	46800.	68.9
50400.	69.6	54000.	69.6
57600.	68.7	61200.	67.5
64800.	66.	68400.	63.8
72000.	62.2	75600.	60.8
79200.	59.5	82800.	58.4
86400.	57.4		

Function
3T
North Solar Flux
Ind. Var.: Time of Day (s)
Dep. Var.: Solar Flux (Btu/s-ft^2)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	3600.	0.

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Function (cont.)
3T
North Solar Flux
Ind. Var.: Time of Day (s)
Dep. Var.: Solar Flux (Btu/s-ft^2)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
7200.	0.	10800.	0.
14400.	0.	18000.	0.
21600.	0.	25200.	0.001038
28800.	0.004789	32400.	0.006947
36000.	0.008278	39600.	0.008947
43200.	0.008986	46800.	0.008394
50400.	0.00715	54000.	0.005114
57600.	0.001617	61200.	0.
64800.	0.	68400.	0.
72000.	0.	75600.	0.
79200.	0.	82800.	0.
86400.	0.		

Function
4T
East Solar Flux
Ind. Var.: Time of Day (s)
Dep. Var.: Solar Flux (Btu/s-ft^2)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	3600.	0.
7200.	0.	10800.	0.
14400.	0.	18000.	0.
21600.	0.	25200.	0.016014
28800.	0.053139	32400.	0.053861
36000.	0.040972	39600.	0.02185
43200.	0.019292	46800.	0.008394
50400.	0.00715	54000.	0.005114
57600.	0.001617	61200.	0.
64800.	0.	68400.	0.
72000.	0.	75600.	0.
79200.	0.	82800.	0.
86400.	0.		

Function
5T
South Solar Flux
Ind. Var.: Time of Day (s)
Dep. Var.: Solar Flux (Btu/s-ft^2)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	3600.	0.
7200.	0.	10800.	0.
14400.	0.	18000.	0.
21600.	0.	25200.	0.008192
28800.	0.041139	32400.	0.062556
36000.	0.076528	39600.	0.083722
43200.	0.084139	46800.	0.077778
50400.	0.064639	54000.	0.044222

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Function (cont.)
5T
South Solar Flux
Ind. Var.: Time of Day (s)
Dep. Var.: Solar Flux (Btu/s-ft^2)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
57600.	0.012933	61200.	0.
64800.	0.	68400.	0.
72000.	0.	75600.	0.
79200.	0.	82800.	0.
86400.	0.		

Function
6T
West Solar Flux
Ind. Var.: Time of Day (s)
Dep. Var.: Solar Flux (Btu/s-ft^2)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	3600.	0.
7200.	0.	10800.	0.
14400.	0.	18000.	0.
21600.	0.	25200.	0.001038
28800.	0.004789	32400.	0.006947
36000.	0.008278	39600.	0.009342
43200.	0.009478	46800.	0.038889
50400.	0.052806	54000.	0.054417
57600.	0.023961	61200.	0.
64800.	0.	68400.	0.
72000.	0.	75600.	0.
79200.	0.	82800.	0.
86400.	0.		

Function
7T
Roof Solar Flux
Ind. Var.: Time of Day (s)
Dep. Var.: Solar Flux (Btu/s-ft^2)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	3600.	0.
7200.	0.	10800.	0.
14400.	0.	18000.	0.
21600.	0.	25200.	0.002842
28800.	0.019667	32400.	0.034028
36000.	0.044222	39600.	0.049667
43200.	0.049972	46800.	0.045167
50400.	0.0355	54000.	0.021611
57600.	0.004769	61200.	0.
64800.	0.	68400.	0.
72000.	0.	75600.	0.
79200.	0.	82800.	0.
86400.	0.		

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Function
8T
Ramp Up
Ind. Var.:
Dep. Var.:

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	10.	1.
1e+009	1.		

Control Variables

CV #	Description	Func. Form	Initial Value	Coeff. G	Coeff. a0	Min	Max	Upd. Int. Mult.
1C	Time of Day	tfunc	0.	1.	0.	-1e+03	1e+032	0.
2C	Desired T_amb	tfunc	0.	1.	0.	-1e+03	1e+032	0.
3C	T_amb Error	sum	0.	1.	0.	-1e+03	1e+032	0.
4C	Max T N Pit	max	0.	1.	0.	-1e+03	1e+032	0.
5C	Max T S Pit	max	0.	1.	0.	-1e+03	1e+032	0.
6C	Concrete Heat	sum	0.	1.	0.	-1e+03	1e+032	0.
7C	Siding Heat	sum	0.	1.	0.	-1e+03	1e+032	0.
8C	Roof Heat	sum	0.	1.	0.	-1e+03	1e+032	0.
9C	Max Exh Temp	max	0.	1.	0.	-1e+03	1e+032	0.

Function Components
Control Variable 1C
Time of Day
tfunc
Y=G*interp(X1,tableX2)

#	Gothic_s Name	Variable location	Coef. a	Min. Value	Max Value
1	Etime	cM	1.	-1e+032	1e+032
2	Table	DC1T	1.	-1e+032	1e+032

Function Components
Control Variable 2C
Desired T_amb
tfunc
Y=G*interp(X1,tableX2)

#	Gothic_s Name	Variable location	Coef. a	Min. Value	Max Value
1	Cvval(0)	cv1C	1.	-1e+032	1e+032
2	Table	DC2T	1.	-1e+032	1e+032

Fuel Handling Area (October 2014)
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Function Components
Control Variable 3C
T_amb Error
sum
Y=G*(a0+a1X1+a2X2+...+anXn)

#	Gothic_s Name	Variable location	Coef. a	Min. Value	Max Value
1	Temv	cV3	1.	-1e+032	1e+032
2	Cvval(0)	cv2C	-1.	-1e+032	1e+032

Function Components
Control Variable 4C
Max T N Pit
max
Y=G*max(a0,a1X1,a2X2,...,anXn)

#	Gothic_s Name	Variable location	Coef. a	Min. Value	Max Value
1	Temv	cV1s61	1.	-1e+032	1e+032
2	Temv	cV1s62	1.	-1e+032	1e+032
3	Temv	cV1s63	1.	-1e+032	1e+032
4	Temv	cV1s64	1.	-1e+032	1e+032
5	Temv	cV1s60	1.	-1e+032	1e+032
6	Temv	cV1s56	1.	-1e+032	1e+032
7	Temv	cV1s52	1.	-1e+032	1e+032
8	Temv	cV1s51	1.	-1e+032	1e+032
9	Temv	cV1s57	1.	-1e+032	1e+032
10	Temv	cV1s54	1.	-1e+032	1e+032

Function Components
Control Variable 5C
Max T S Pit
max
Y=G*max(a0,a1X1,a2X2,...,anXn)

#	Gothic_s Name	Variable location	Coef. a	Min. Value	Max Value
1	Temv	cV1s45	1.	-1e+032	1e+032
2	Temv	cV1s46	1.	-1e+032	1e+032
3	Temv	cV1s47	1.	-1e+032	1e+032
4	Temv	cV1s48	1.	-1e+032	1e+032
5	Temv	cV1s44	1.	-1e+032	1e+032
6	Temv	cV1s40	1.	-1e+032	1e+032
7	Temv	cV1s36	1.	-1e+032	1e+032
8	Temv	cV1s35	1.	-1e+032	1e+032
9	Temv	cV1s34	1.	-1e+032	1e+032
10	Temv	cV1s33	1.	-1e+032	1e+032
11	Temv	cV1s37	1.	-1e+032	1e+032
12	Temv	cV1s41	1.	-1e+032	1e+032

Fuel Handling Area (October 2014)
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Function Components
Control Variable 6C
Concrete Heat
sum
Y=G*(a0+a1X1+a2X2+...+anXn)

#	Gothic_s Name	Variable location	Coef. a	Min. Value	Max Value
1	Cond_grp_heat(1)	cC3s1	1.	-1e+032	1e+032
2	Cond_grp_heat(2)	cC3s1	1.	-1e+032	1e+032
3	Qw_tot(2)	cC1s1	-1.	-1e+032	1e+032
4	Qw_tot(2)	cC1s2	-1.	-1e+032	1e+032
5	Qw_tot(2)	cC1s3	-1.	-1e+032	1e+032
6	Qw_tot(2)	cC1s4	-1.	-1e+032	1e+032
7	Qw_tot(2)	cC1s5	-1.	-1e+032	1e+032
8	Qw_tot(2)	cC1s6	-1.	-1e+032	1e+032
9	Qw_tot(2)	cC1s7	-1.	-1e+032	1e+032
10	Qw_tot(2)	cC1s8	-1.	-1e+032	1e+032
11	Qw_tot(2)	cC1s9	-1.	-1e+032	1e+032
12	Qw_tot(2)	cC1s10	-1.	-1e+032	1e+032
13	Qw_tot(2)	cC1s11	-1.	-1e+032	1e+032
14	Qw_tot(2)	cC1s12	-1.	-1e+032	1e+032
15	Qw_tot(2)	cC1s13	-1.	-1e+032	1e+032
16	Qw_tot(2)	cC1s14	-1.	-1e+032	1e+032
17	Qw_tot(2)	cC1s15	-1.	-1e+032	1e+032
18	Qw_tot(2)	cC1s16	-1.	-1e+032	1e+032

Function Components
Control Variable 7C
Siding Heat
sum
Y=G*(a0+a1X1+a2X2+...+anXn)

#	Gothic_s Name	Variable location	Coef. a	Min. Value	Max Value
1	Cond_grp_heat(1)	cC24s1	1.	-1e+032	1e+032

Function Components
Control Variable 8C
Roof Heat
sum
Y=G*(a0+a1X1+a2X2+...+anXn)

#	Gothic_s Name	Variable location	Coef. a	Min. Value	Max Value
1	Cond_grp_heat(1)	cC27s1	1.	-1e+032	1e+032

Function Components
Control Variable 9C
Max Exh Temp
max
Y=G*max(a0,a1X1,a2X2,...,anXn)

#	Gothic_s Name	Variable location	Coef. a	Min. Value	Max Value
1	Temv	cV1s129	1.	-1e+032	1e+032

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Function Components (cont.)
Control Variable 9C
Max Exh Temp
max
Y=G*max(a0,a1X1,a2X2,...,anXn)

#	Gothic_s Name	Variable location	Coef. a	Min. Value	Max Value
2	Temv	cV2s70	1.	-1e+032	1e+032

Time Domain Data

Time Dom	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Gas Error Relax T	Dump Int	Ph Chng T Scale	L Flow Shutoff
1	0.001	1.	1.	9e+005	5000.	5000.	DEFAULT	0.	DEFAULT	DEFAULT

Solution Options

Time Dom	Solution Method	Imp Conv Limit	Imp Iter Limit	Pres Sol Method	Pres Conv Limit	Pres Iter Limit	Differ Scheme	Burn Sharp
1	SEMI-IMP	0.	1	DIRECT	0.	1	FOUP	0.

Time Step and Backup Control Limits

Time Dom	Tot. Pres. Change (psia)	Stm. Enth. Change (Btu/lbm)	Domain End Dt Controls
1	DEFAULT	DEFAULT	ON

Run Options

Option	Setting
Start Time (sec)	0.0
Restart Time Step #	0
Restart Time Control	NEW
Parallel Processes	4
Preprocessor Multithreading	YES
Revaporization Fraction	DEFAULT
Maximum Mist Density (lbm/ft3)	DEFAULT
Drop Diam. From Mist (in)	DEFAULT
Minimum HT Coeff. (B/h-ft2-F)	0.0
Reference Pressure (psia)	IGNORE
Maximum Pressure (psia)	DEFAULT
Forced Ent. Drop Diam. (in)	DEFAULT
Vapor Phase Head Correction	INCLUDE
Kinetic Energy	IGNORE
Vapor Phase	INCLUDE
Liquid Phase	NONE
Drop Phase	INCLUDE
Force Equilibrium	IGNORE

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Run Options (cont.)	
Option	Setting
Drop-Liq. Conversion	INCLUDE
QA Logging	OFF
Debug Output Level	0
Restart Dump on CPU Interval (sec)	3600.
Pressure Initialization Iteration	1000
Pressure Initialization Convergenc	1.0e-6

Graphs

Graph #	Title	Mon	Curve Number 1	2	3	4	5
0	M&E Imbalance		EM	EE			
1	Check T_amb Err		cv3C				
2	Temperature Bel		cv4C	cv5C			
3	Flow thru Roll-		VV3	VV4	VV5	VV6	
4	Heat Rate to He		cv6C	cv7C	cv8C		

Envelope Sets

Set No.	Description	Set Type	No. Items

Data Files

File #	Name	Type	Inter-polate	Output Files	Detail Level
1	temp_oct.txt	TIME	YES	SINGLE	FULL

File Comparison: Double entries indicate differences.
/ Current File: D:\0p4738\Kewaunee\Fuel Handling Area (May 2015).GTH
\ Compare File: D:\0p4738\Kewaunee\Fuel Handling Area (October 2014).GTH
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Thermal Conductors

Cond #	Description	Vol A	Srf Opt	Vol B	Srf Opt	Cond Type	S. A. (ft2)	Init. T.(F)	Or	Grp #
1s	N Pit N Wall	1s29-1	1	1s29-1	4	6	785.	/175. \160.	I	1
2s	N Pit W Wall	1s17-1	1	2s23	1	4	712.	/175. \160.	X	1
3s	Dividing Wall	1s17-1	1	1s13-1	1	2	717.	/175. \160.	X	1
4s	N Pit E Wall	1s20-1	1	2s25	1	3	644.	/175. \160.	X	1
5s	N Pit Floor	1s29-2	3	1s29-2	10	7	325.	/175. \160.	I	1
6s	S Pit W Wall	1s1-10	1	2s9	1	4	1349.	/175. \160.	X	1
7s	S Pit S Wall	1s1-10	1	1s1-10	9	2	785.	/175. \160.	I	1
8s	S Pit NE Wall	1s12-1	1	2s18	1	3	387.	/175. \160.	X	1
9s	S Pit SE Wall	1s4-10	1	2s11	1	3	734.	/175. \160.	X	1
10s	S Pit Floor	1s1-16	3	1s1-16	10	7	615.	/175. \160.	I	1
11s	N Canal N Wall	2s25-5	1	2s25-5	4	6	166.	/175. \160.	I	1
12s	N Canal E Bott	2s18-5	1	2s18-5	9	5	778.	/175. \160.	I	1
13s	N Canal E Top	2s46-5	1	2s76-8	1	5	488.	/175. \160.	X	1
14s	N Canal Floor	2s26-1	3	2s26-1	10	7	122.	/175. \160.	I	1
15s	S Canal W Wall	2s4-32	1	2s4-32	9	3	1134.	/175. \160.	I	1
16s	S Canal E Bott	2s4-39	1	2s4-39	9	5	1190.	/175. \160.	I	1
17s	S Canal E Top	2s32-3	1	2s62-6	1	5	747.	/175. \160.	X	1
18s	S Canal Floor	2s4-11	3	2s4-11	10	7	187.	/175. \160.	I	1
19s	Truck Bay N	2s22-1	1	2s22-1	4	8	3849.	/175. \160.	I	2
20s	Truck Bay W	2s1-13	1	2s1-13	4	11	7484.	/175. \160.	I	2
21s	Truck Bay S	2s2-11	1	2s2-11	4	10	3922.	/175. \160.	I	2
22s	Shield Wall	2s60-1	1	2s60-1	11	1	4807.	/175. \160.	I	2
23s	Op Fl N Wall 1	1s157-	1	1s157-	4	8	1407.	/175. \160.	I	2
24s	Op Fl N Wall 2	2s81-1	1	2s81-1	4	8	3453.	/175. \160.	I	2
25s	Op Fl E Wall	2s90-1	1	2s90-1	4	9	2206.	/175. \160.	I	2
26s	Roof over CV1	1s193-	2	1s193-	4	12	2386.	/175. \160.	I	3
27s	Roof over CV2	2s113-	2	2s113-	4	12	10099.	/175. \160.	I	3
28s	Lower Roof	2s91-1	2	2s91-1	5	12	2855.	/175. \160.	I	3
29	N Pit Decay 1	1s58	8	1s58	11	13	1.	/175. \160.	I	4
30s	N Pit Decay 2	1s55-5	8	1s55-5	11	14	1.	/175. \160.	I	4
31s	S Pit Decay Ht	1s38-4	8	1s38-4	11	15	1.	/175. \160.	I	4

Thermal Conductor Types

Type #	Description	Geom	Thick. (in)	O.D. (in)	Regions	Heat (Btu/ft3-s)	Heat FF
1	2.5' Concrete	WALL	30.	0.	5	0.	
2	4' Concrete	WALL	48.	0.	17	0.	
3	4.75' Concrete	WALL	57.	0.	18	0.	
4	5.67' Concrete	WALL	68.	0.	18	0.	
5	6' Concrete	WALL	72.	0.	18	0.	
6	6' Conc w Solar	WALL	72.	0.	18	0.26	3T
7	7' Concrete	WALL	84.	0.	18	0.	
8	Ins Siding N	WALL	3.25	0.	26	0.26	3T
9	Ins Siding E	WALL	3.25	0.	26	0.26	4T
10	Ins Siding S	WALL	3.25	0.	26	0.26	5T
11	Ins Siding W	WALL	3.25	0.	26	0.26	6T
12	Upper Roof	WALL	5.5	0.	39	0.29	7T
13	N Decay Heat 1	WALL	12.	0.	1	/56. \65.1	
14	N Decay Heat 2	WALL	12.	0.	1	/112. \130.2	
15	S Decay Heat	WALL	12.	0.	1	/532. \618.6	

File Comparison: Double entries indicate differences.
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Data Files

File #	Name	Type	Inter-polate	Output Files	Detail Level
1	/temp_may.txt \temp_oct.txt	TIME	YES	SINGLE	FULL

Fluid Boundary Conditions - Table 2

BC#	Liq. V. Frac.	FF	Stm. V. Frac.	FF	Drop D. (in)	FF	Drop GSD	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF	Outlet Quality	FF
1F			/h53 \h57		NONE		1.						DEFAULT	
2P			/h53 \h57		NONE		1.						DEFAULT	
3F					NONE		1.						DEFAULT	
4F					NONE		1.						DEFAULT	
5F					NONE		1.						DEFAULT	

Function

2T

Outside Temp

Ind. Var.: Time of Day (s)

Dep. Var.: Temperature (F)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	/72.1 \57.4	3600.	/71.1 \56.5
7200.	/70.5 \55.9	10800.	/69.9 \55.4
14400.	/69.4 \55.	18000.	/69.1 \54.7
21600.	/69.4 \55.	25200.	/70.6 \56.
28800.	/73.5 \58.6	32400.	/76.7 \61.4
36000.	/79.6 \63.9	39600.	/82.1 \66.2
43200.	/83.8 \67.7	46800.	/85.2 \68.9
50400.	/86. \69.6	54000.	/86. \69.6
57600.	/85. \68.7	61200.	/83.6 \67.5
64800.	/81.9 \66.	68400.	/79.4 \63.8
72000.	/77.6 \62.2	75600.	/76. \60.8
79200.	/74.5 \59.5	82800.	/73.3 \58.4
86400.	/72.1 \57.4		

Function

3T

North Solar Flux

Ind. Var.: Time of Day (s)

Dep. Var.: Solar Flux (Btu/s-ft^2)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	3600.	0.
7200.	0.	10800.	0.
14400.	0.	18000.	/0.013981 \0.
21600.	/0.021844 \0.	25200.	/0.016247 \0.001038
28800.	/0.011156 \0.004789	32400.	/0.012281 \0.006947
36000.	/0.013125 \0.008278	39600.	/0.013786 \0.008947
43200.	/0.013967 \0.008986	46800.	/0.013644 \0.008394
50400.	/0.012919 \0.00715	54000.	/0.011994 \0.005114

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Function (cont.)
3T
North Solar Flux
Ind. Var.: Time of Day (s)
Dep. Var.: Solar Flux (Btu/s-ft^2)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
57600.	/0.010786 \0.001617	61200.	/0.018431 \0.
64800.	/0.021711 \0.	68400.	/0.00705 \0.
72000.	0.	75600.	0.
79200.	0.	82800.	0.
86400.	0.		

Function
4T
East Solar Flux
Ind. Var.: Time of Day (s)
Dep. Var.: Solar Flux (Btu/s-ft^2)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	3600.	0.
7200.	0.	10800.	0.
14400.	0.	18000.	/0.026906 \0.
21600.	/0.061722 \0.	25200.	/0.074917 \0.016014
28800.	/0.075278 \0.053139	32400.	/0.06675 \0.053861
36000.	/0.051917 \0.040972	39600.	/0.033 \0.02185
43200.	/0.018047 \0.019292	46800.	/0.0137 \0.008394
50400.	/0.012833 \0.00715	54000.	/0.011558 \0.005114
57600.	/0.009847 \0.001617	61200.	/0.007692 \0.
64800.	/0.004914 \0.	68400.	/9.71e-004 \0.
72000.	0.	75600.	0.
79200.	0.	82800.	0.
86400.	0.		

Function
5T
South Solar Flux
Ind. Var.: Time of Day (s)
Dep. Var.: Solar Flux (Btu/s-ft^2)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	3600.	0.
7200.	0.	10800.	0.
14400.	0.	18000.	/0.002194 \0.
21600.	/0.005831 \0.	25200.	/0.008911 \0.008192
28800.	/0.015883 \0.041139	32400.	/0.028694 \0.062556
36000.	/0.038833 \0.076528	39600.	/0.045111 \0.083722
43200.	/0.046833 \0.084139	46800.	/0.043806 \0.077778
50400.	/0.036361 \0.064639	54000.	/0.025311 \0.044222
57600.	/0.012072 \0.012933	61200.	/0.008089 \0.
64800.	/0.004914 \0.	68400.	/9.71e-004 \0.
72000.	0.	75600.	0.
79200.	0.	82800.	0.
86400.	0.		

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Function
6T
West Solar Flux
Ind. Var.: Time of Day (s)
Dep. Var.: Solar Flux (Btu/s-ft^2)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	3600.	0.
7200.	0.	10800.	0.
14400.	0.	18000.	/0.002194 \0.
21600.	/0.005775 \0.	25200.	/0.008344 \0.001038
28800.	/0.010369 \0.004789	32400.	/0.011958 \0.006947
36000.	/0.013108 \0.008278	39600.	/0.014053 \0.009342
43200.	/0.014939 \0.009478	46800.	/0.038556 \0.038889
50400.	/0.056556 \0.052806	54000.	/0.069861 \0.054417
57600.	/0.076194 \0.023961	61200.	/0.07275 \0.
64800.	/0.05475 \0.	68400.	/0.012278 \0.
72000.	0.	75600.	0.
79200.	0.	82800.	0.
86400.	0.		

Function
7T
Roof Solar Flux
Ind. Var.: Time of Day (s)
Dep. Var.: Solar Flux (Btu/s-ft^2)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	3600.	0.
7200.	0.	10800.	0.
14400.	0.	18000.	/0.006664 \0.
21600.	/0.024044 \0.	25200.	/0.041444 \0.002842
28800.	/0.057417 \0.019667	32400.	/0.070861 \0.034028
36000.	/0.080972 \0.044222	39600.	/0.087056 \0.049667
43200.	/0.088694 \0.049972	46800.	/0.085778 \0.045167
50400.	/0.078528 \0.0355	54000.	/0.067417 \0.021611
57600.	/0.053167 \0.004769	61200.	/0.036694 \0.
64800.	/0.019083 \0.	68400.	/0.002574 \0.
72000.	0.	75600.	0.
79200.	0.	82800.	0.
86400.	0.		

Controlled File Detail - GOTHIC (S&L Program No. 03.7.759-8.0)
Type: 2 Status: P Effective Date: 07-31-2013
Executed 10-25-2013 11:39

Controlled File Path: C:\Gothic\8.0(QA)\

File Size	Date/Time Stamp	File Name
56320	01-06-2012 17:18	bin\gcksum.exe
53	05-25-2004 16:50	bin\gedit.bat
114176	01-06-2012 17:18	bin\gisp.exe
65889	01-08-2012 07:19	bin\gothic.b
2540544	01-06-2012 17:19	bin\gothic.exe
131	05-04-2004 23:18	bin\gothic_g.bat
267776	01-06-2012 17:19	bin\gothic_g.exe
315	12-15-2011 16:29	bin\gothic_s.bat
1749504	01-06-2012 17:21	bin\gothic_s.exe
226	01-06-2012 14:01	bin\gprint.bat
2773	01-08-2012 07:01	bin\gtest.bat
107285	01-08-2012 07:19	bin\menu.got
572	05-09-2011 21:05	bin\Microsoft.VC80.OPENMP\Microsoft.VC80.OpenMP.manifest
65536	05-09-2011 21:05	bin\Microsoft.VC80.OPENMP\vcomp.dll
60	12-19-2012 13:00	bin\readhelp.bat
51024	05-25-2011 17:24	bin\vcomp100.dll
4353	02-23-2010 12:24	lib\add_pic1.1
6743	02-23-2010 12:24	lib\add_pic3.1
1273	02-23-2010 12:24	lib\add_pic3.4
2586	02-23-2010 12:24	lib\add_pic7.1a
265	02-23-2010 12:24	lib\add_tab.3dc
979	02-23-2010 12:24	lib\add_tab.net
228	02-23-2010 12:24	lib\add_tab.slp
1817	02-23-2010 12:24	lib\add_tab1.1
338	02-23-2010 12:24	lib\add_tab3.1
234	02-23-2010 12:24	lib\add_tab3.2
382	02-23-2010 12:24	lib\add_tab4.0
1636	02-23-2010 12:24	lib\add_tab4.1
565	02-23-2010 12:24	lib\add_tab4.1a
1224	02-23-2010 12:24	lib\add_tab4.1b
408	02-23-2010 12:24	lib\add_tab4.1c
303	02-23-2010 12:24	lib\add_tab4.1e
375	02-23-2010 12:24	lib\add_tab4.2a
363	02-23-2010 12:24	lib\add_tab4.2b
266	02-23-2010 12:24	lib\add_tab4.2c
824	02-23-2010 12:24	lib\add_tab4.2d
534	02-23-2010 12:24	lib\add_tab4.2e
368	02-23-2010 12:24	lib\add_tab5.1a
408	02-23-2010 12:24	lib\add_tab5.1b
745	02-23-2010 12:24	lib\add_tab5.1c
388	02-23-2010 12:24	lib\add_tab5.1d
437	02-23-2010 12:24	lib\add_tab6.1a
1299	02-23-2010 12:24	lib\add_tab6.1b
687	02-23-2010 12:24	lib\add_tab6.1c
117	02-23-2010 12:24	lib\add_tab6.1d
480	02-23-2010 12:24	lib\add_tab6.1e
141	02-23-2010 12:24	lib\add_tab6.1f
133	02-23-2010 12:24	lib\add_tab6.1g
452	02-23-2010 12:24	lib\add_tab6.1h
196	02-23-2010 12:24	lib\add_tab7.1a
400	02-23-2010 12:24	lib\add_tab7.1b
376	02-23-2010 12:24	lib\add_tab7.2a
502	02-23-2010 12:24	lib\add_tab7.2b
289	02-23-2010 12:24	lib\add_tab7.2c
128	01-08-2012 07:19	lib\add_tab7.2d
827	01-08-2012 07:19	lib\add_tab7.2e
714	01-08-2012 07:19	lib\add_tab7.2f
2170	01-08-2012 07:19	lib\add_tab7.2g

```
  194  01-08-2012 07:19  lib\add_tab7.2h
  345  01-08-2012 07:19  lib\add_tab7.3a
  234  01-08-2012 07:19  lib\add_tab7.3b
  726  01-08-2012 07:19  lib\add_tab7.3c
  588  01-08-2012 07:19  lib\add_tab7.3d
  661  01-08-2012 07:19  lib\add_tab7.3e
  412  01-08-2012 07:19  lib\add_tab7.3f
  544  02-23-2010 12:24  lib\add_tab7.3g
  358  01-08-2012 07:19  lib\add_tab7.3h
  917  01-08-2012 07:19  lib\add_tab7.3i
  181  01-08-2012 07:19  lib\add_tab7.3j
  245  02-23-2010 12:24  lib\add_tab7.3k
  288  01-08-2012 07:19  lib\add_tab7.3l
 2330  02-23-2010 12:24  lib\add_tabs.3d
  676  02-23-2010 12:24  lib\add_tabs.blk
  548  02-23-2010 12:24  lib\add_tabs.env
  979  02-23-2010 12:24  lib\add_tabs.net
  122  01-08-2012 07:19  lib\concrete
15758  01-08-2012 07:19  lib\convert_tmp
  586  03-13-2000 11:11  lib\gases\acetone.gas
  599  03-13-2000 11:11  lib\gases\air.gas
  644  03-13-2000 11:11  lib\gases\ammonia.gas
  825  03-13-2000 11:11  lib\gases\argon.gas
  604  03-13-2000 11:11  lib\gases\bcl3.gas
  586  03-13-2000 11:11  lib\gases\benzene.gas
  605  03-13-2000 11:11  lib\gases\bf3.gas
  584  03-13-2000 11:11  lib\gases\bromine.gas
  658  03-13-2000 11:11  lib\gases\c2h2.gas
  655  03-13-2000 11:11  lib\gases\c2h4.gas
  651  03-13-2000 11:11  lib\gases\c2h6.gas
  597  03-13-2000 11:11  lib\gases\c3h6.gas
  673  03-13-2000 11:11  lib\gases\c4h10.gas
  595  03-13-2000 11:11  lib\gases\c6h12.gas
  589  03-13-2000 11:11  lib\gases\c6h14.gas
  676  03-13-2000 11:11  lib\gases\ccl4.gas
  611  03-13-2000 11:11  lib\gases\cf4.gas
  589  03-13-2000 11:11  lib\gases\ch2chch3.gas
  599  03-13-2000 11:11  lib\gases\ch3br.gas
  602  03-13-2000 11:11  lib\gases\ch3cl.gas
  591  03-13-2000 11:11  lib\gases\chcl3.gas
  651  03-13-2000 11:11  lib\gases\chlorine.gas
  891  03-13-2000 11:11  lib\gases\co.gas
  918  03-13-2000 11:11  lib\gases\co2.gas
  602  03-13-2000 11:11  lib\gases\cs2.gas
  587  03-13-2000 11:11  lib\gases\ethanol.gas
  585  03-13-2000 11:11  lib\gases\fluorine.gas
  918  03-13-2000 11:11  lib\gases\gas_lib.idx
  602  03-13-2000 11:11  lib\gases\h2s.gas
  602  03-13-2000 11:11  lib\gases\hbr.gas
  605  03-13-2000 11:11  lib\gases\hcl.gas
  601  03-13-2000 11:11  lib\gases\hcn.gas
  824  03-13-2000 11:11  lib\gases\helium.gas
  601  03-13-2000 11:11  lib\gases\hf.gas
 1008  03-13-2000 11:11  lib\gases\hydrogen.gas
  592  03-13-2000 11:11  lib\gases\ic4h10.gas
  835  03-13-2000 11:11  lib\gases\krypton.gas
  645  03-13-2000 11:11  lib\gases\methane.gas
  588  03-13-2000 11:11  lib\gases\methanol.gas
  889  03-13-2000 11:11  lib\gases\n2o.gas
  530  03-13-2000 11:11  lib\gases\neon.gas
  879  03-13-2000 11:11  lib\gases\nitrogen.gas
  654  03-13-2000 11:11  lib\gases\no.gas
  874  03-13-2000 11:11  lib\gases\oxygen.gas
  590  03-13-2000 11:11  lib\gases\pentane.gas
  645  03-13-2000 11:11  lib\gases\propane.gas
 3152  03-13-2000 11:11  lib\gases\sample.gas
  662  03-13-2000 11:11  lib\gases\so2.gas
```

```
     660  03-13-2000 11:11  lib\gases\xenon.gas
    3297  10-24-2002 15:58  lib\Generic
   52224  07-13-2005 09:31  lib\gmacros.xls
     415  08-09-2003 09:25  lib\ice_cond_eng
     415  03-01-2004 13:12  lib\ice_cond_si
   10228  05-09-2005 16:04  lib\ipc.c
   20995  03-13-2000 11:11  lib\Large_Dry
     132  04-21-2004 16:44  lib\ss_hdm
     215  05-04-2004 17:47  lib\ss_hsp1
     171  05-04-2004 17:48  lib\ss_hsp2
     125  05-04-2004 17:48  lib\ss_hsp3
      62  05-04-2004 17:49  lib\ss_hsp4
     218  01-08-2012 07:19  lib\ss_htp1
      90  04-21-2004 16:42  lib\ss_htp2
     237  04-21-2004 16:43  lib\ss_htp3
      98  04-21-2004 16:43  lib\ss_htp4
     108  05-04-2004 17:49  lib\ss_tdm
     161  05-04-2004 17:50  lib\ss_tsp1
     167  05-04-2004 17:51  lib\ss_tsp2
     138  05-04-2004 17:51  lib\ss_tsp3
     161  05-04-2004 17:52  lib\ss_tsp4
     161  05-04-2004 17:52  lib\ss_ttp1
     167  05-04-2004 17:53  lib\ss_ttp2
     138  05-04-2004 17:54  lib\ss_ttp3
     161  05-04-2004 17:54  lib\ss_ttp4
     124  01-08-2012 07:19  lib\steel
    1643  01-08-2012 07:19  lib\v_names\bound.var
    3269  01-08-2012 07:19  lib\v_names\cond.var
     156  01-08-2012 07:19  lib\v_names\dfbc.var
    1013  01-08-2012 07:19  lib\v_names\dfjunc.var
    2156  01-08-2012 07:19  lib\v_names\dfvol.var
     617  01-08-2012 07:19  lib\v_names\gas.var
     303  01-08-2012 07:19  lib\v_names\heater.var
    5629  01-08-2012 07:19  lib\v_names\hex.var
      71  01-08-2012 07:19  lib\v_names\iso.var
    6498  01-08-2012 07:19  lib\v_names\junction.var
    2719  01-08-2012 07:19  lib\v_names\lp.var
    7867  01-08-2012 07:19  lib\v_names\misc.var
     487  01-08-2012 07:19  lib\v_names\ntwklink.var
    1520  01-08-2012 07:19  lib\v_names\ntwknode.var
     671  01-08-2012 07:19  lib\v_names\prv.var
     636  01-08-2012 07:19  lib\v_names\pump.var
     144  01-08-2012 07:19  lib\v_names\trip.var
     820  01-08-2012 07:19  lib\v_names\valve.var
     498  01-08-2012 07:19  lib\v_names\vfan.var
   15758  01-08-2012 07:19  lib\v_names\vol.var
      54  09-23-2013 10:14  license\got806b5.lic
      54  08-20-2013 16:31  license\got806b5.lic-1
      55  12-20-2012 12:00  license\got806c6.lic-old
  238158  01-06-2012 17:32  manuals\inst_man\inst_man.pdf
 6690267  01-06-2012 17:32  manuals\qual_rep\qual_rep.pdf
 3216110  01-06-2012 17:32  manuals\tech_man\tech_man.pdf
 3840515  01-06-2012 17:32  manuals\user_man\user_man.pdf
   12430  07-14-2005 16:37  manuals\using_help.pdf
  149304  01-07-2012 07:35  sample\example.GTH
    9046  01-07-2012 07:35  sample\example.SIN
   79090  01-07-2012 07:35  sample\example.SOT
  304364  01-07-2012 07:36  sample\example_bwr.GTH
  303190  04-25-2013 16:54  sample\example_bwr.SAV
   23232  01-07-2012 07:35  sample\example_bwr.SIN
  200523  01-07-2012 07:36  sample\example_bwr.SOT
  193956  01-07-2012 07:36  sample\example_pwr.GTH
  194021  07-18-2013 09:10  sample\example_pwr.SAV
   10616  01-07-2012 07:36  sample\example_pwr.SIN
  144028  01-07-2012 07:36  sample\example_pwr.SOT
     338  09-25-2011 17:30  sample\pb_file
  117517  01-07-2012 07:35  sample\pre_example.GTH
```

```
  7803  01-07-2012 07:35  sample\pre_example.SIN
 58878  01-07-2012 07:35  sample\pre_example.SOT
   601  12-13-2011 17:55  sample\runem.bat
167315  01-07-2012 07:36  sample\test15.GTH
  8575  01-07-2012 07:36  sample\test15.SIN
117094  01-07-2012 07:36  sample\test15.SOT
131146  01-07-2012 07:36  sample\test23.GTH
  9389  01-07-2012 07:36  sample\test23.SIN
 82041  01-07-2012 07:36  sample\test23.SOT
 98941  01-07-2012 07:36  sample\test26.GTH
  7026  01-07-2012 07:36  sample\test26.SIN
 51318  01-07-2012 07:36  sample\test26.SOT
    65  01-08-2012 07:19  sample\test_list
 38014  12-19-2012 13:00  uninstall.exe
```

UHSSIM Output File for October 30

```
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#
#  1) Case Title and Surface Solar Radiation Options
#
#     Case title
#
Kewaunee Power Station Solar Radiation
#
#     Surface Solar Radiation Options
#
#     Solar Heating Option
#       0 - no     solar heating
#       1 - MAWC   solar heating model
#       2 - ASHRAE solar heating model
#       3 - SAMSON solar heating data
#     System of Units Option
#       0 => F, psia, btu/hr, lbm/hr,
#       1 => C, kPa,  J,      kg/sec
 2 0 0
#
#  2) Start Time
#
#     Analysis start time   [hr of day]
 0.0
#
#  3) Solar Radiation Heat Rate Parameters
#
#     Only provide these when solar option is 1, 2, or 3!
#
#     MAWC solar radiation heat rate parameters
#
#     North latitude                        [degrees]
#     Longitude                             [degrees]
#     Time zone west of greenwich           [whole number]
#       ATLANTIC STANDARD  4
#       EASTERN STANDARD   5
#       CENTRAL STANDARD   6
#       MOUNTAIN STANDARD  7
#       PACIFIC STANDARD   8
#       ALASKA  STANDARD   9
#       HAWAII STANDARD   10
#     Year used to determine day of year    [four digits]
#     Month used to determine day of year   [1 .. 12]
#     Day of month used to determine doy    [1 ... 31]
#
# 33.38 112.85 7 1990 2 21
#
```

UHSSIM Output File for October 30 (cont'd)

```
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#     ASHRAE solar radiation heat rate parameters
#
#     Latitude                              [degrees]
#     Longitude                             [degrees]
#     Time zone west of greenwich           [whole number]
#     Year used to determine day of year    [four digits]
#     Month used to determine day of year   [1 .. 12]
#     Day of month used to determine doy    [1 ... 31]
#
  44.35 87.53 6 2014 10 30 0.2 1.05
#
#     SAMSON solar radiation heat rate parameters
#
#     Latitude                              [degrees]
#     Longitude                             [degrees]
#     Time zone west of greenwich           [whole number]
#     Year used to determine day of year    [four digits]
#     Month used to determine day of year   [1 .. 12]
#     Day of month used to determine doy    [1 ... 31]
#
# 33.38 112.85 7 1990 7 21
#
#  4) Time Dependent Wall Surface Temperatures
#
#     Number of times for surface temperature data
 25
#
#     Surface Temperature Data
#       Each line contains:
#         Time
#         Time units (s = second, h = hour, d = day)
#         Wall surface temperature [F, C]
#
   0 h 90.0
   1 h 90.0
   2 h 90.0
   3 h 90.0
   4 h 90.0
   5 h 90.0
   6 h 90.0
   7 h 90.0
   8 h 90.0
   9 h 90.0
  10 h 90.0
  11 h 90.0
```

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```
Program : UHSSIM                                                                    Page :          3
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  12 h 90.0
  13 h 90.0
  14 h 90.0
  15 h 90.0
  16 h 90.0
  17 h 90.0
  18 h 90.0
  19 h 90.0
  20 h 90.0
  21 h 90.0
  22 h 90.0
  23 h 90.0
  24 h 90.0
#
#  5) Basin Wall Option and Wall Parameters
#
#     Number of basin walls
 5
#
#     Basin wall data, one line for each wall
#
#         Wall surface azimuth angle [degrees,     degrees]
#         Wall tilt angle            [degrees,     degrees]
#         Wall emission coefficient  [fraction,    fraction]
#         Wall sky radiation option  [0 - on  during the day on  during the night]
#                                    [1 - on  during the day off during the night]
#                                    [2 - off during the day on  during the night]
#                                    [3 - off during the day off during the night]
#
  180.0 90.0 1.0 3
  -90.0 90.0 1.0 3
  0.0   90.0 1.0 3
  90.0  90.0 1.0 3
  0.0   0.0  1.0 3
#
#  6) Weather Data Parameters
#
#     Wet bulb temperature adjustment [F, C] to account for humidity difference
#     between meteorological tower location and cooling tower location
 0.0
```

UHSSIM Output File for October 30 (cont'd)

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Ambient Data for Surface Solar Test

# TIME (hr)	WB (F)	DB (F)	P (psia)	WS (ft/s)	Cloud (tenths)	Ceiling (100ft)	Snow (0/1)	Dir Norm (Btu/hr-ft2)	Diff Hor (Btu/hr-ft2)
0	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
1	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
2	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
3	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
4	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
5	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
6	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
7	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
8	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
9	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
10	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
11	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
12	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
13	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
14	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
15	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
16	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
17	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
18	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
19	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
20	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
21	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
22	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
23	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
24	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000

*

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Surface Solar Heating Module: Kewaunee Power Station Solar Radiation

Wall Number : 1
Surface Azimuth Angle : 180.0 (degrees)
Wall Tilt Angle : 90.0 (degrees)
Emission Coefficient : 1.000 (fraction)
Sky Radiation Option : 3 (sky radiation off day and off night)

time [hr]	wall temp [F]	dry bulb [F]	dew point [F]	sun-to-wall [Btu/hr-ft2]	wall-to-sky [Btu/hr-ft2]
0.0	90.0	106.0	55.6	0.000E+00	0.000E+00
1.0	90.0	106.0	55.6	0.000E+00	0.000E+00
2.0	90.0	106.0	55.6	0.000E+00	0.000E+00
3.0	90.0	106.0	55.6	0.000E+00	0.000E+00
4.0	90.0	106.0	55.6	0.000E+00	0.000E+00
5.0	90.0	106.0	55.6	0.000E+00	0.000E+00
6.0	90.0	106.0	55.6	0.000E+00	0.000E+00
7.0	90.0	106.0	55.6	3.736E+00	0.000E+00
8.0	90.0	106.0	55.6	1.724E+01	0.000E+00
9.0	90.0	106.0	55.6	2.501E+01	0.000E+00
10.0	90.0	106.0	55.6	2.980E+01	0.000E+00
11.0	90.0	106.0	55.6	3.221E+01	0.000E+00
12.0	90.0	106.0	55.6	3.235E+01	0.000E+00
13.0	90.0	106.0	55.6	3.022E+01	0.000E+00
14.0	90.0	106.0	55.6	2.574E+01	0.000E+00
15.0	90.0	106.0	55.6	1.841E+01	0.000E+00
16.0	90.0	106.0	55.6	5.820E+00	0.000E+00
17.0	90.0	106.0	55.6	0.000E+00	0.000E+00
18.0	90.0	106.0	55.6	0.000E+00	0.000E+00
19.0	90.0	106.0	55.6	0.000E+00	0.000E+00
20.0	90.0	106.0	55.6	0.000E+00	0.000E+00
21.0	90.0	106.0	55.6	0.000E+00	0.000E+00
22.0	90.0	106.0	55.6	0.000E+00	0.000E+00
23.0	90.0	106.0	55.6	0.000E+00	0.000E+00
24.0	90.0	106.0	55.6	0.000E+00	0.000E+00

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Surface Solar Heating Module: Kewaunee Power Station Solar Radiation

Wall Number : 2
Surface Azimuth Angle : -90.0 (degrees)
Wall Tilt Angle : 90.0 (degrees)
Emission Coefficient : 1.000 (fraction)
Sky Radiation Option : 3 (sky radiation off day and off night)

time [hr]	wall temp [F]	dry bulb [F]	dew point [F]	sun-to-wall [Btu/hr-ft2]	wall-to-sky [Btu/hr-ft2]
0.0	90.0	106.0	55.6	0.000E+00	0.000E+00
1.0	90.0	106.0	55.6	0.000E+00	0.000E+00
2.0	90.0	106.0	55.6	0.000E+00	0.000E+00
3.0	90.0	106.0	55.6	0.000E+00	0.000E+00
4.0	90.0	106.0	55.6	0.000E+00	0.000E+00
5.0	90.0	106.0	55.6	0.000E+00	0.000E+00
6.0	90.0	106.0	55.6	0.000E+00	0.000E+00
7.0	90.0	106.0	55.6	5.765E+01	0.000E+00
8.0	90.0	106.0	55.6	1.913E+02	0.000E+00
9.0	90.0	106.0	55.6	1.939E+02	0.000E+00
10.0	90.0	106.0	55.6	1.475E+02	0.000E+00
11.0	90.0	106.0	55.6	7.866E+01	0.000E+00
12.0	90.0	106.0	55.6	6.945E+01	0.000E+00
13.0	90.0	106.0	55.6	3.022E+01	0.000E+00
14.0	90.0	106.0	55.6	2.574E+01	0.000E+00
15.0	90.0	106.0	55.6	1.841E+01	0.000E+00
16.0	90.0	106.0	55.6	5.820E+00	0.000E+00
17.0	90.0	106.0	55.6	0.000E+00	0.000E+00
18.0	90.0	106.0	55.6	0.000E+00	0.000E+00
19.0	90.0	106.0	55.6	0.000E+00	0.000E+00
20.0	90.0	106.0	55.6	0.000E+00	0.000E+00
21.0	90.0	106.0	55.6	0.000E+00	0.000E+00
22.0	90.0	106.0	55.6	0.000E+00	0.000E+00
23.0	90.0	106.0	55.6	0.000E+00	0.000E+00
24.0	90.0	106.0	55.6	0.000E+00	0.000E+00

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Surface Solar Heating Module: Kewaunee Power Station Solar Radiation

Wall Number : 3
Surface Azimuth Angle : 0.0 (degrees)
Wall Tilt Angle : 90.0 (degrees)
Emission Coefficient : 1.000 (fraction)
Sky Radiation Option : 3 (sky radiation off day and off night)

time [hr]	wall temp [F]	dry bulb [F]	dew point [F]	sun-to-wall [Btu/hr-ft2]	wall-to-sky [Btu/hr-ft2]
0.0	90.0	106.0	55.6	0.000E+00	0.000E+00
1.0	90.0	106.0	55.6	0.000E+00	0.000E+00
2.0	90.0	106.0	55.6	0.000E+00	0.000E+00
3.0	90.0	106.0	55.6	0.000E+00	0.000E+00
4.0	90.0	106.0	55.6	0.000E+00	0.000E+00
5.0	90.0	106.0	55.6	0.000E+00	0.000E+00
6.0	90.0	106.0	55.6	0.000E+00	0.000E+00
7.0	90.0	106.0	55.6	2.949E+01	0.000E+00
8.0	90.0	106.0	55.6	1.481E+02	0.000E+00
9.0	90.0	106.0	55.6	2.252E+02	0.000E+00
10.0	90.0	106.0	55.6	2.755E+02	0.000E+00
11.0	90.0	106.0	55.6	3.014E+02	0.000E+00
12.0	90.0	106.0	55.6	3.029E+02	0.000E+00
13.0	90.0	106.0	55.6	2.800E+02	0.000E+00
14.0	90.0	106.0	55.6	2.327E+02	0.000E+00
15.0	90.0	106.0	55.6	1.592E+02	0.000E+00
16.0	90.0	106.0	55.6	4.656E+01	0.000E+00
17.0	90.0	106.0	55.6	0.000E+00	0.000E+00
18.0	90.0	106.0	55.6	0.000E+00	0.000E+00
19.0	90.0	106.0	55.6	0.000E+00	0.000E+00
20.0	90.0	106.0	55.6	0.000E+00	0.000E+00
21.0	90.0	106.0	55.6	0.000E+00	0.000E+00
22.0	90.0	106.0	55.6	0.000E+00	0.000E+00
23.0	90.0	106.0	55.6	0.000E+00	0.000E+00
24.0	90.0	106.0	55.6	0.000E+00	0.000E+00

UHSSIM Output File for October 30 (cont'd)

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Surface Solar Heating Module: Kewaunee Power Station Solar Radiation

Wall Number : 4
Surface Azimuth Angle : 90.0 (degrees)
Wall Tilt Angle : 90.0 (degrees)
Emission Coefficient : 1.000 (fraction)
Sky Radiation Option : 3 (sky radiation off day and off night)

time [hr]	wall temp [F]	dry bulb [F]	dew point [F]	sun-to-wall [Btu/hr-ft2]	wall-to-sky [Btu/hr-ft2]
0.0	90.0	106.0	55.6	0.000E+00	0.000E+00
1.0	90.0	106.0	55.6	0.000E+00	0.000E+00
2.0	90.0	106.0	55.6	0.000E+00	0.000E+00
3.0	90.0	106.0	55.6	0.000E+00	0.000E+00
4.0	90.0	106.0	55.6	0.000E+00	0.000E+00
5.0	90.0	106.0	55.6	0.000E+00	0.000E+00
6.0	90.0	106.0	55.6	0.000E+00	0.000E+00
7.0	90.0	106.0	55.6	3.736E+00	0.000E+00
8.0	90.0	106.0	55.6	1.724E+01	0.000E+00
9.0	90.0	106.0	55.6	2.501E+01	0.000E+00
10.0	90.0	106.0	55.6	2.980E+01	0.000E+00
11.0	90.0	106.0	55.6	3.363E+01	0.000E+00
12.0	90.0	106.0	55.6	3.412E+01	0.000E+00
13.0	90.0	106.0	55.6	1.400E+02	0.000E+00
14.0	90.0	106.0	55.6	1.901E+02	0.000E+00
15.0	90.0	106.0	55.6	1.959E+02	0.000E+00
16.0	90.0	106.0	55.6	8.626E+01	0.000E+00
17.0	90.0	106.0	55.6	0.000E+00	0.000E+00
18.0	90.0	106.0	55.6	0.000E+00	0.000E+00
19.0	90.0	106.0	55.6	0.000E+00	0.000E+00
20.0	90.0	106.0	55.6	0.000E+00	0.000E+00
21.0	90.0	106.0	55.6	0.000E+00	0.000E+00
22.0	90.0	106.0	55.6	0.000E+00	0.000E+00
23.0	90.0	106.0	55.6	0.000E+00	0.000E+00
24.0	90.0	106.0	55.6	0.000E+00	0.000E+00

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```
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Surface Solar Heating Module: Kewaunee Power Station Solar Radiation

Wall Number              :          5
Surface Azimuth Angle    :        0.0 (degrees)
Wall    Tilt    Angle    :        0.0 (degrees)
Emission Coefficient     :      1.000 (fraction)
Sky Radiation Option     :          3 (sky radiation off day and off night)
```

time [hr]	wall temp [F]	dry bulb [F]	dew point [F]	sun-to-wall [Btu/hr-ft2]	wall-to-sky [Btu/hr-ft2]
0.0	90.0	106.0	55.6	0.000E+00	0.000E+00
1.0	90.0	106.0	55.6	0.000E+00	0.000E+00
2.0	90.0	106.0	55.6	0.000E+00	0.000E+00
3.0	90.0	106.0	55.6	0.000E+00	0.000E+00
4.0	90.0	106.0	55.6	0.000E+00	0.000E+00
5.0	90.0	106.0	55.6	0.000E+00	0.000E+00
6.0	90.0	106.0	55.6	0.000E+00	0.000E+00
7.0	90.0	106.0	55.6	1.023E+01	0.000E+00
8.0	90.0	106.0	55.6	7.080E+01	0.000E+00
9.0	90.0	106.0	55.6	1.225E+02	0.000E+00
10.0	90.0	106.0	55.6	1.592E+02	0.000E+00
11.0	90.0	106.0	55.6	1.788E+02	0.000E+00
12.0	90.0	106.0	55.6	1.799E+02	0.000E+00
13.0	90.0	106.0	55.6	1.626E+02	0.000E+00
14.0	90.0	106.0	55.6	1.278E+02	0.000E+00
15.0	90.0	106.0	55.6	7.780E+01	0.000E+00
16.0	90.0	106.0	55.6	1.717E+01	0.000E+00
17.0	90.0	106.0	55.6	0.000E+00	0.000E+00
18.0	90.0	106.0	55.6	0.000E+00	0.000E+00
19.0	90.0	106.0	55.6	0.000E+00	0.000E+00
20.0	90.0	106.0	55.6	0.000E+00	0.000E+00
21.0	90.0	106.0	55.6	0.000E+00	0.000E+00
22.0	90.0	106.0	55.6	0.000E+00	0.000E+00
23.0	90.0	106.0	55.6	0.000E+00	0.000E+00
24.0	90.0	106.0	55.6	0.000E+00	0.000E+00

UHSSIM Output File for June 21

```
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Created : 10/16/2012 15:32:42                                       Time : 08:38:08.578

#
#  1) Case Title and Surface Solar Radiation Options
#
#     Case title
#
Kewaunee Power Station Solar Radiation
#
#     Surface Solar Radiation Options
#
#     Solar Heating Option
#       0 - no     solar heating
#       1 - MAWC   solar heating model
#       2 - ASHRAE solar heating model
#       3 - SAMSON solar heating data
#     System of Units Option
#       0 => F, psia, btu/hr, lbm/hr,
#       1 => C, kPa,  J,      kg/sec
 2 0 0
#
#  2) Start Time
#
#     Analysis start time   [hr of day]
 0.0
#
#  3) Solar Radiation Heat Rate Parameters
#
#     Only provide these when solar option is 1, 2, or 3!
#
#     MAWC solar radiation heat rate parameters
#
#     North latitude                        [degrees]
#     Longitude                             [degrees]
#     Time zone west of greenwich           [whole number]
#       ATLANTIC STANDARD  4
#       EASTERN STANDARD   5
#       CENTRAL STANDARD   6
#       MOUNTAIN STANDARD  7
#       PACIFIC STANDARD   8
#       ALASKA  STANDARD   9
#       HAWAII STANDARD   10
#     Year used to determine day of year    [four digits]
#     Month used to determine day of year   [1 .. 12]
#     Day of month used to determine doy    [1 ... 31]
#
# 33.38 112.85 7 1990 2 21
#
```

UHSSIM Output File for June 21 (cont'd)

```
Program : UHSSIM                                                    Page :          2
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#     ASHRAE solar radiation heat rate parameters
#
#     Latitude                              [degrees]
#     Longitude                             [degrees]
#     Time zone west of greenwich           [whole number]
#     Year used to determine day of year    [four digits]
#     Month used to determine day of year   [1 .. 12]
#     Day of month used to determine doy    [1 ... 31]
#
  44.35 87.53 6 2013 6 21 0.2 1.05
#
#     SAMSON solar radiation heat rate parameters
#
#     Latitude                              [degrees]
#     Longitude                             [degrees]
#     Time zone west of greenwich           [whole number]
#     Year used to determine day of year    [four digits]
#     Month used to determine day of year   [1 .. 12]
#     Day of month used to determine doy    [1 ... 31]
#
# 33.38 112.85 7 1990 7 21
#
#  4) Time Dependent Wall Surface Temperatures
#
#     Number of times for surface temperature data
 25
#
#     Surface Temperature Data
#       Each line contains:
#         Time
#         Time units (s = second, h = hour, d = day)
#         Wall surface temperature [F, C]
#
   0 h 90.0
   1 h 90.0
   2 h 90.0
   3 h 90.0
   4 h 90.0
   5 h 90.0
   6 h 90.0
   7 h 90.0
   8 h 90.0
   9 h 90.0
  10 h 90.0
  11 h 90.0
```

UHSSIM Output File for June 21 (cont'd)

```
Program : UHSSIM                                                                    Page :          3
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  12 h 90.0
  13 h 90.0
  14 h 90.0
  15 h 90.0
  16 h 90.0
  17 h 90.0
  18 h 90.0
  19 h 90.0
  20 h 90.0
  21 h 90.0
  22 h 90.0
  23 h 90.0
  24 h 90.0
#
#  5) Basin Wall Option and Wall Parameters
#
#     Number of basin walls
 5
#
#     Basin wall data, one line for each wall
#
#         Wall surface azimuth angle [degrees,     degrees]
#         Wall tilt angle            [degrees,     degrees]
#         Wall emission coefficient  [fraction,    fraction]
#         Wall sky radiation option  [0 - on  during the day on  during the night]
#                                    [1 - on  during the day off during the night]
#                                    [2 - off during the day on  during the night]
#                                    [3 - off during the day off during the night]
#
  180.0 90.0 1.0 3
  -90.0 90.0 1.0 3
  0.0   90.0 1.0 3
  90.0  90.0 1.0 3
  0.0   0.0  1.0 3
#
#  6) Weather Data Parameters
#
#     Wet bulb temperature adjustment [F, C] to account for humidity difference
#     between meteorological tower location and cooling tower location
 0.0
```

UHSSIM Output File for June 21 (cont'd)

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Ambient Data for Surface Solar Test

# TIME (hr)	WB (F)	DB (F)	P (psia)	WS (ft/s)	Cloud (tenths)	Ceiling (100ft)	Snow (0/1)	Dir Norm (Btu/hr-ft2)	Diff Hor (Btu/hr-ft2)
0	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
1	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
2	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
3	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
4	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
5	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
6	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
7	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
8	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
9	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
10	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
11	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
12	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
13	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
14	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
15	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
16	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
17	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
18	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
19	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
20	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
21	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
22	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
23	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000
24	73.000	106.00	14.696	0.000	0.00	0.000	0.0	0.0000	0.0000

*

UHSSIM Output File for June 21 (cont'd)

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Surface Solar Heating Module: Kewaunee Power Station Solar Radiation

Wall Number : 1
Surface Azimuth Angle : 180.0 (degrees)
Wall Tilt Angle : 90.0 (degrees)
Emission Coefficient : 1.000 (fraction)
Sky Radiation Option : 3 (sky radiation off day and off night)

time [hr]	wall temp [F]	dry bulb [F]	dew point [F]	sun-to-wall [Btu/hr-ft2]	wall-to-sky [Btu/hr-ft2]
0.0	90.0	106.0	55.6	0.000E+00	0.000E+00
1.0	90.0	106.0	55.6	0.000E+00	0.000E+00
2.0	90.0	106.0	55.6	0.000E+00	0.000E+00
3.0	90.0	106.0	55.6	0.000E+00	0.000E+00
4.0	90.0	106.0	55.6	0.000E+00	0.000E+00
5.0	90.0	106.0	55.6	5.033E+01	0.000E+00
6.0	90.0	106.0	55.6	7.864E+01	0.000E+00
7.0	90.0	106.0	55.6	5.849E+01	0.000E+00
8.0	90.0	106.0	55.6	4.016E+01	0.000E+00
9.0	90.0	106.0	55.6	4.421E+01	0.000E+00
10.0	90.0	106.0	55.6	4.725E+01	0.000E+00
11.0	90.0	106.0	55.6	4.963E+01	0.000E+00
12.0	90.0	106.0	55.6	5.028E+01	0.000E+00
13.0	90.0	106.0	55.6	4.912E+01	0.000E+00
14.0	90.0	106.0	55.6	4.651E+01	0.000E+00
15.0	90.0	106.0	55.6	4.318E+01	0.000E+00
16.0	90.0	106.0	55.6	3.883E+01	0.000E+00
17.0	90.0	106.0	55.6	6.635E+01	0.000E+00
18.0	90.0	106.0	55.6	7.816E+01	0.000E+00
19.0	90.0	106.0	55.6	2.538E+01	0.000E+00
20.0	90.0	106.0	55.6	0.000E+00	0.000E+00
21.0	90.0	106.0	55.6	0.000E+00	0.000E+00
22.0	90.0	106.0	55.6	0.000E+00	0.000E+00
23.0	90.0	106.0	55.6	0.000E+00	0.000E+00
24.0	90.0	106.0	55.6	0.000E+00	0.000E+00

UHSSIM Output File for June 21 (cont'd)

```
Program : UHSSIM                                                          Page :          6
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Surface Solar Heating Module: Kewaunee Power Station Solar Radiation

Wall Number              :          2
Surface Azimuth Angle    :      -90.0 (degrees)
Wall    Tilt    Angle    :       90.0 (degrees)
Emission Coefficient     :      1.000 (fraction)
Sky Radiation Option     :          3 (sky radiation off day and off night)
```

time [hr]	wall temp [F]	dry bulb [F]	dew point [F]	sun-to-wall [Btu/hr-ft2]	wall-to-sky [Btu/hr-ft2]
0.0	90.0	106.0	55.6	0.000E+00	0.000E+00
1.0	90.0	106.0	55.6	0.000E+00	0.000E+00
2.0	90.0	106.0	55.6	0.000E+00	0.000E+00
3.0	90.0	106.0	55.6	0.000E+00	0.000E+00
4.0	90.0	106.0	55.6	0.000E+00	0.000E+00
5.0	90.0	106.0	55.6	9.686E+01	0.000E+00
6.0	90.0	106.0	55.6	2.222E+02	0.000E+00
7.0	90.0	106.0	55.6	2.697E+02	0.000E+00
8.0	90.0	106.0	55.6	2.710E+02	0.000E+00
9.0	90.0	106.0	55.6	2.403E+02	0.000E+00
10.0	90.0	106.0	55.6	1.869E+02	0.000E+00
11.0	90.0	106.0	55.6	1.188E+02	0.000E+00
12.0	90.0	106.0	55.6	6.497E+01	0.000E+00
13.0	90.0	106.0	55.6	4.932E+01	0.000E+00
14.0	90.0	106.0	55.6	4.620E+01	0.000E+00
15.0	90.0	106.0	55.6	4.161E+01	0.000E+00
16.0	90.0	106.0	55.6	3.545E+01	0.000E+00
17.0	90.0	106.0	55.6	2.769E+01	0.000E+00
18.0	90.0	106.0	55.6	1.769E+01	0.000E+00
19.0	90.0	106.0	55.6	3.494E+00	0.000E+00
20.0	90.0	106.0	55.6	0.000E+00	0.000E+00
21.0	90.0	106.0	55.6	0.000E+00	0.000E+00
22.0	90.0	106.0	55.6	0.000E+00	0.000E+00
23.0	90.0	106.0	55.6	0.000E+00	0.000E+00
24.0	90.0	106.0	55.6	0.000E+00	0.000E+00

UHSSIM Output File for June 21 (cont'd)

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Program : UHSSIM                                                          Page :          7
Number  : 03.7.870-1.0 O                                                  Date : 10/08/2013
Created : 10/16/2012 15:32:42                                             Time : 08:38:08.593

Surface Solar Heating Module: Kewaunee Power Station Solar Radiation

Wall Number              :          3
Surface Azimuth Angle    :        0.0 (degrees)
Wall    Tilt    Angle    :       90.0 (degrees)
Emission Coefficient     :      1.000 (fraction)
Sky Radiation Option     :          3 (sky radiation off day and off night)
```

time [hr]	wall temp [F]	dry bulb [F]	dew point [F]	sun-to-wall [Btu/hr-ft2]	wall-to-sky [Btu/hr-ft2]
0.0	90.0	106.0	55.6	0.000E+00	0.000E+00
1.0	90.0	106.0	55.6	0.000E+00	0.000E+00
2.0	90.0	106.0	55.6	0.000E+00	0.000E+00
3.0	90.0	106.0	55.6	0.000E+00	0.000E+00
4.0	90.0	106.0	55.6	0.000E+00	0.000E+00
5.0	90.0	106.0	55.6	7.898E+00	0.000E+00
6.0	90.0	106.0	55.6	2.099E+01	0.000E+00
7.0	90.0	106.0	55.6	3.208E+01	0.000E+00
8.0	90.0	106.0	55.6	5.718E+01	0.000E+00
9.0	90.0	106.0	55.6	1.033E+02	0.000E+00
10.0	90.0	106.0	55.6	1.398E+02	0.000E+00
11.0	90.0	106.0	55.6	1.624E+02	0.000E+00
12.0	90.0	106.0	55.6	1.686E+02	0.000E+00
13.0	90.0	106.0	55.6	1.577E+02	0.000E+00
14.0	90.0	106.0	55.6	1.309E+02	0.000E+00
15.0	90.0	106.0	55.6	9.112E+01	0.000E+00
16.0	90.0	106.0	55.6	4.346E+01	0.000E+00
17.0	90.0	106.0	55.6	2.912E+01	0.000E+00
18.0	90.0	106.0	55.6	1.769E+01	0.000E+00
19.0	90.0	106.0	55.6	3.494E+00	0.000E+00
20.0	90.0	106.0	55.6	0.000E+00	0.000E+00
21.0	90.0	106.0	55.6	0.000E+00	0.000E+00
22.0	90.0	106.0	55.6	0.000E+00	0.000E+00
23.0	90.0	106.0	55.6	0.000E+00	0.000E+00
24.0	90.0	106.0	55.6	0.000E+00	0.000E+00

UHSSIM Output File for June 21 (cont'd)

```
Program : UHSSIM                                                                    Page :          8
Number  : 03.7.870-1.0 O                                                            Date : 10/08/2013
Created : 10/16/2012 15:32:42                                                       Time : 08:38:08.593

Surface Solar Heating Module: Kewaunee Power Station Solar Radiation

Wall Number              :          4
Surface Azimuth Angle    :       90.0 (degrees)
Wall    Tilt    Angle    :       90.0 (degrees)
Emission Coefficient     :      1.000 (fraction)
Sky Radiation Option     :          3 (sky radiation off day and off night)
```

time [hr]	wall temp [F]	dry bulb [F]	dew point [F]	sun-to-wall [Btu/hr-ft2]	wall-to-sky [Btu/hr-ft2]
0.0	90.0	106.0	55.6	0.000E+00	0.000E+00
1.0	90.0	106.0	55.6	0.000E+00	0.000E+00
2.0	90.0	106.0	55.6	0.000E+00	0.000E+00
3.0	90.0	106.0	55.6	0.000E+00	0.000E+00
4.0	90.0	106.0	55.6	0.000E+00	0.000E+00
5.0	90.0	106.0	55.6	7.898E+00	0.000E+00
6.0	90.0	106.0	55.6	2.079E+01	0.000E+00
7.0	90.0	106.0	55.6	3.004E+01	0.000E+00
8.0	90.0	106.0	55.6	3.733E+01	0.000E+00
9.0	90.0	106.0	55.6	4.305E+01	0.000E+00
10.0	90.0	106.0	55.6	4.719E+01	0.000E+00
11.0	90.0	106.0	55.6	5.059E+01	0.000E+00
12.0	90.0	106.0	55.6	5.378E+01	0.000E+00
13.0	90.0	106.0	55.6	1.388E+02	0.000E+00
14.0	90.0	106.0	55.6	2.036E+02	0.000E+00
15.0	90.0	106.0	55.6	2.515E+02	0.000E+00
16.0	90.0	106.0	55.6	2.743E+02	0.000E+00
17.0	90.0	106.0	55.6	2.619E+02	0.000E+00
18.0	90.0	106.0	55.6	1.971E+02	0.000E+00
19.0	90.0	106.0	55.6	4.420E+01	0.000E+00
20.0	90.0	106.0	55.6	0.000E+00	0.000E+00
21.0	90.0	106.0	55.6	0.000E+00	0.000E+00
22.0	90.0	106.0	55.6	0.000E+00	0.000E+00
23.0	90.0	106.0	55.6	0.000E+00	0.000E+00
24.0	90.0	106.0	55.6	0.000E+00	0.000E+00

UHSSIM Output File for June 21 (cont'd)

```
Program : UHSSIM                                                          Page :          9
Number  : 03.7.870-1.0 O                                                  Date : 10/08/2013
Created : 10/16/2012 15:32:42                                             Time : 08:38:08.593`

Surface Solar Heating Module: Kewaunee Power Station Solar Radiation

Wall Number              :          5
Surface Azimuth Angle    :        0.0 (degrees)
Wall    Tilt    Angle    :        0.0 (degrees)
Emission Coefficient     :      1.000 (fraction)
Sky Radiation Option     :          3 (sky radiation off day and off night)
```

time [hr]	wall temp [F]	dry bulb [F]	dew point [F]	sun-to-wall [Btu/hr-ft2]	wall-to-sky [Btu/hr-ft2]
0.0	90.0	106.0	55.6	0.000E+00	0.000E+00
1.0	90.0	106.0	55.6	0.000E+00	0.000E+00
2.0	90.0	106.0	55.6	0.000E+00	0.000E+00
3.0	90.0	106.0	55.6	0.000E+00	0.000E+00
4.0	90.0	106.0	55.6	0.000E+00	0.000E+00
5.0	90.0	106.0	55.6	2.399E+01	0.000E+00
6.0	90.0	106.0	55.6	8.656E+01	0.000E+00
7.0	90.0	106.0	55.6	1.492E+02	0.000E+00
8.0	90.0	106.0	55.6	2.067E+02	0.000E+00
9.0	90.0	106.0	55.6	2.551E+02	0.000E+00
10.0	90.0	106.0	55.6	2.915E+02	0.000E+00
11.0	90.0	106.0	55.6	3.134E+02	0.000E+00
12.0	90.0	106.0	55.6	3.193E+02	0.000E+00
13.0	90.0	106.0	55.6	3.088E+02	0.000E+00
14.0	90.0	106.0	55.6	2.827E+02	0.000E+00
15.0	90.0	106.0	55.6	2.427E+02	0.000E+00
16.0	90.0	106.0	55.6	1.914E+02	0.000E+00
17.0	90.0	106.0	55.6	1.321E+02	0.000E+00
18.0	90.0	106.0	55.6	6.870E+01	0.000E+00
19.0	90.0	106.0	55.6	9.265E+00	0.000E+00
20.0	90.0	106.0	55.6	0.000E+00	0.000E+00
21.0	90.0	106.0	55.6	0.000E+00	0.000E+00
22.0	90.0	106.0	55.6	0.000E+00	0.000E+00
23.0	90.0	106.0	55.6	0.000E+00	0.000E+00
24.0	90.0	106.0	55.6	0.000E+00	0.000E+00

Attachment 4: Materials Properties and Conversions

Air Properties from Kreith

T (F)	rho (lb/ft^3)	Vol (ft^3/lb)	k (BTU/hr-ft-F)	cp (BTU/lb-F)	mu (lb/ft-sec)	mu (lb/ft-hr)
0	0.086	11.628	0.0133	0.239	0.0000111	0.04
100	0.071	14.085	0.0154	0.24	0.00001285	0.0463
200	0.06	16.667	0.0174	0.241	0.0000144	0.0518
300	0.052	19.231	0.0193	0.243	0.0000161	0.058
400	0.046	21.739	0.0212	0.245	0.0000175	0.063
500	0.0412	24.272	0.0231	0.247	0.0000189	0.068
600	0.0373	26.81	0.025	0.25	0.00002	0.072
700	0.0341	29.326	0.0268	0.253	2.14E-05	0.077
800	0.0314	31.847	0.0286	0.256	2.25E-05	0.081
900	0.0291	34.364	0.0303	0.259	2.36E-05	0.085
1000	0.0271	36.9	0.0319	0.262	2.47E-05	0.0889
1500	0.0202	49.505	0.04	0.276	3.00E-05	0.108

Air Properties from Fundamentals of Thermodynamics

T (R)	T (F)	h (BTU/lb)
440	-19.7	105.212
480	20.3	114.794
560	100.3	133.98
640	180.3	153.216
680	220.3	162.86
760	300.3	182.221
840	380.3	201.701
880	420.3	211.494
960	500.3	231.202
1040	580.3	251.086
1080	620.3	261.099
1160	700.3	281.273
1240	780.3	301.65
1280	820.3	311.915
1360	900.3	332.598
1440	980.3	353.483
1480	1020.3	364
1950	1490.3	490.928
2000	1540.3	504.755

T (F)	h (BTU/lb)
0	109.9
100	133.9
200	158
300	182.1
400	206.5
500	231.1
600	256
700	281.2
800	306.7
900	332.5
1000	358.7
1500	493.6

Assembly Wall Material Properties From Kreith

Stainless Steel	k (BTU/hr-ft-F @ 572 F)
	10.9

Fuel Properties Properties from Nuclear Reactor Engineering at 500F

k (BTU/hr-ft-F)	rho (lb/ft^3)	cp (BTU/lb-F)
4.3	684.	.070

The fuel is at 96.56% maximum density

Actual rho (lb/ft^3)

660

Cladding Properties Properties from Fundamentals of Heat Transfer at 600K (620F)

k (W/m-K)	k (BTU/hr-ft-F)	rho (kg/m^3)	rho (lb/ft^3)	cp (J/kg-K)	cp (BTU/lb-F)
20.7	12.0	6570	410.	322	.077

Fuel Gap Conductance Section 3.2.4

563.

	A	B	C
1	Attachment 4: Materials Properties and Conversions		
2			
3	Air Properties from Kreith		
4	T (F)	rho (lb/ft^3)	Vol (ft^3/lb)
5	0	0.086	=ROUND(1/B5,3)
6	100	0.071	=ROUND(1/B6,3)
7	200	0.06	=ROUND(1/B7,3)
8	300	0.052	=ROUND(1/B8,3)
9	400	0.046	=ROUND(1/B9,3)
10	500	0.0412	=ROUND(1/B10,3)
11	600	0.0373	=ROUND(1/B11,3)
12	700	0.0341	=ROUND(1/B12,3)
13	800	0.0314	=ROUND(1/B13,3)
14	900	0.0291	=ROUND(1/B14,3)
15	1000	0.0271	=ROUND(1/B15,3)
16	1500	0.0202	=ROUND(1/B16,3)
17			
18			
19	Air Properties from Funda		
20	T (R)	T (F)	h (BTU/lb)
21	440	=A21-459.7	105.212
22	480	=A22-459.7	114.794
23	560	=A23-459.7	133.98
24	640	=A24-459.7	153.216
25	680	=A25-459.7	162.86
26	760	=A26-459.7	182.221
27	840	=A27-459.7	201.701
28	880	=A28-459.7	211.494
29	960	=A29-459.7	231.202
30	1040	=A30-459.7	251.086
31	1080	=A31-459.7	261.099
32	1160	=A32-459.7	281.273
33	1240	=A33-459.7	301.65
34	1280	=A34-459.7	311.915
35	1360	=A35-459.7	332.598
36	1440	=A36-459.7	353.483
37	1480	=A37-459.7	364
38	1950	=A38-459.7	490.928
39	2000	=A39-459.7	504.755
40			
41			
42	Assembly Wall Material P		
43	Stainless Steel		(BTU/hr-ft-F @ 572 F
44			10.9
45			
46	Fuel Properties Propertie		
47	k (BTU/hr-ft-F)	rho (lb/ft^3)	cp (BTU/lb-F)
48	4.3	684	0.07
49			
50	The fuel is at 96.56% ma		
51	Actual rho (lb/ft^3)		
52	=ROUND(D48*0.9656,0)		
53			
54	Cladding Properties Prop		
55	k (W/m-K)	k (BTU/hr-ft-F)	rho (kg/m^3)
56	20.7	=ROUND(A56*3600*0.9478/1000/3.28084/(9/5),1)	6570
57			
58	Fuel Gap Conductance S		
59	563		

	D	E	F	G
1				
2				
3				
4	k (BTU/hr-ft-F)	) (BTU/lb-	mu (lb/ft-sec)	mu (lb/ft-hr)
5	0.0133	0.239	0.0000111	=ROUND(F5*3600,4)
6	0.0154	0.24	0.00001285	=ROUND(F6*3600,4)
7	0.0174	0.241	0.0000144	=ROUND(F7*3600,4)
8	0.0193	0.243	0.0000161	=ROUND(F8*3600,4)
9	0.0212	0.245	0.0000175	=ROUND(F9*3600,4)
10	0.0231	0.247	0.0000189	=ROUND(F10*3600,4)
11	0.025	0.25	0.00002	=ROUND(F11*3600,4)
12	0.0268	0.253	0.0000214	=ROUND(F12*3600,4)
13	0.0286	0.256	0.0000225	=ROUND(F13*3600,4)
14	0.0303	0.259	0.0000236	=ROUND(F14*3600,4)
15	0.0319	0.262	0.0000247	=ROUND(F15*3600,4)
16	0.04	0.276	0.00003	=ROUND(F16*3600,4)
17				
18				
19				
20		T (F)	h (BTU/lb)	
21		0	=ROUND(C22-(B22-E21)*(C22-C21)/(B22-B21),1)	
22		100	=ROUND(C23-(B23-E22)*(C23-C22)/(B23-B22),1)	
23		200	=ROUND(C24-(B24-E23)*(C24-C23)/(B24-B23),1)	
24		300	=ROUND(C26-(B26-E24)*(C26-C25)/(B26-B25),1)	
25		400	=ROUND(C28-(B28-E25)*(C28-C27)/(B28-B27),1)	
26		500	=ROUND(C29-(B29-E26)*(C29-C28)/(B29-B28),1)	
27		600	=ROUND(C31-(B31-E27)*(C31-C30)/(B31-B30),1)	
28		700	=ROUND(C32-(B32-E28)*(C32-C31)/(B32-B31),1)	
29		800	=ROUND(C34-(B34-E29)*(C34-C33)/(B34-B33),1)	
30		900	=ROUND(C35-(B35-E30)*(C35-C34)/(B35-B34),1)	
31		1000	=ROUND(C37-(B37-E31)*(C37-C36)/(B37-B36),1)	
32		1500	=ROUND(C39-(B39-E32)*(C39-C38)/(B39-B38),1)	
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				
51				
52				
53				
54				
55	rho (lb/ft^3)	cp (J/kg-K	cp (BTU/lb-F)	
56	=ROUND(C56*2.20462/3.28084^3,0)	322	=ROUND(E56*0.9478/1000/2.20462/(9/5),3)	
57				
58				
59				

Attachment 5: Geometry Calculations and Tables

Cell Length (L)	8.3 in	Input 4.2
Cell Width (W)	8.3 in	Input 4.2
Cell Inner Wall Thickness (t)	0.125 in	Input 4.2
Heated Rod Length	144 in	Section 3.2.3
Total Assembly Length (H)	159.775 in	Input 4.2
Number of Rods and Tubes	196	=14x14
Fuel Rod Inputs		
Fuel Pellet Diameter (P)	0.3659 in	Input 4.2
Cladding ID	0.3734 in	Input 4.2
Cladding OD (D)	0.422 in	Input 4.2
Cladding Circumf	1.325752 in	=π*D
Cladding Thickness	0.0243 in	=(OD-ID) / 2
Fuel Rod Pitch	0.556 in	Input 4.2
Gap Thickness	0.00375 in	=(ID-P) / 2
Pitch Area	0.3091 in^2	$=P^2$
Cladding+Pellet Area	0.1399 in^2	$=\pi*D^2/4$
Distance from Center of Pellet to Wall (C)	0.536 in	
Assembly Spacing	10 in	Input 4.2
Steel Wall Section Count	2	Input 4.2
Steel Outer Wall Thickness	0.062 in	
Steel Outer Wall Count	2	
Boron Carbide Sheet Count	2	Input 4.2
Boron Carbide Thickness	0.21 in	Input 4.2
Air Gap Total	0.906 in	
Slab Geom Factor Corner	0.1166 in	Eq. 3.2-7
Slab Geom Factor Side	0.1124 in	Eq. 3.2-8

Channel Location	Middle	Edge	Corner
Area (in^2)	0.1692	0.2281	0.2523
Wetted Perimeter (in)	1.326	1.219	1.403
Heated Perimeter (in)	1.326	0.6629	0.3314
	Equations 3.2-1, 3.2-2, 3.2-3		

Connection Location	Middle	Middle/Edge	Edges	Edge/Corner
Connection Width (in)	0.134	0.134	0.325	0.325
Connection Length (in)	0.556	0.546	0.556	0.546
	Equations 3.2-4 and 3.2-5			

List of non-heated rods		
Reference 2.16	31	Guide Tube
	34	GT
	37	GT
	40	GT
	61	GT
	66	GT
	73	GT
	82	GT
	92	Instrument Tube
	115	GT
	124	GT
	131	GT
	136	GT
	157	GT
	160	GT
	163	GT
	166	GT

	A	B	C	D	E	F	G	H	I	J
1	Attachment 5: Geometry Calculations and Tables									
2										
3	Cell Length (L)	8.3	in	Input 4.2		Channel Location	Middle	Edge	Corner	
4	Cell Width (W)	8.3	in	Input 4.2		Area (in^2)	=ROUND(B19-B20,4)	=ROUND(B16*B21-B20/2,4)	=ROUND(B21^2-B20/4,4)	
5	Cell Inner Wall Thickness (t)	0.125	in	Input 4.2		Wetted Perimeter (in)	=ROUND(B14,3)	=ROUND(B14/2+B16,3)	=ROUND(B21*2+B14/4,3)	
6	Heated Rod Length	144	in	Section 3.2.3		Heated Perimeter (in)	=ROUND(B14,3)	=ROUND(B14/2,4)	=ROUND(B14/4,4)	
7	Total Assembly Length (H)	159.775	in	Input 4.2			Equations 3.2-1, 3.2-2,			
8	Number of Rods and Tubes	=14^2		=14x14						
9						Connection Location	Middle	Middle/Edge	Edges	Edge/Corner
10	Fuel Rod Inputs					Connection Width (in)	=ROUND(B16-B13,4)	=ROUND(B16-B13,4)	=ROUND(B21-B13/2,4)	=ROUND(B21-B13/2,4)
11	Fuel Pellet Diameter (P)	0.3659	in	Input 4.2		Connection Length (in)	=B16	=ROUND((B16+B21)/2,3)	=B16	=ROUND((B16+B21)/2,3)
12	Cladding ID	0.3734	in	Input 4.2			Equations 3.2-4 and 3.2			
13	Cladding OD (D)	0.422	in	Input 4.2						
14	Cladding Circumf	=PI()*B13	in	=π*D		List of non-heated rods	31	Guide Tube		
15	Cladding Thickness	=ROUND((B13-B12)/2,4)	in	=(OD-ID) / 2		Reference 2.16	34	GT		
16	Fuel Rod Pitch	0.556	in	Input 4.2			37	GT		
17	Gap Thickness	=(B12-B11)/2	in	=(ID-P) / 2			40	GT		
18							61	GT		
19	Pitch Area	=ROUND(B16^2,4)	in^2	$=P^2$			66	GT		
20	Cladding+Pellet Area	=ROUND(PI()*B13^2/4,4)	in^2	$=\pi*D^2/4$			73	GT		
21	Distance from Center of Pell	=ROUND((B3-13*B16)/2,3)	in				82	GT		
22							92	Instrument Tube		
23	Assembly Spacing	10	in	Input 4.2			=197-G21	GT		
24	Steel Wall Section Count	2		Input 4.2			=197-G20	GT		
25	Steel Outer Wall Thickness	0.062	in				=197-G19	GT		
26	Steel Outer Wall Count	2					=197-G18	GT		
27	Boron Carbide Sheet Count	2		Input 4.2			=197-G17	GT		
28	Boron Carbide Thickness	0.21	in	Input 4.2			=197-G16	GT		
29	Air Gap Total	=B23-B3-B24*B5-B27*B28-B	in				=197-G15	GT		
30							=197-G14	GT		
31	Slab Geom Factor Corner	=ROUND((B5/2)/B21,4)	in	Eq. 3.2-7						
32	Slab Geom Factor Side	=ROUND((B5/2)/B16,4)	in	Eq. 3.2-8						

Attachment 6: Drag and Heat Generation Calculations - October 2014

Equation 6.9 of the COBRA manual defines the coefficients of a heat transfer correlation as:

$H = (a1 * Re^{a2} * Pr^{a3} + a4) * k / D$ Equation 3.2-9

Page 7.5 of the COBRA manual (in a validation model) suggests the following coefficients:

	a1	a2	a3	a4		
Laminar	0.83	0.33	0.33	0	Equation 3.2-10	
Turbulent	0.33	0.6	0.3	0	Equation 3.2-11	

Equations 6.14 and 6.15 of the COBRA manual define the coefficients of wall friction factors as:

$f_T = a * Re^b + c * Re^d + e$ Equation 3.2-12

$f_L = a * Re^b + c$ Equation 3.2-13

From Table 4.1 of NUREG/CR-6441 for interior flow and a P/D of 1.318

Where $f = C / Re^n$ and $C = a + b_1 * (P/D - 1) + b_2 * (P/D - 1)^2$

	n	a	b1	b2	
Laminar	1	35.55	263.7	-190.2	Reference 2.21, pgs. 4-16, 4-17
Turbulent	0.18	0.1339	0.09059	-0.09926	Reference 2.21, pgs. 4-16, 4-17

	a	b	c	d	e	
Laminar	100.2	-1	0	0	0	Equation 3.2-30
Turbulent	0.153	-0.18	0	0	0	Equation 3.2-31

Highest assem heat generation 10/30/2014	11455	BTU/hr	Input 4.2
Number of rods per assembly	196	rods	=14x14
Number of heated rods per assembly	179	rods	Input 4.2
Decay heat per rod	63.99	BTU/hr-rod	
Rod outer diameter (D)	0.422	inches	Input 4.2
Rod heated length	144	inches	Input 4.2
Heated volume per rod	0.01166	ft^3	
Volumetric heat generation rate	5490.2	$BTU/hr\text{-}ft^3$	
Volumetric heat generation rate	0.0055	$MBTU/hr\text{-}ft^3$	

Average assem heat generation 10/30/2014	2300	BTU/hr	Input 4.2
Number of rods per assembly	196	rods	=14x14
Number of heated rods per assembly	179	rods	Input 4.2
Decay heat per rod	12.85	BTU/hr-rod	
Rod outer diameter (D)	0.422	inches	Input 4.2
Rod heated length	144	inches	Input 4.2
Heated volume per rod	0.01166	ft^3	
Volumetric heat generation rate	1102.4	$BTU/hr\text{-}ft^3$	
Volumetric heat generation rate	0.0011	$MBTU/hr\text{-}ft^3$	

Form friction is located in the assembly due to spacers and plates

Total Loss in the Assembly 39 Section 3.2.8

Losses are Uniformly Distributed see Section 3.2.8	Location	Loss
	0	3.9
	0.111111	3.9
	0.222222	3.9
	0.333333	3.9
	0.444444	3.9
	0.555556	3.9
	0.666667	3.9
	0.777778	3.9
	0.888889	3.9
	1	3.9

Attachment 6: Drag and Heat Generation Calculations - May 2015

Equation 6.9 of the COBRA manual defines the coefficients of a heat transfer correlation as:

$H = (a1 * Re^{a2} * Pr^{a3} + a4) * k / D$ Equation 3.2-9

Page 7.5 of the COBRA manual (in a validation model) suggests the following coefficients:

	a1	a2	a3	a4		
Laminar	0.83	0.33	0.33		0	Equation 3.2-10
Turbulent	0.33	0.6	0.3		0	Equation 3.2-11

Equations 6.14 and 6.15 of the COBRA manual define the coefficients of wall friction factors as:

$f_T = a * Re^b + c * Re^d + e$ Equation 3.2-12

$f_L = a * Re^b + c$ Equation 3.2-13

From Table 4.1 of NUREG/CR-6441 for interior flow and a P/D of 1.318

Where $f = C / Re^n$ and $C = a + b_1 * (P/D - 1) + b_2 * (P/D - 1)^2$

	n	a	b1	b2		
Laminar	1	35.55	263.7	-190.2		Reference 2.21, pgs. 4-16, 4-17
Turbulent	0.18	0.1339	0.09059	-0.09926		Reference 2.21, pgs. 4-16, 4-17

	a	b	c	d	e		
Laminar	100.2	-1	0	0		0	Equation 3.2-30
Turbulent	0.153	-0.18	0	0		0	Equation 3.2-31

Highest assem heat generation 5/18/2015	8,247	BTU/hr	Input 4.2
Number of rods per assembly	196	rods	=14x14
Number of heated rods per assembly	179	rods	Input 4.2
Decay heat per rod	46.07	BTU/hr-rod	
Rod outer diameter (D)	0.422	inches	Input 4.2
Rod heated length	144	inches	Input 4.2
Heated volume per rod	0.01166	ft^3	
Volumetric heat generation rate	3953.0	$BTU/hr\text{-}ft^3$	
Volumetric heat generation rate	0.0040	$MBTU/hr\text{-}ft^3$	

Highest assem heat generation 5/18/2015	2300	BTU/hr	Input 4.2
Number of rods per assembly	196	rods	=14x14
Number of heated rods per assembly	179	rods	Input 4.2
Decay heat per rod	12.85	BTU/hr-rod	
Rod outer diameter (D)	0.422	inches	Input 4.2
Rod heated length	144	inches	Input 4.2
Heated volume per rod	0.01166	ft^3	
Volumetric heat generation rate	1102.4	$BTU/hr\text{-}ft^3$	
Volumetric heat generation rate	0.0011	$MBTU/hr\text{-}ft^3$	

Form friction is located in the assembly due to spacers and plates

Total Loss in the Assembly 39 Section 3.2.8

Losses are Uniformly Distributed see Section 3.2.8	Location	Loss
	0	3.9
	0.111111	3.9
	0.222222	3.9
	0.333333	3.9
	0.444444	3.9
	0.555556	3.9
	0.666667	3.9
	0.777778	3.9
	0.888889	3.9
	1	3.9

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Attachment 6: Drag and Heat Generation Calculations - October 2014												
2													
3	Equation 6.9 of th										Form friction is locate		
4	H = (a1 * Re^{a2} * P				Equation 3.2-9						Total Loss in the Ass	39	Section 3.2.8
5	Page 7.5 of the C												
6		a1	a2	a3	a4						Losses are Uniformly	Location	Loss
7	Laminar	0.83	0.33	0.33	0	Equation 3.2-1					see Section 3.2.8	0	=ROUND($L$4/10,2)
8	Turbulent	0.33	0.6	0.3	0	Equation 3.2-1						=1/9	=ROUND($L$4/10,2)
9												=L8+$L$8	=ROUND($L$4/10,2)
10												=L9+$L$8	=ROUND($L$4/10,2)
11	Equations 6.14 ar											=L10+$L$8	=ROUND($L$4/10,2)
12	f_T = a * Re^b + c *			Equation 3.2								=L11+$L$8	=ROUND($L$4/10,2)
13	f_L = a * Re^b + c			Equation 3.2								=L12+$L$8	=ROUND($L$4/10,2)
14	From Table 4.1 o						=ROUND(Att5!B16/Att5!B13,3)					=L13+$L$8	=ROUND($L$4/10,2)
15	Where f = C / Re^n											=L14+$L$8	=ROUND($L$4/10,2)
16		n	a	b1	b2							=L15+$L$8	=ROUND($L$4/10,2)
17	Laminar	1	35.55	263.7	-190.2	Reference 2.2							
18	Turbulent	0.18	0.1339	0.09059	-0.09926	Reference 2.2							
19													
20		a	b	c	d	e							
21	Laminar	=ROUND(C17+D17*(G14-1)+E17*(G14-1)^2,1)	=-B17	0	0	0	Equation 3.2-30						
22	Turbulent	=ROUND(C18+D18*(G14-1)+E18*(G14-1)^2,3)	=-B18	0	0	0	Equation 3.2-31						
23													
24													
25				n 10/30/2014	=Att12S2!I84	BTU/hr	Input 4.2						
26				per assembly	196	rods	=14x14						
27				per assembly	=E26-COUNT(Att5!$G$14:$G$30)	rods	Input 4.2						
28				heat per rod	=E25/E27	BTU/hr-rod							
29				diameter (D)	=Att5!$B$13	inches	Input 4.2						
30				eated length	=Att5!$B$6	inches	Input 4.2						
31				lume per rod	=E30*E29^2/4*PI()/12^3	ft^3							
32				neration rate	=E28/E31	BTU/hr-ft^3							
33				neration rate	=ROUNDUP(E32/10^6,4)	MBTU/hr-ft^3							
34													
35				n 10/30/2014	=Att12S1!E28	BTU/hr	Input 4.2						
36				per assembly	196	rods	=14x14						
37				per assembly	=E36-COUNT(Att5!$G$14:$G$30)	rods	Input 4.2						
38				heat per rod	=E35/E37	BTU/hr-rod							
39				diameter (D)	=Att5!$B$13	inches	Input 4.2						
40				eated length	=Att5!$B$6	inches	Input 4.2						
41				lume per rod	=E40*E39^2/4*PI()/12^3	ft^3							
42				neration rate	=E38/E41	BTU/hr-ft^3							
43				neration rate	=ROUNDUP(E42/10^6,4)	MBTU/hr-ft^3							

Attachment 7: Air Flux Calculation (October 2014, Maximum Assembly)

Inlet Temperature	200	F	FHB Temp, Section 7.1
Pressure	14.7	psia	Assm. 5.2
Gas Constant	1545	ft-lbf/lbmol-R	Ref. 2.4, pg. 62
Air MW	28.97	g/mol	Ref. 2.4, pg. 740
Building Density	0.0602	lbm/ft^3	Ideal Gas Law
Gravity Constant	32.2	ft/sec^2	Ref. 2.22

Estimated Flow Rate (Iterated)	0.050292	$lb/sec\text{-}ft^2$	Iterated

Actual Heat Transfer	10371	BTU/hr	Converted from Input 4.2, iterated to match outlet temperature
Outlet Temperature	995.37	F	Eq. 3.2-35
Exit Density	0.0273	lbm/ft^3	Ideal Gas Law

Average Air Conditions

Temperature	597.61	F	Average of Tin, Tout
Assembly Average Density	0.0395	lbm/ft^3	Eq. 3.2-24
Dynamic Viscosity	2.00E-05	lb/sec-ft	Interpolated from Input 4.4
Specific Heat	0.250	BTU/lb-F	Interpolated from Input 4.4

Losses

Hydraulic Area	41.48	in^2	Eq. 3.2-28
Hydraulic Area	0.2880	ft^2	Conversion
Wetted Perimeter	293.05	in	Eq. 3.2-29
Hydraulic Diameter	0.566	in	Eq. 3.2-27
Hydraulic Diameter	0.0472	ft	Conversion
Reynolds Number	118.790		Eq. 3.2-32
Friction Factor	0.844		Eq. 3.2-31
Total Line Physical Loss Coef. (K)	39		Input 4.2
Total Length	13.3	feet	Input 4.2
Total Line Loss	277		Eq. 3.2-26
Mass Flux	0.050292	$lb/sec\text{-}ft^2$	Eq. 3.2-34
Mass Flux	1.8105E-04	$Mlb/hr\text{-}ft^2$	Conversion

Difference	0.000		Check Iteration

Attachment 7: Air Flux Calculation (October 2014, Cold Adjacent Assembly)

Inlet Temperature	200	F	FHB Temp, Iterated
Pressure	14.7	psia	Assm. 5.2
Gas Constant	1545	ft-lbf/lbmol-R	Ref. 2.4, pg. 62
Air MW	28.97	lb/lbmol	Ref. 2.4, pg. 740
Building Density	0.0602	lbm/ft^3	Ideal Gas Law
Gravity Constant	32.2	ft/sec^2	Ref. 2.23

Estimated Flow Rate (Iterated)	0.038229	lb/sec-ft^2	Iterated

Actual Heat Transfer	2842	BTU/hr	Converted from Input 4.2, iterated to match outlet temperature
Outlet Temperature	493.65	F	Eq. 3.2-35
Exit Density	0.0416	lbm/ft^3	Ideal Gas Law

Average Air Conditions

Average Temperature	346.75	F	Average of Tin, Tout
Density at Average Temperature	0.0498	lbm/ft^3	Eq. 3.2-24
Dynamic Viscosity	1.69E-05	lb/sec-ft	Interpolated from Input 4.4
Specific Heat	0.244	BTU/lb-F	Interpolated from Input 4.4

Losses

Hydraulic Area	41.48	in^2	Eq. 3.2-28
Hydraulic Area	0.2880	ft^2	Conversion
Wetted Perimeter	293.05	in	Eq. 3.2-29
Hydraulic Diameter	0.566	in	Eq. 3.2-27
Hydraulic Diameter	0.0472	ft	Conversion
Reynolds Number	106.753		Eq. 3.2-32
Friction Factor	0.939		Eq. 3.2-31
Total Line Physical Loss Coef. (K)	39		Input 4.2
Total Length	13.3	feet	Input 4.2
Total Line Loss	304		Eq. 3.2-26
Mass Flux	0.038229	lb/sec-ft^2	Eq. 3.2-34
Mass Flux	1.3762E-04	Mlb/hr-ft^2	Conversion

Difference	0.000		Check Iteration

Attachment 7: Air Flux Calculation (October 2014, Average Assembly)

Inlet Temperature	200	F	FHB Temp, Iterated
Pressure	14.7	psia	Assm. 5.2
Gas Constant	1545	ft-lbf/lbmol-R	Ref. 2.4, pg. 62
Air MW	28.97	lb/lbmol	Ref. 2.4, pg. 740
Building Density	0.0602	lbm/ft^3	Ideal Gas Law
Gravity Constant	32.2	ft/sec^2	Ref. 2.23

Estimated Flow Rate (Iterated)	0.039810	lb/sec-ft^2	Iterated

Actual Heat Transfer	3266	BTU/hr	Converted from Input 4.2
Outlet Temperature	524.31	F	Eq. 3.2-35
Exit Density	0.0403	lbm/ft^3	Ideal Gas Law

Average Air Conditions

Average Temperature	362.15	F	Average of Tin, Tout
Density at Average Temperature	0.0489	lbm/ft^3	Eq. 3.2-24
Dynamic Viscosity	1.72E-05	lb/sec-ft	Interpolated from Input 4.4
Specific Heat	0.244	BTU/lb-F	Interpolated from Input 4.4

Losses

Hydraulic Area	41.48	in^2	Eq. 3.2-28
Hydraulic Area	0.2880	ft^2	Conversion
Wetted Perimeter	293.05	in	Eq. 3.2-29
Hydraulic Diameter	0.566	in	Eq. 3.2-27
Hydraulic Diameter	0.0472	ft	Conversion
Reynolds Number	109.470		Eq. 3.2-32
Friction Factor	0.915		Eq. 3.2-31
Total Line Physical Loss Coef. (K)	39		Input 4.2
Total Length	13.3	feet	Input 4.2
Total Line Loss	297		Eq. 3.2-26
Mass Flux	0.039810	lb/sec-ft^2	Eq. 3.2-34
Mass Flux	1.4331E-04	Mlb/hr-ft^2	Conversion

Difference	0.000		Check Iteration

Attachment 7: Downcomer Temperature Rise (October 2014)

Downcomer Air Incoming T (GOTHIC)	180	F
Downcomer Air Flux per Cell (Average Cell/Assembly)	0.0398	lb/sec-ft^2
Flow Area in Storage Cell Area (Eq. 3.2-28, Conversion)	0.2880	ft^2
Number of Assemblies in Pool B (Attachment 12)	680	
Maximum Air Flow (Avg flux x Area x # of Assemblies)	7.7971	lb/sec
Heat Capacity at Air Temp (Attachment 4)	0.241	BTU/lb-F
Heat Transfer into Downcomer (50% of Edge Storage Cells)	134,304	BTU/hr
Temperature at Bottom of Downcomer (Equation 3.2-37)	200	F
Downcomer Temperature Rise	20	F

Attachment 7: Air Flux Calculation (May 2015, Maximum Assembly)

Inlet Temperature	217	F	FHB Temp, Section 7.1
Pressure	14.7	psia	Assm. 5.2
Gas Constant	1545	ft-lbf/lbmol-R	Ref. 2.4, pg. 62
Air MW	28.97	g/mol	Ref. 2.4, pg. 740
Building Density	0.0587	lbm/ft^3	Ideal Gas Law
Gravity Constant	32.2	ft/sec^2	Ref. 2.22

Estimated Flow Rate (Iterated)	0.045967	$lb/sec\text{-}ft^2$	Iterated

Actual Heat Transfer	7509	BTU/hr	Converted from Input 4.2, iterated to match outlet temperature
Outlet Temperature	852.10	F	Eq. 3.2-35
Exit Density	0.0303	lbm/ft^3	Ideal Gas Law

Average Air Conditions

Temperature	534.46	F	Average of Tin, Tout
Assembly Average Density	0.0414	lbm/ft^3	Eq. 3.2-24
Dynamic Viscosity	1.93E-05	lb/sec-ft	Interpolated from Input 4.4
Specific Heat	0.248	BTU/lb-F	Interpolated from Input 4.4

Losses

Hydraulic Area	41.48	in^2	Eq. 3.2-28
Hydraulic Area	0.2880	ft^2	Conversion
Wetted Perimeter	293.05	in	Eq. 3.2-29
Hydraulic Diameter	0.566	in	Eq. 3.2-27
Hydraulic Diameter	0.0472	ft	Conversion
Reynolds Number	112.487		Eq. 3.2-32
Friction Factor	0.891		Eq. 3.2-31
Total Line Physical Loss Coef. (K)	39		Input 4.2
Total Length	13.3	feet	Input 4.2
Total Line Loss	290		Eq. 3.2-26
Mass Flux	0.045967	$lb/sec\text{-}ft^2$	Eq. 3.2-34
Mass Flux	1.6548E-04	$Mlb/hr\text{-}ft^2$	Conversion

Difference	0.000		Check Iteration

Attachment 7: Air Flux Calculation (May 2015, Cold Adjacent Assembly)

Inlet Temperature	217	F	FHB Temp, Iterated
Pressure	14.7	psia	Assm. 5.2
Gas Constant	1545	ft-lbf/lbmol-R	Ref. 2.4, pg. 62
Air MW	28.97	lb/lbmol	Ref. 2.4, pg. 740
Building Density	0.0587	lbm/ft^3	Ideal Gas Law
Gravity Constant	32.2	ft/sec^2	Ref. 2.23

Estimated Flow Rate (Iterated)	0.035662	$lb/sec\text{-}ft^2$	Iterated

Actual Heat Transfer	2669	BTU/hr	Converted from Input 4.2, iterated to match outlet temperature
Outlet Temperature	512.64	F	Eq. 3.2-35
Exit Density	0.0408	lbm/ft^3	Ideal Gas Law

Average Air Conditions

Average Temperature	364.74	F	Average of Tin, Tout
Density at Average Temperature	0.0487	lbm/ft^3	Eq. 3.2-24
Dynamic Viscosity	1.72E-05	lb/sec-ft	Interpolated from Input 4.4
Specific Heat	0.244	BTU/lb-F	Interpolated from Input 4.4

Losses

Hydraulic Area	41.48	in^2	Eq. 3.2-28
Hydraulic Area	0.2880	ft^2	Conversion
Wetted Perimeter	293.05	in	Eq. 3.2-29
Hydraulic Diameter	0.566	in	Eq. 3.2-27
Hydraulic Diameter	0.0472	ft	Conversion
Reynolds Number	97.815		Eq. 3.2-32
Friction Factor	1.024		Eq. 3.2-31
Total Line Physical Loss Coef. (K)	39		Input 4.2
Total Length	13.3	feet	Input 4.2
Total Line Loss	328		Eq. 3.2-26
Mass Flux	0.035662	$lb/sec\text{-}ft^2$	Eq. 3.2-34
Mass Flux	1.2838E-04	$Mlb/hr\text{-}ft^2$	Conversion

Difference	0.000		Check Iteration

Attachment 7: Air Flux Calculation (May 2015, Average Assembly)

Inlet Temperature	217	F	FHB Temp, Iterated
Pressure	14.7	psia	Assm. 5.2
Gas Constant	1545	ft-lbf/lbmol-R	Ref. 2.4, pg. 62
Air MW	28.97	lb/lbmol	Ref. 2.4, pg. 740
Building Density	0.0587	lbm/ft^3	Ideal Gas Law
Gravity Constant	32.2	ft/sec^2	Ref. 2.23

Estimated Flow Rate (Iterated)	0.036203	lb/sec-ft^2	Iterated

Actual Heat Transfer	2809	BTU/hr	Converted from Input 4.2
Outlet Temperature	523.71	F	Eq. 3.2-35
Exit Density	0.0404	lbm/ft^3	Ideal Gas Law

Average Air Conditions

Average Temperature	370.36	F	Average of Tin, Tout
Density at Average Temperature	0.0484	lbm/ft^3	Eq. 3.2-24
Dynamic Viscosity	1.73E-05	lb/sec-ft	Interpolated from Input 4.4
Specific Heat	0.244	BTU/lb-F	Interpolated from Input 4.4

Losses

Hydraulic Area	41.48	in^2	Eq. 3.2-28
Hydraulic Area	0.2880	ft^2	Conversion
Wetted Perimeter	293.05	in	Eq. 3.2-29
Hydraulic Diameter	0.566	in	Eq. 3.2-27
Hydraulic Diameter	0.0472	ft	Conversion
Reynolds Number	98.751		Eq. 3.2-32
Friction Factor	1.015		Eq. 3.2-31
Total Line Physical Loss Coef. (K)	39		Input 4.2
Total Length	13.3	feet	Input 4.2
Total Line Loss	325		Eq. 3.2-26
Mass Flux	0.036203	lb/sec-ft^2	Eq. 3.2-34
Mass Flux	1.3033E-04	Mlb/hr-ft^2	Conversion

Difference	0.000		Check Iteration

Attachment 7: Downcomer Temperature Rise

Downcomer Air Incoming T (GOTHIC)	195	F
Downcomer Air Flux per Cell (Average Cell/Assembly)	0.0362	lb/sec-ft^2
Flow Area in Storage Cell Area (Eq. 3.2-28, Conversion)	0.2880	ft^2
Number of Assemblies in Pool B (Attachment 12)	680	
Maximum Air Flow (Avg flux x Area x # of Assemblies)	7.0908	lb/sec
Heat Capacity at Air Temp (Attachment 4)	0.241	BTU/lb-F
Heat Transfer into Downcomer (50% of Edge Storage Cells)	134,304	BTU/hr
Temperature at Bottom of Downcomer (Equation 3.2-37)	217	F
Downcomer Temperature Rise	22	F

	A	B	C	D
1	Attachment 7: Air Flux Calculation (October 2014, Maximum Assembly)			
2				
3				
4	Inlet Temperature	=DCHeatOct!B10	F	FHB Temp, Section 7.1
5	Pressure	14.7	psia	Assm. 5.2
6	Gas Constant	1545	ft-lbf/lbmol-R	Ref. 2.4, pg. 62
7	Air MW	28.97	g/mol	Ref. 2.4, pg. 740
8	Building Density	=B5*144*B7/((459.7+B4)*B6)	lbm/ft^3	Ideal Gas Law
9	Gravity Constant	32.2	ft/sec^2	Ref. 2.22
10				
11	Estimated Flow Rate (Iterated	0.0502923202176272	lb/sec-ft^2	Iterated
12				
13	Actual Heat Transfer	=(Att6Oct!E25+2*Att6Oct!E35)*0.646	BTU/hr	Converted from Input 4.2, iterated to match outlet temperature
14	Outlet Temperature	=B4+B13/(3600*B11*B25*B21)	F	Eq. 3.2-35
15	Exit Density	=B5*144*B7/((459.7+B14)*B6)	lbm/ft^3	Ideal Gas Law
16				
17	Average Air Conditions			
18	Temperature	=(B4+B14)/2	F	Average of Tin, Tout
19	Assembly Average Density	=B5*144*B7/((B14-B4)*B6)*LN((B14+459.7)/(B4+459.7))	lbm/ft^3	Eq. 3.2-24
20	Dynamic Viscosity	=(B18-Att4!A10)/(Att4!A11-Att4!A10)*(Att4!F11-Att4!F10)+Att4!F10	lb/sec-ft	Interpolated from Input 4.4
21	Specific Heat	0.25	BTU/lb-F	Interpolated from Input 4.4
22				
23	Losses			
24	Hydraulic Area	=Att5!B3*Att5!B4-Att5!B8*PI()*Att5!B13^2/4	in^2	Eq. 3.2-28
25	Hydraulic Area	=B24/144	ft^2	Conversion
26	Wetted Perimeter	=2*(Att5!B3+Att5!B4)+Att5!B8*PI()*Att5!B13	in	Eq. 3.2-29
27	Hydraulic Diameter	=4*B24/B26	in	Eq. 3.2-27
28	Hydraulic Diameter	=B27/12	ft	Conversion
29	Reynolds Number	=B11*B28/B20		Eq. 3.2-32
30	Friction Factor	=Att6Oct!B21*B29^Att6Oct!C21		Eq. 3.2-31
31	Total Line Physical Loss Coe	=Att6Oct!L4		Input 4.2
32	Total Length	=Att5!B7/12	feet	Input 4.2
33	Total Line Loss	=B30*B32/B28+B31		Eq. 3.2-26
34	Mass Flux	=SQRT(2*B19*B9*B32/B33*(B8-B19))	lb/sec-ft^2	Eq. 3.2-34
35	Mass Flux	=B34*3600/1000000	Mlb/hr-ft^2	Conversion
36				
37	Difference	=(B34-B11)*1000000		Check Iteration

	A	B	C	D
1	Attachment 7: Air Flux Calculation (October 2014, Cold Adjacent Assembly)			
2				
3				
4	Inlet Temperature	=DCHeatOct!B10	F	FHB Temp, Iterated
5	Pressure	14.7	psia	Assm. 5.2
6	Gas Constant	1545	ft-lbf/lbmol-R	Ref. 2.4, pg. 62
7	Air MW	28.97	lb/lbmol	Ref. 2.4, pg. 740
8	Building Density	=B5*144*B7/((459.7+B4)*B6)	lbm/ft^3	Ideal Gas Law
9	Gravity Constant	32.2	ft/sec^2	Ref. 2.23
10				
11	Estimated Flow Rate (Iterated)	0.0382291601448615	lb/sec-ft^2	Iterated
12				
13	Actual Heat Transfer	=(Att6Oct!E25+2*Att6Oct!E35-Att7Oct!B13)/2	BTU/hr	Converted from Input 4.2, iterated to match outlet temperature
14	Outlet Temperature	=B4+B13/(3600*B11*B24/144*B21)	F	Eq. 3.2-35
15	Exit Density	=B5*144*B7/((459.7+B14)*B6)	lbm/ft^3	Ideal Gas Law
16				
17	Average Air Conditions			
18	Average Temperature	=(B4+B14)/2	F	Average of Tin, Tout
19	Density at Average Temperature	=B5*144*B7/((B14-B4)*B6)*LN((B14+459.7)/(B4+459.7))	lbm/ft^3	Eq. 3.2-24
20	Dynamic Viscosity	=(B18-Att4!A7)/(Att4!A8-Att4!A7)*(Att4!F8-Att4!F7)+Att4!F7	lb/sec-ft	Interpolated from Input 4.4
21	Specific Heat	0.244	BTU/lb-F	Interpolated from Input 4.4
22				
23	Losses			
24	Hydraulic Area	=Att5!B3*Att5!B4-Att5!B8*PI()*Att5!B13^2/4	in^2	Eq. 3.2-28
25	Hydraulic Area	=B24/144	ft^2	Conversion
26	Wetted Perimeter	=2*(Att5!B3+Att5!B4)+Att5!B8*PI()*Att5!B13	in	Eq. 3.2-29
27	Hydraulic Diameter	=4*B24/B26	in	Eq. 3.2-27
28	Hydraulic Diameter	=B27/12	ft	Conversion
29	Reynolds Number	=B11*B28/B20		Eq. 3.2-32
30	Friction Factor	=Att6Oct!B21*B29^Att6Oct!C21		Eq. 3.2-31
31	Total Line Physical Loss Coef. (K)	=Att6Oct!L4		Input 4.2
32	Total Length	=Att5!B7/12	feet	Input 4.2
33	Total Line Loss	=B30*B32/B28+B31		Eq. 3.2-26
34	Mass Flux	=SQRT(2*B19*B9*B32/B33*(B8-B19))	lb/sec-ft^2	Eq. 3.2-34
35	Mass Flux	=B34*3600/1000000	Mlb/hr-ft^2	Conversion
36				
37	Difference	=(B34-B11)*1000000		Check Iteration

	A	B	C	D
1	Attachment 7: Air Flux Calculation (October 2014, Average Assembly)			
2				
3				
4	Inlet Temperature	=DCHeatOct!B3+20	F	FHB Temp, Iterated
5	Pressure	14.7	psia	Assm. 5.2
6	Gas Constant	1545	ft-lbf/lbmol-R	Ref. 2.4, pg. 62
7	Air MW	28.97	lb/lbmol	Ref. 2.4, pg. 740
8	Building Density	=B5*144*B7/((459.7+B4)*B6)	lbm/ft^3	Ideal Gas Law
9	Gravity Constant	32.2	ft/sec^2	Ref. 2.23
10				
11	Estimated Flow Rate (Iterate	0.0398095677979529	lb/sec-ft^2	Iterated
12				
13	Actual Heat Transfer	=Att12S2!J84	BTU/hr	Converted from Input 4.2
14	Outlet Temperature	=B4+B13/(3600*B11*B24/144*B21)	F	Eq. 3.2-35
15	Exit Density	=B5*144*B7/((459.7+B14)*B6)	lbm/ft^3	Ideal Gas Law
16				
17	Average Air Conditions			
18	Average Temperature	=(B4+B14)/2	F	Average of Tin, Tout
19	Density at Average Tempera	=B5*144*B7/((B14-B4)*B6)*LN((B14+459.7)/(B4+459.7))	lbm/ft^3	Eq. 3.2-24
20	Dynamic Viscosity	=(B18-Att4!A7)/(Att4!A8-Att4!A7)*(Att4!F8-Att4!F7)+Att4!F7	lb/sec-ft	Interpolated from Input 4.4
21	Specific Heat	0.244	BTU/lb-F	Interpolated from Input 4.4
22				
23	Losses			
24	Hydraulic Area	=Att5!B3*Att5!B4-Att5!B8*PI()*Att5!B13^2/4	in^2	Eq. 3.2-28
25	Hydraulic Area	=B24/144	ft^2	Conversion
26	Wetted Perimeter	=2*(Att5!B3+Att5!B4)+Att5!B8*PI()*Att5!B13	in	Eq. 3.2-29
27	Hydraulic Diameter	=4*B24/B26	in	Eq. 3.2-27
28	Hydraulic Diameter	=B27/12	ft	Conversion
29	Reynolds Number	=B11*B28/B20		Eq. 3.2-32
30	Friction Factor	=Att6Oct!B21*B29^Att6Oct!C21		Eq. 3.2-31
31	Total Line Physical Loss Coe	=Att6Oct!L4		Input 4.2
32	Total Length	=Att5!B7/12	feet	Input 4.2
33	Total Line Loss	=B30*B32/B28+B31		Eq. 3.2-26
34	Mass Flux	=SQRT(2*B19*B9*B32/B33*(B8-B19))	lb/sec-ft^2	Eq. 3.2-34
35	Mass Flux	=B34*3600/1000000	Mlb/hr-ft^2	Conversion
36				
37	Difference	=(B34-B11)*1000000		Check Iteration

	A	B	C
1	Attachment 7: Downcomer Temperature Rise (October 2014)		
2			
3	Downcomer Air Incoming T (GOTHIC)	180	F
4	Downcomer Air Flux per Cell (Average Cell/Assembly)	=Att7AvgOct!B11	lb/sec-ft^2
5	Flow Area in Storage Cell Area (Eq. 3.2-28, Conversion)	=Att7AvgOct!B25	ft^2
6	Number of Assemblies in Pool B (Attachment 12)	=Att12S1!E18	
7	Maximum Air Flow (Avg flux x Area x # of Assemblies)	=B4*B5*B6	lb/sec
8	Heat Capacity at Air Temp (Attachment 4)	=Att4!E7	BTU/lb-F
9	Heat Transfer into Downcomer (50% of Edge Storage Cells)	=Att12S1!E27*0.5	BTU/hr
10	Temperature at Bottom of Downcomer (Equation 3.2-37)	=B9/B8/B7/3600+B3	F
11	Downcomer Temperature Rise	=ROUND(B10-B3,0)	

```
99999    0
    1    1  Calculation No. 2013-11284 Rev. 0, October 2014 Case
prop    12    1
                 0.     109.9     .0133      .239    11.628     .0400
               100.     133.9     .0154      .240    14.085     .0463
               200.     158.0     .0174      .241    16.667     .0518
               300.     182.1     .0193      .243    19.231     .0580
               400.     206.5     .0212      .245    21.739     .0630
               500.     231.1     .0231      .247    24.272     .0680
               600.     256.0     .0250      .250    26.810     .0720
               700.     281.2     .0268      .253    29.326     .0770
               800.     306.7     .0286      .256    31.847     .0810
               900.     332.5     .0303      .259    34.364     .0850
              1000.     358.7     .0319      .262    36.900     .0889
              1500.     493.6     .0400      .276    49.505     .1080
    10                        10.9
chan     3   24
     144.0       0.0
    1    1  225    0    0
    1    1    0    0    1
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  199.16921.3261.326  200.13400.556  214.13400.546
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  201.16921.3261.326  202.13400.556  216.13400.546
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  204.16921.3261.326  205.13400.556  219.13400.546
  205.16921.3261.326  206.13400.556  220.13400.546
  206.16921.3261.326  207.13400.556  221.13400.546
  207.16921.3261.326  208.13400.556  222.13400.546
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    7 .422   1.    7  .25    8  .25   22  .25   23  .25
    8 .422   1.    8  .25    9  .25   23  .25   24  .25
    9 .422   1.    9  .25   10  .25   24  .25   25  .25
   10 .422   1.   10  .25   11  .25   25  .25   26  .25
   11 .422   1.   11  .25   12  .25   26  .25   27  .25
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   13 .422   1.   13  .25   14  .25   28  .25   29  .25
   14 .422   1.   14  .25   15  .25   29  .25   30  .25
   15 .422   1.   16  .25   17  .25   31  .25   32  .25
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   17 .422   1.   18  .25   19  .25   33  .25   34  .25
   18 .422   1.   19  .25   20  .25   34  .25   35  .25
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KOct.i

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22	.422	1.	23	.25	24	.25	38	.25	39	.25
23	.422	1.	24	.25	25	.25	39	.25	40	.25
24	.422	1.	25	.25	26	.25	40	.25	41	.25
25	.422	1.	26	.25	27	.25	41	.25	42	.25
26	.422	1.	27	.25	28	.25	42	.25	43	.25
27	.422	1.	28	.25	29	.25	43	.25	44	.25
28	.422	1.	29	.25	30	.25	44	.25	45	.25
29	.422	1.	31	.25	32	.25	46	.25	47	.25
30	.422	1.	32	.25	33	.25	47	.25	48	.25
31	.422	0.	33	.25	34	.25	48	.25	49	.25
32	.422	1.	34	.25	35	.25	49	.25	50	.25
33	.422	1.	35	.25	36	.25	50	.25	51	.25
34	.422	0.	36	.25	37	.25	51	.25	52	.25
35	.422	1.	37	.25	38	.25	52	.25	53	.25
36	.422	1.	38	.25	39	.25	53	.25	54	.25
37	.422	0.	39	.25	40	.25	54	.25	55	.25
38	.422	1.	40	.25	41	.25	55	.25	56	.25
39	.422	1.	41	.25	42	.25	56	.25	57	.25
40	.422	0.	42	.25	43	.25	57	.25	58	.25
41	.422	1.	43	.25	44	.25	58	.25	59	.25
42	.422	1.	44	.25	45	.25	59	.25	60	.25
43	.422	1.	46	.25	47	.25	61	.25	62	.25
44	.422	1.	47	.25	48	.25	62	.25	63	.25
45	.422	1.	48	.25	49	.25	63	.25	64	.25
46	.422	1.	49	.25	50	.25	64	.25	65	.25
47	.422	1.	50	.25	51	.25	65	.25	66	.25
48	.422	1.	51	.25	52	.25	66	.25	67	.25
49	.422	1.	52	.25	53	.25	67	.25	68	.25
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52	.422	1.	55	.25	56	.25	70	.25	71	.25
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54	.422	1.	57	.25	58	.25	72	.25	73	.25
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56	.422	1.	59	.25	60	.25	74	.25	75	.25
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61	.422	0.	65	.25	66	.25	80	.25	81	.25
62	.422	1.	66	.25	67	.25	81	.25	82	.25
63	.422	1.	67	.25	68	.25	82	.25	83	.25
64	.422	1.	68	.25	69	.25	83	.25	84	.25
65	.422	1.	69	.25	70	.25	84	.25	85	.25
66	.422	0.	70	.25	71	.25	85	.25	86	.25
67	.422	1.	71	.25	72	.25	86	.25	87	.25
68	.422	1.	72	.25	73	.25	87	.25	88	.25
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72	.422	1.	77	.25	78	.25	92	.25	93	.25
73	.422	0.	78	.25	79	.25	93	.25	94	.25
74	.422	1.	79	.25	80	.25	94	.25	95	.25
75	.422	1.	80	.25	81	.25	95	.25	96	.25
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79	.422	1.	84	.25	85	.25	99	.25	100	.25
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81	.422	1.	86	.25	87	.25	101	.25	102	.25
82	.422	0.	87	.25	88	.25	102	.25	103	.25
83	.422	1.	88	.25	89	.25	103	.25	104	.25
84	.422	1.	89	.25	90	.25	104	.25	105	.25
85	.422	1.	91	.25	92	.25	106	.25	107	.25
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87	.422	1.	93	.25	94	.25	108	.25	109	.25
88	.422	1.	94	.25	95	.25	109	.25	110	.25
89	.422	1.	95	.25	96	.25	110	.25	111	.25
90	.422	1.	96	.25	97	.25	111	.25	112	.25
91	.422	1.	97	.25	98	.25	112	.25	113	.25
92	.422	0.	98	.25	99	.25	113	.25	114	.25
93	.422	1.	99	.25	100	.25	114	.25	115	.25
94	.422	1.	100	.25	101	.25	115	.25	116	.25
95	.422	1.	101	.25	102	.25	116	.25	117	.25
96	.422	1.	102	.25	103	.25	117	.25	118	.25
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121	.422	1.	129	.25	130	.25	144	.25	145	.25
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123	.422	1.	131	.25	132	.25	146	.25	147	.25
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135	.422	1.	144	.25	145	.25	159	.25	160	.25
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159	.422	1.	170	.25	171	.25	185	.25	186	.25
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173	.422	1.	185	.25	186	.25	200	.25	201	.25
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175	.422	1.	187	.25	188	.25	202	.25	203	.25
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190	.422	1.	203	.25	204	.25	218	.25	219	.25
191	.422	1.	204	.25	205	.25	219	.25	220	.25
192	.422	1.	205	.25	206	.25	220	.25	221	.25
193	.422	1.	206	.25	207	.25	221	.25	222	.25
194	.422	1.	207	.25	208	.25	222	.25	223	.25
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3	1	196								

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   28    8    3    8    6    3    9    5    3   10    5    3   11    5
              3   12    5    3   13    5    3   14    5    3   15    4

radg     3    1    0
    1    1    8   23   24    3    4   26   25    7    8
    2    1    8   11   12   13   14   22   21    9   10
    3    1    8   27   28   15   16   17   18   19   20
```

```
heat     1    0    1    0    0
 0.33  0.6  0.3  0.0 0.83 0.33 0.33  0.0
  1.0
drag     1    1
 .153-0.18                100.2 -1.0
    1    1    0
   10    1  225  0.0  3.90.111  3.90.222  3.90.333  3.90.444  3.90.556  3.9
                0.667  3.90.778  3.90.889  3.91.000  3.9
calc     1
  0.0 .001 0.01 .001 .001
       500
oper     1    2    0    1                                        0         0
  0.0           200.    0.0001     0.001
1.8111.3761.376
5.4901.1031.103
outp 11011                                  3
endd
```

```
99999    0
    1    1  Calculation No. 2013-11284 Rev. 0, May 2015 Case
prop    12    1
                 0.      109.9     .0133      .239    11.628      .0400
               100.      133.9     .0154      .240    14.085      .0463
               200.      158.0     .0174      .241    16.667      .0518
               300.      182.1     .0193      .243    19.231      .0580
               400.      206.5     .0212      .245    21.739      .0630
               500.      231.1     .0231      .247    24.272      .0680
               600.      256.0     .0250      .250    26.810      .0720
               700.      281.2     .0268      .253    29.326      .0770
               800.      306.7     .0286      .256    31.847      .0810
               900.      332.5     .0303      .259    34.364      .0850
              1000.      358.7     .0319      .262    36.900      .0889
              1500.      493.6     .0400      .276    49.505      .1080
    10                          10.9
chan     3   24
     144.0       0.0
    1    1  225    0    0
    1    1    0    0    1
    1.25231.403.3314    2.32500.546   16.32500.546
    2.22811.219.6629    3.32500.556   17.13400.546
    3.22811.219.6629    4.32500.556   18.13400.546
    4.22811.219.6629    5.32500.556   19.13400.546
    5.22811.219.6629    6.32500.556   20.13400.546
    6.22811.219.6629    7.32500.556   21.13400.546
    7.22811.219.6629    8.32500.556   22.13400.546
    8.22811.219.6629    9.32500.556   23.13400.546
    9.22811.219.6629   10.32500.556   24.13400.546
   10.22811.219.6629   11.32500.556   25.13400.546
   11.22811.219.6629   12.32500.556   26.13400.546
   12.22811.219.6629   13.32500.556   27.13400.546
   13.22811.219.6629   14.32500.556   28.13400.546
   14.22811.219.6629   15.32500.546   29.13400.546
   15.25231.403.3314   30.32500.546
   16.22811.219.6629   17.13400.546   31.32500.556
   17.16921.3261.326   18.13400.556   32.13400.556
   18.16921.3261.326   19.13400.556   33.13400.556
   19.16921.3261.326   20.13400.556   34.13400.556
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   27.16921.3261.326   28.13400.556   42.13400.556
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   29.16921.3261.326   30.13400.546   44.13400.556
   30.22811.219.6629   45.32500.556
   31.22811.219.6629   32.13400.546   46.32500.556
   32.16921.3261.326   33.13400.556   47.13400.556
   33.16921.3261.326   34.13400.556   48.13400.556
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   58.16921.3261.326   59.13400.556   73.13400.556
   59.16921.3261.326   60.13400.546   74.13400.556
   60.22811.219.6629   75.32500.556
   61.22811.219.6629   62.13400.546   76.32500.556
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   63.16921.3261.326   64.13400.556   78.13400.556
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   67.16921.3261.326   68.13400.556   82.13400.556
   68.16921.3261.326   69.13400.556   83.13400.556
   69.16921.3261.326   70.13400.556   84.13400.556
   70.16921.3261.326   71.13400.556   85.13400.556
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74.16921.3261.326	75.13400.546	89.13400.556
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82.16921.3261.326	83.13400.556	97.13400.556
83.16921.3261.326	84.13400.556	98.13400.556
84.16921.3261.326	85.13400.556	99.13400.556
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88.16921.3261.326	89.13400.556	103.13400.556
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104.16921.3261.326	105.13400.546	119.13400.556
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110.16921.3261.326	111.13400.556	125.13400.556
111.16921.3261.326	112.13400.556	126.13400.556
112.16921.3261.326	113.13400.556	127.13400.556
113.16921.3261.326	114.13400.556	128.13400.556
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134.16921.3261.326	135.13400.546	149.13400.556
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148.16921.3261.326	149.13400.556	163.13400.556
149.16921.3261.326	150.13400.546	164.13400.556
150.22811.219.6629	165.32500.556	
151.22811.219.6629	152.13400.546	166.32500.556
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156.16921.3261.326	157.13400.556	171.13400.556
157.16921.3261.326	158.13400.556	172.13400.556
158.16921.3261.326	159.13400.556	173.13400.556
159.16921.3261.326	160.13400.556	174.13400.556
160.16921.3261.326	161.13400.556	175.13400.556

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  163.16921.3261.326  164.13400.556  178.13400.556
  164.16921.3261.326  165.13400.546  179.13400.556
  165.22811.219.6629  180.32500.556
  166.22811.219.6629  167.13400.546  181.32500.556
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  173.16921.3261.326  174.13400.556  188.13400.556
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  189.16921.3261.326  190.13400.556  204.13400.556
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  193.16921.3261.326  194.13400.556  208.13400.556
  194.16921.3261.326  195.13400.546  209.13400.556
  195.22811.219.6629  210.32500.556
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  199.16921.3261.326  200.13400.556  214.13400.546
  200.16921.3261.326  201.13400.556  215.13400.546
  201.16921.3261.326  202.13400.556  216.13400.546
  202.16921.3261.326  203.13400.556  217.13400.546
  203.16921.3261.326  204.13400.556  218.13400.546
  204.16921.3261.326  205.13400.556  219.13400.546
  205.16921.3261.326  206.13400.556  220.13400.546
  206.16921.3261.326  207.13400.556  221.13400.546
  207.16921.3261.326  208.13400.556  222.13400.546
  208.16921.3261.326  209.13400.556  223.13400.546
  209.16921.3261.326  210.13400.546  224.13400.546
  210.22811.219.6629  225.32500.546
  211.25231.403.3314  212.32500.546
  212.22811.219.6629  213.32500.556
  213.22811.219.6629  214.32500.556
  214.22811.219.6629  215.32500.556
  215.22811.219.6629  216.32500.556
  216.22811.219.6629  217.32500.556
  217.22811.219.6629  218.32500.556
  218.22811.219.6629  219.32500.556
  219.22811.219.6629  220.32500.556
  220.22811.219.6629  221.32500.556
  221.22811.219.6629  222.32500.556
  222.22811.219.6629  223.32500.556
  223.22811.219.6629  224.32500.556
  224.22811.219.6629  225.32500.546
  225.25231.403.3314
    2    1  225    0    0
    1    1    0    0    1
    3    1  225    0    0
    1    1    0    0    1

rods     1    1    0    0    1
    1    1  196
    1 .422   1.    1  .25    2  .25   16  .25   17  .25
    2 .422   1.    2  .25    3  .25   17  .25   18  .25
    3 .422   1.    3  .25    4  .25   18  .25   19  .25
    4 .422   1.    4  .25    5  .25   19  .25   20  .25
    5 .422   1.    5  .25    6  .25   20  .25   21  .25
    6 .422   1.    6  .25    7  .25   21  .25   22  .25
    7 .422   1.    7  .25    8  .25   22  .25   23  .25
    8 .422   1.    8  .25    9  .25   23  .25   24  .25
    9 .422   1.    9  .25   10  .25   24  .25   25  .25
   10 .422   1.   10  .25   11  .25   25  .25   26  .25
   11 .422   1.   11  .25   12  .25   26  .25   27  .25
   12 .422   1.   12  .25   13  .25   27  .25   28  .25
   13 .422   1.   13  .25   14  .25   28  .25   29  .25
   14 .422   1.   14  .25   15  .25   29  .25   30  .25
   15 .422   1.   16  .25   17  .25   31  .25   32  .25
   16 .422   1.   17  .25   18  .25   32  .25   33  .25
   17 .422   1.   18  .25   19  .25   33  .25   34  .25
   18 .422   1.   19  .25   20  .25   34  .25   35  .25
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20	.422	1.	21	.25	22	.25	36	.25	37	.25
21	.422	1.	22	.25	23	.25	37	.25	38	.25
22	.422	1.	23	.25	24	.25	38	.25	39	.25
23	.422	1.	24	.25	25	.25	39	.25	40	.25
24	.422	1.	25	.25	26	.25	40	.25	41	.25
25	.422	1.	26	.25	27	.25	41	.25	42	.25
26	.422	1.	27	.25	28	.25	42	.25	43	.25
27	.422	1.	28	.25	29	.25	43	.25	44	.25
28	.422	1.	29	.25	30	.25	44	.25	45	.25
29	.422	1.	31	.25	32	.25	46	.25	47	.25
30	.422	1.	32	.25	33	.25	47	.25	48	.25
31	.422	0.	33	.25	34	.25	48	.25	49	.25
32	.422	1.	34	.25	35	.25	49	.25	50	.25
33	.422	1.	35	.25	36	.25	50	.25	51	.25
34	.422	0.	36	.25	37	.25	51	.25	52	.25
35	.422	1.	37	.25	38	.25	52	.25	53	.25
36	.422	1.	38	.25	39	.25	53	.25	54	.25
37	.422	0.	39	.25	40	.25	54	.25	55	.25
38	.422	1.	40	.25	41	.25	55	.25	56	.25
39	.422	1.	41	.25	42	.25	56	.25	57	.25
40	.422	0.	42	.25	43	.25	57	.25	58	.25
41	.422	1.	43	.25	44	.25	58	.25	59	.25
42	.422	1.	44	.25	45	.25	59	.25	60	.25
43	.422	1.	46	.25	47	.25	61	.25	62	.25
44	.422	1.	47	.25	48	.25	62	.25	63	.25
45	.422	1.	48	.25	49	.25	63	.25	64	.25
46	.422	1.	49	.25	50	.25	64	.25	65	.25
47	.422	1.	50	.25	51	.25	65	.25	66	.25
48	.422	1.	51	.25	52	.25	66	.25	67	.25
49	.422	1.	52	.25	53	.25	67	.25	68	.25
50	.422	1.	53	.25	54	.25	68	.25	69	.25
51	.422	1.	54	.25	55	.25	69	.25	70	.25
52	.422	1.	55	.25	56	.25	70	.25	71	.25
53	.422	1.	56	.25	57	.25	71	.25	72	.25
54	.422	1.	57	.25	58	.25	72	.25	73	.25
55	.422	1.	58	.25	59	.25	73	.25	74	.25
56	.422	1.	59	.25	60	.25	74	.25	75	.25
57	.422	1.	61	.25	62	.25	76	.25	77	.25
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59	.422	1.	63	.25	64	.25	78	.25	79	.25
60	.422	1.	64	.25	65	.25	79	.25	80	.25
61	.422	0.	65	.25	66	.25	80	.25	81	.25
62	.422	1.	66	.25	67	.25	81	.25	82	.25
63	.422	1.	67	.25	68	.25	82	.25	83	.25
64	.422	1.	68	.25	69	.25	83	.25	84	.25
65	.422	1.	69	.25	70	.25	84	.25	85	.25
66	.422	0.	70	.25	71	.25	85	.25	86	.25
67	.422	1.	71	.25	72	.25	86	.25	87	.25
68	.422	1.	72	.25	73	.25	87	.25	88	.25
69	.422	1.	73	.25	74	.25	88	.25	89	.25
70	.422	1.	74	.25	75	.25	89	.25	90	.25
71	.422	1.	76	.25	77	.25	91	.25	92	.25
72	.422	1.	77	.25	78	.25	92	.25	93	.25
73	.422	0.	78	.25	79	.25	93	.25	94	.25
74	.422	1.	79	.25	80	.25	94	.25	95	.25
75	.422	1.	80	.25	81	.25	95	.25	96	.25
76	.422	1.	81	.25	82	.25	96	.25	97	.25
77	.422	1.	82	.25	83	.25	97	.25	98	.25
78	.422	1.	83	.25	84	.25	98	.25	99	.25
79	.422	1.	84	.25	85	.25	99	.25	100	.25
80	.422	1.	85	.25	86	.25	100	.25	101	.25
81	.422	1.	86	.25	87	.25	101	.25	102	.25
82	.422	0.	87	.25	88	.25	102	.25	103	.25
83	.422	1.	88	.25	89	.25	103	.25	104	.25
84	.422	1.	89	.25	90	.25	104	.25	105	.25
85	.422	1.	91	.25	92	.25	106	.25	107	.25
86	.422	1.	92	.25	93	.25	107	.25	108	.25
87	.422	1.	93	.25	94	.25	108	.25	109	.25
88	.422	1.	94	.25	95	.25	109	.25	110	.25
89	.422	1.	95	.25	96	.25	110	.25	111	.25
90	.422	1.	96	.25	97	.25	111	.25	112	.25
91	.422	1.	97	.25	98	.25	112	.25	113	.25
92	.422	0.	98	.25	99	.25	113	.25	114	.25
93	.422	1.	99	.25	100	.25	114	.25	115	.25
94	.422	1.	100	.25	101	.25	115	.25	116	.25
95	.422	1.	101	.25	102	.25	116	.25	117	.25
96	.422	1.	102	.25	103	.25	117	.25	118	.25
97	.422	1.	103	.25	104	.25	118	.25	119	.25
98	.422	1.	104	.25	105	.25	119	.25	120	.25
99	.422	1.	106	.25	107	.25	121	.25	122	.25
100	.422	1.	107	.25	108	.25	122	.25	123	.25
101	.422	1.	108	.25	109	.25	123	.25	124	.25
102	.422	1.	109	.25	110	.25	124	.25	125	.25
103	.422	1.	110	.25	111	.25	125	.25	126	.25
104	.422	1.	111	.25	112	.25	126	.25	127	.25
105	.422	1.	112	.25	113	.25	127	.25	128	.25
106	.422	1.	113	.25	114	.25	128	.25	129	.25
107	.422	1.	114	.25	115	.25	129	.25	130	.25
108	.422	1.	115	.25	116	.25	130	.25	131	.25

109	.422	1.	116	.25	117	.25	131	.25	132	.25
110	.422	1.	117	.25	118	.25	132	.25	133	.25
111	.422	1.	118	.25	119	.25	133	.25	134	.25
112	.422	1.	119	.25	120	.25	134	.25	135	.25
113	.422	1.	121	.25	122	.25	136	.25	137	.25
114	.422	1.	122	.25	123	.25	137	.25	138	.25
115	.422	0.	123	.25	124	.25	138	.25	139	.25
116	.422	1.	124	.25	125	.25	139	.25	140	.25
117	.422	1.	125	.25	126	.25	140	.25	141	.25
118	.422	1.	126	.25	127	.25	141	.25	142	.25
119	.422	1.	127	.25	128	.25	142	.25	143	.25
120	.422	1.	128	.25	129	.25	143	.25	144	.25
121	.422	1.	129	.25	130	.25	144	.25	145	.25
122	.422	1.	130	.25	131	.25	145	.25	146	.25
123	.422	1.	131	.25	132	.25	146	.25	147	.25
124	.422	0.	132	.25	133	.25	147	.25	148	.25
125	.422	1.	133	.25	134	.25	148	.25	149	.25
126	.422	1.	134	.25	135	.25	149	.25	150	.25
127	.422	1.	136	.25	137	.25	151	.25	152	.25
128	.422	1.	137	.25	138	.25	152	.25	153	.25
129	.422	1.	138	.25	139	.25	153	.25	154	.25
130	.422	1.	139	.25	140	.25	154	.25	155	.25
131	.422	0.	140	.25	141	.25	155	.25	156	.25
132	.422	1.	141	.25	142	.25	156	.25	157	.25
133	.422	1.	142	.25	143	.25	157	.25	158	.25
134	.422	1.	143	.25	144	.25	158	.25	159	.25
135	.422	1.	144	.25	145	.25	159	.25	160	.25
136	.422	0.	145	.25	146	.25	160	.25	161	.25
137	.422	1.	146	.25	147	.25	161	.25	162	.25
138	.422	1.	147	.25	148	.25	162	.25	163	.25
139	.422	1.	148	.25	149	.25	163	.25	164	.25
140	.422	1.	149	.25	150	.25	164	.25	165	.25
141	.422	1.	151	.25	152	.25	166	.25	167	.25
142	.422	1.	152	.25	153	.25	167	.25	168	.25
143	.422	1.	153	.25	154	.25	168	.25	169	.25
144	.422	1.	154	.25	155	.25	169	.25	170	.25
145	.422	1.	155	.25	156	.25	170	.25	171	.25
146	.422	1.	156	.25	157	.25	171	.25	172	.25
147	.422	1.	157	.25	158	.25	172	.25	173	.25
148	.422	1.	158	.25	159	.25	173	.25	174	.25
149	.422	1.	159	.25	160	.25	174	.25	175	.25
150	.422	1.	160	.25	161	.25	175	.25	176	.25
151	.422	1.	161	.25	162	.25	176	.25	177	.25
152	.422	1.	162	.25	163	.25	177	.25	178	.25
153	.422	1.	163	.25	164	.25	178	.25	179	.25
154	.422	1.	164	.25	165	.25	179	.25	180	.25
155	.422	1.	166	.25	167	.25	181	.25	182	.25
156	.422	1.	167	.25	168	.25	182	.25	183	.25
157	.422	0.	168	.25	169	.25	183	.25	184	.25
158	.422	1.	169	.25	170	.25	184	.25	185	.25
159	.422	1.	170	.25	171	.25	185	.25	186	.25
160	.422	0.	171	.25	172	.25	186	.25	187	.25
161	.422	1.	172	.25	173	.25	187	.25	188	.25
162	.422	1.	173	.25	174	.25	188	.25	189	.25
163	.422	0.	174	.25	175	.25	189	.25	190	.25
164	.422	1.	175	.25	176	.25	190	.25	191	.25
165	.422	1.	176	.25	177	.25	191	.25	192	.25
166	.422	0.	177	.25	178	.25	192	.25	193	.25
167	.422	1.	178	.25	179	.25	193	.25	194	.25
168	.422	1.	179	.25	180	.25	194	.25	195	.25
169	.422	1.	181	.25	182	.25	196	.25	197	.25
170	.422	1.	182	.25	183	.25	197	.25	198	.25
171	.422	1.	183	.25	184	.25	198	.25	199	.25
172	.422	1.	184	.25	185	.25	199	.25	200	.25
173	.422	1.	185	.25	186	.25	200	.25	201	.25
174	.422	1.	186	.25	187	.25	201	.25	202	.25
175	.422	1.	187	.25	188	.25	202	.25	203	.25
176	.422	1.	188	.25	189	.25	203	.25	204	.25
177	.422	1.	189	.25	190	.25	204	.25	205	.25
178	.422	1.	190	.25	191	.25	205	.25	206	.25
179	.422	1.	191	.25	192	.25	206	.25	207	.25
180	.422	1.	192	.25	193	.25	207	.25	208	.25
181	.422	1.	193	.25	194	.25	208	.25	209	.25
182	.422	1.	194	.25	195	.25	209	.25	210	.25
183	.422	1.	196	.25	197	.25	211	.25	212	.25
184	.422	1.	197	.25	198	.25	212	.25	213	.25
185	.422	1.	198	.25	199	.25	213	.25	214	.25
186	.422	1.	199	.25	200	.25	214	.25	215	.25
187	.422	1.	200	.25	201	.25	215	.25	216	.25
188	.422	1.	201	.25	202	.25	216	.25	217	.25
189	.422	1.	202	.25	203	.25	217	.25	218	.25
190	.422	1.	203	.25	204	.25	218	.25	219	.25
191	.422	1.	204	.25	205	.25	219	.25	220	.25
192	.422	1.	205	.25	206	.25	220	.25	221	.25
193	.422	1.	206	.25	207	.25	221	.25	222	.25
194	.422	1.	207	.25	208	.25	222	.25	223	.25
195	.422	1.	208	.25	209	.25	223	.25	224	.25
196	.422	1.	209	.25	210	.25	224	.25	225	.25
2	1	196								
3	1	196								

```
                                                                    KMay.i
  4.3 .070660.0.3659 12.0 .077 410..0243 563. .422
slab     1    6   28
    1                          17011
    1    1.5344              2   21    1   23    1
    2    1.5344              2   22    1   24    1
    3    1.5188
    4    1.5188
    5    1.5344              2   26    1   28    1
    6    1.5344              2   25    1   27    1
    7    1.5188
    8    1.5188
    9    1.5188
   10    1.5188
   11    1.5344
   12    1.5344
   13    1.5188
   14    1.5188
   15    1.5188
   16    1.5188
   17    1.5344
   18    1.5344
   19    1.5188
   20    1.5188
   21    1.0000
   22    1.0000
   23    1.0000
   24    1.0000
   25    1.0000
   26    1.0000
   27    1.0000
   28    1.0000
    1.1166          0.536
    2.1124          0.556
    3.2248          0.278
    4.0000          0.536
    5.0000          0.556
    6.0000          0.278
    3    8    1   15    1    1   30    2    1   45    2    1   60    2
              1   75    2    1   90    2    1  105    2    1  120    3
    4    8    1  120    3    1  135    2    1  150    2    1  165    2
              1  180    2    1  195    2    1  210    2    1  225    1
    7    8    1  211    1    1  196    2    1  181    2    1  166    2
              1  151    2    1  136    2    1  121    2    1  106    3
    8    8    1  106    3    1   91    2    1   76    2    1   61    2
              1   46    2    1   31    2    1   16    2    1    1    1
    9    8    2  211    1    2  196    2    2  181    2    2  166    2
              2  151    2    2  136    2    2  121    2    2  106    3
   10    8    2  106    3    2   91    2    2   76    2    2   61    2
              2   46    2    2   31    2    2   16    2    2    1    1
   11    8    2    1    1    2    2    2    2    3    2    2    4    2
              2    5    2    2    6    2    2    7    2    2    8    3
   12    8    2    8    3    2    9    2    2   10    2    2   11    2
              2   12    2    2   13    2    2   14    2    2   15    1
   13    8    2   15    1    2   30    2    2   45    2    2   60    2
              2   75    2    2   90    2    2  105    2    2  120    3
   14    8    2  120    3    2  135    2    2  150    2    2  165    2
              2  180    2    2  195    2    2  210    2    2  225    1
   15    8    3   15    1    3   30    2    3   45    2    3   60    2
              3   75    2    3   90    2    3  105    2    3  120    3
   16    8    3  120    3    3  135    2    3  150    2    3  165    2
              3  180    2    3  195    2    3  210    2    3  225    1
   17    8    3  225    1    3  224    2    3  223    2    3  222    2
              3  221    2    3  220    2    3  219    2    3  218    3
   18    8    3  218    3    3  217    2    3  216    2    3  215    2
              3  214    2    3  213    2    3  212    2    3  211    1
   19    8    3  211    1    3  196    2    3  181    2    3  166    2
              3  151    2    3  136    2    3  121    2    3  106    3
   20    8    3  106    3    3   91    2    3   76    2    3   61    2
              3   46    2    3   31    2    3   16    2    3    1    1
   21    8    2  218    6    2  217    5    2  216    5    2  215    5
              2  214    5    2  213    5    2  212    5    2  211    4
   22    8    2  225    4    2  224    5    2  223    5    2  222    5
              2  221    5    2  220    5    2  219    5    2  218    6
   23    8    1    1    4    1    2    5    1    3    5    1    4    5
              1    5    5    1    6    5    1    7    5    1    8    6
   24    8    1    8    6    1    9    5    1   10    5    1   11    5
              1   12    5    1   13    5    1   14    5    1   15    4
   25    8    1  218    6    1  217    5    1  216    5    1  215    5
              1  214    5    1  213    5    1  212    5    1  211    4
   26    8    1  225    4    1  224    5    1  223    5    1  222    5
              1  221    5    1  220    5    1  219    5    1  218    6
   27    8    3    1    4    3    2    5    3    3    5    3    4    5
              3    5    5    3    6    5    3    7    5    3    8    6
   28    8    3    8    6    3    9    5    3   10    5    3   11    5
              3   12    5    3   13    5    3   14    5    3   15    4

radg     3    1    0
    1    1    8   23   24    3    4   26   25    7    8
    2    1    8   11   12   13   14   22   21    9   10
    3    1    8   27   28   15   16   17   18   19   20
```

```
heat     1    0    1    0    0
 0.33  0.6  0.3  0.0 0.83 0.33 0.33  0.0
  1.0
drag     1    1
 .153-0.18               100.2 -1.0
    1    1    0
   10    1  225  0.0  3.90.111  3.90.222  3.90.333  3.90.444  3.90.556  3.9
                0.667  3.90.778  3.90.889  3.91.000  3.9
calc     1
  0.0 .001 0.01 .001 .001
       500
oper     1    2    0    1                                        0         0
  0.0           217.    0.0001     0.001
1.6551.2841.284
3.9531.1031.103
outp 11011                                  3
endd
```

KOCTselected.O

1

```
   CCCCC        00000     BBBBBBBBB    RRRRRRRRR       AAAAA
  CCCCCCC      0000000    BBBBBBBBBB   RRRRRRRRRR     AAAAAAA
 CCCCCCCCC    000000000   BBBBBBBBBBB  RRRRRRRRRRR   AAAAAAAAA
CCCCCCCCCCC  00000000000  BBBB  BBBBB  RRRR  RRRRR  AAAAAAAAAAA
CCCCC CCCCC  00000 00000  BBBB   BBBB  RRRR   RRRR  AAAAA AAAAA
CCCC   CCCC  0000   0000  BBBB  BBBB   RRRR  RRRR   AAAA   AAAA
CCCC         0000   0000  BBBBBBBBB    RRRRRRRRR    AAAA   AAAA
CCCC         0000   0000  BBBBBBBB     RRRRRRRR     AAAAAAAAAAA
CCCC         0000   0000  BBBBBBBBB    RRRR RRRR    AAAAAAAAAAA
CCCC   CCCC  0000   0000  BBBB  BBBB   RRRR  RRRR   AAAAAAAAAAA    FFFFF
CCCCC CCCCC  0000   0000  BBBB   BBBB  RRRR   RRRR  AAAA   AAAA  FF     FF
CCCCCCCCCCC  00000 00000  BBBB  BBBBB  RRRR   RRRR  AAAA   AAAA  F       F
 CCCCCCCCC    000000000   BBBBBBBBBBB  RRRR   RRRR  AAAA   AAAA  FFFFFFFFF
  CCCCCCC      0000000    BBBBBBBBBB   RRRR   RRRR  AAAA   AAAA  FF  F   FSS
   CCCCC        00000     BBBBBBBBB    RRRR   RRRR  AAAA   AAAA  FF  F   FSSS
                                                               FF  F   FSS S
                                                             SFF  F   FS  SS
                                                            SSFF  F   FS   SS
                                                           SSSFF  F   FSSSSSSS
                                                          SSSSFF  F   F SSSSS
                                                         SSS SFF  F   SSSSSSSSS
                                                        SSS  SFF  F  SS SSSSS SS
                                                        SSSSSSFF  F SSS  SSS  SSS
                                                        SSSSSSSF  F SS *  S  * SS
                                                        SSSS SSS  F  S         S
                                                        SSS    SS F   SS     SS
                                                         SSSSSSSSSS   F SS SS
                                                 S        SSSSSSS SS  F   S
                                                SSS        SSSSS   SS F   S
                                                   S        SSSS    SSS   S
                                                    SS        SSSS    SS
                                                   SS          FSSSSSSS SSS
                                                  SS           FFSSSSSS   SS
                                                 SSSSS         FFSSSSS     SS
                                                   S  SSS      FF SSSSS     SS
                                                    SS  SSS    FF  SSSSS     SS
                                                      SS SSS   FF  FSSSSSS   SS
                                                        S SSS  FF  F SSSSSS   SS
                                                        S SSS  FF  F  SSSSSS  SS
                                                       SS SS   FF  F   SSSSSSSSS
                                                     S   SS   SFF  F   FSSSSS SS
                                                    SS  SSSSSSSFF  F   FSSSSS SS
                                                   S   SSSSSSSSFF  F   FSSSSS SS
                                                   SS     SSSSSFF  F   FSSS  SS
      COBRA-SFS (SPENT FUEL STORAGE) CODE           SSS     SSSFF  F   FSSSSSS
 FOR MULTIASSEMBLY SPENT FUEL CASK ANALYSIS            SSSS    FF  F   FSSSSS
                                                          SSSSFF  F   FSSSS
                                                               FF  F   F
 WRITTEN AT PACIFIC NORTHWEST LABORATORY 1982-1986             FF  F  FF
 CREATION DATE FOR THIS VERSION (Cycle 3            ) 09-25-97    FFFFFFF

 CONTACT:  T.E. MICHENER (509) 375-2162
           D.R. RECTOR   (509) 372-4530
           J.M. CUTA     (509) 375-3673

  Calculation No. 2013-11284 Rev. 0, October 2014 Case                date: 11/04/13 time: 14:11:56


data from iterative solution using the recirculation module
time =      0.0000    dt =0.1000E+11

iteration  sweep          peak clad            total flow     pressure                 error
    no.      no.   --------------------------    (lbm/s)      drop(psi)    ----------------------------------
```

FFFFFFFFFFFFF SSSSSSSSSS
FFFFFFFFFFFFF SSSSSS SSSSS
FFFFF F FFFF SSSSSSS SSSS
FFF F FFFF SSSSSSSSS SS
FFF FF FFFFF SSSSSSSSSSS SSS
FF FFFFFFFFF SSS SSSS SSSSSSS
FF FFFFFFFFF SSS SSS SSSSSS
FFFFFFF SS SSS SSSSSS
FFFFFFF SSS SS
FFFFFFF SSSSSSS
FFFFFFF SSSSSSS
FFFFFFF SSS SSS
FFFFF FFFFFFFF SS SSSS
FFFF FFFFFFF SSSSSS SS
FFFFF FFFFF SS SS SSS
FFFFF FFFF S SSSSSSS
FFFFF FFFF SS SSSSSS
F FFFFF FF SS SSSSSS
F FFFFFFFFFF S SSSSSSSS
FF FFFFFFFFFF SSSSSS SS
FF FFF SSSSSS SSS
FFF FFF SSSS SSSS
FFF FFF SSSS SSS
FF FF SSSS SSS
FF FF SSS SSS
FF FFF SS SSS
FFFFFFF SSSSSS SSSSSSS
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FFFFFFF SSS SSS SSSSSSSS
FFF FFF SS SSSSSSSSSSS
FF FFFF SSS SSSSSSS SSS
F FFF SSS SSSS SS
FFF FFF SSSSSSSSS SS
FFFFFFF SSSSSSSSS S
FFFFFFF SSSSSSSSS

KOCTselected.O

		temp(f)	level	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	995.7	25	105	1	0.365E-01	0.0050676	-0.0037	1.8380	0.0354	0.0228
2	1	1023.6	25	105	1	0.365E-01	0.0051023	0.0006	0.0248	0.0036	0.0042
3	1	1020.6	25	105	1	0.365E-01	0.0051051	0.0007	0.0046	0.0010	0.0006
4	1	1020.8	25	105	1	0.365E-01	0.0051050	0.0005	0.0011	0.0008	0.0001
5	1	1021.1	25	105	1	0.365E-01	0.0051050	0.0003	0.0009	0.0006	0.0001
6	1	1021.3	25	105	1	0.365E-01	0.0051051	0.0001	0.0007	0.0005	0.0000
7	1	1021.5	25	105	1	0.365E-01	0.0051052	0.0001	0.0006	0.0004	0.0000
8	1	1021.6	25	105	1	0.365E-01	0.0051052	0.0000	0.0005	0.0004	0.0000
9	1	1021.7	25	105	1	0.365E-01	0.0051052	0.0000	0.0004	0.0003	0.0000
10	1	1021.8	25	105	1	0.365E-01	0.0051053	0.0000	0.0003	0.0002	0.0000
11	1	1021.8	25	105	1	0.365E-01	0.0051053	0.0000	0.0003	0.0002	0.0000

cobra-sfs code results
case 1 Calculation No. 2013-11284 Rev. 0, October 2014 Case date: 11/04/13 time: 14:11:59

assembly average results for assembly 1 time = 0.00000

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0052244	158.0000	200.0000	0.0600	0.0144855	0.0001811	0.8384427	41.46493
6.0	0.0049928	167.2995	238.5873	0.0566	0.0144855	0.0001811	0.8881182	41.46493
12.0	0.0047679	176.3672	276.2126	0.0537	0.0144855	0.0001811	0.9364678	41.46493
18.0	0.0045277	185.3331	313.2503	0.0511	0.0144855	0.0001811	0.9836002	41.46493
24.0	0.0043130	194.2215	349.6782	0.0489	0.0144855	0.0001811	1.0295654	41.46493
30.0	0.0041022	203.0354	385.8009	0.0468	0.0144855	0.0001811	1.0750734	41.46493
36.0	0.0038708	211.7753	421.4445	0.0449	0.0144855	0.0001811	1.1202787	41.46493
42.0	0.0036657	220.4432	456.6797	0.0432	0.0144855	0.0001811	1.1651722	41.46493
48.0	0.0034370	229.0380	491.6180	0.0416	0.0144855	0.0001811	1.2096517	41.46493
54.0	0.0032357	237.5608	525.9470	0.0401	0.0144855	0.0001811	1.2535480	41.46493
60.0	0.0030358	246.0141	559.8961	0.0388	0.0144855	0.0001811	1.2969502	41.46493
66.0	0.0028084	254.3969	593.5618	0.0375	0.0144855	0.0001811	1.3398427	41.46493
72.0	0.0026098	262.7109	626.6304	0.0364	0.0144855	0.0001811	1.3819332	41.46493
78.0	0.0024111	270.9583	659.3582	0.0353	0.0144855	0.0001811	1.4234197	41.46493
84.0	0.0021811	279.1381	691.8180	0.0344	0.0144855	0.0001811	1.4644936	41.46493
90.0	0.0019818	287.2524	723.7350	0.0334	0.0144855	0.0001811	1.5050175	41.46493
96.0	0.0017820	295.3032	755.3068	0.0326	0.0144855	0.0001811	1.5450986	41.46493
102.0	0.0015480	303.2895	786.6256	0.0317	0.0144855	0.0001811	1.5848217	41.46493
108.0	0.0013466	311.2130	817.4923	0.0310	0.0144855	0.0001811	1.6239506	41.46493
114.0	0.0011089	319.0760	847.9689	0.0303	0.0144855	0.0001811	1.6625898	41.46493
120.0	0.0009051	326.8774	878.2069	0.0296	0.0144855	0.0001811	1.7008951	41.46493
126.0	0.0007000	334.6172	908.0808	0.0289	0.0144855	0.0001811	1.7387834	41.46493
132.0	0.0004558	342.2957	937.3883	0.0283	0.0144855	0.0001811	1.7762183	41.46493
138.0	0.0002477	349.8926	966.3839	0.0277	0.0144855	0.0001811	1.8132214	41.46493
144.0	0.0000000	357.2544	994.4826	0.0272	0.0144855	0.0001811	1.8489520	41.46493

rod power delivered to the coolant 2.782 btu/sec 0.00294 mw

assembly average results for assembly 2 time = 0.00000

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distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0050458	158.0000	200.0000	0.0600	0.0110061	0.0001376	0.6370498	41.46493
6.0	0.0048170	160.5870	210.7345	0.0590	0.0110061	0.0001376	0.6475667	41.46493
12.0	0.0045907	163.1253	221.2669	0.0581	0.0110061	0.0001376	0.6578818	41.46493
18.0	0.0043562	165.6901	231.9092	0.0572	0.0110061	0.0001376	0.6683038	41.46493
24.0	0.0041347	168.2957	242.7208	0.0563	0.0110061	0.0001376	0.6788911	41.46493
30.0	0.0039156	170.9457	253.7167	0.0554	0.0110061	0.0001376	0.6896573	41.46493
36.0	0.0036875	173.6414	264.9019	0.0546	0.0110061	0.0001376	0.7006060	41.46493
42.0	0.0034728	176.3830	276.2780	0.0537	0.0110061	0.0001376	0.7117375	41.46493
48.0	0.0032486	179.1706	287.8450	0.0529	0.0110061	0.0001376	0.7230440	41.46493
54.0	0.0030380	182.0043	299.6029	0.0520	0.0110061	0.0001376	0.7344289	41.46493
60.0	0.0028295	184.8837	311.4088	0.0512	0.0110061	0.0001376	0.7458268	41.46493
66.0	0.0026106	187.8091	323.3981	0.0505	0.0110061	0.0001376	0.7573048	41.46493
72.0	0.0024058	190.7798	335.5729	0.0497	0.0110061	0.0001376	0.7689349	41.46493
78.0	0.0022028	193.7948	347.9296	0.0490	0.0110061	0.0001376	0.7807356	41.46493
84.0	0.0019887	196.8536	360.4658	0.0482	0.0110061	0.0001376	0.7927056	41.46493
90.0	0.0017891	199.9557	373.1790	0.0475	0.0110061	0.0001376	0.8048448	41.46493
96.0	0.0015910	203.1003	386.0666	0.0468	0.0110061	0.0001376	0.8171526	41.46493
102.0	0.0013811	206.2868	399.1262	0.0461	0.0110061	0.0001376	0.8296289	41.46493
108.0	0.0011860	209.5147	412.2548	0.0454	0.0110061	0.0001376	0.8422733	41.46493
114.0	0.0009786	212.7830	425.5406	0.0447	0.0110061	0.0001376	0.8550833	41.46493
120.0	0.0007862	216.0913	438.9892	0.0440	0.0110061	0.0001376	0.8680585	41.46493
126.0	0.0005951	219.4379	452.5932	0.0434	0.0110061	0.0001376	0.8811847	41.46493
132.0	0.0003908	222.8175	466.3315	0.0427	0.0110061	0.0001376	0.8944360	41.46493
138.0	0.0002021	226.2079	480.1136	0.0421	0.0110061	0.0001376	0.9077219	41.46493
144.0	0.0000000	229.4994	493.4934	0.0415	0.0110061	0.0001376	0.9206025	41.46493

rod power delivered to the coolant 0.662 btu/sec 0.00070 mw

assembly average results for assembly 3 time = 0.00000

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0050457	158.0000	200.0000	0.0600	0.0110061	0.0001376	0.6370498	41.46493
6.0	0.0048169	160.5871	210.7348	0.0590	0.0110061	0.0001376	0.6475670	41.46493
12.0	0.0045907	163.1255	221.2677	0.0581	0.0110061	0.0001376	0.6578826	41.46493
18.0	0.0043561	165.6905	231.9108	0.0572	0.0110061	0.0001376	0.6683055	41.46493
24.0	0.0041347	168.2964	242.7236	0.0563	0.0110061	0.0001376	0.6788940	41.46493
30.0	0.0039155	170.9468	253.7211	0.0554	0.0110061	0.0001376	0.6896619	41.46493
36.0	0.0036874	173.6429	264.9082	0.0546	0.0110061	0.0001376	0.7006127	41.46493
42.0	0.0034727	176.3851	276.2866	0.0537	0.0110061	0.0001376	0.7117467	41.46493
48.0	0.0032485	179.1733	287.8562	0.0529	0.0110061	0.0001376	0.7230561	41.46493
54.0	0.0030380	182.0077	299.6169	0.0520	0.0110061	0.0001376	0.7344447	41.46493
60.0	0.0028294	184.8878	311.4254	0.0512	0.0110061	0.0001376	0.7458447	41.46493
66.0	0.0026106	187.8139	323.4177	0.0505	0.0110061	0.0001376	0.7573254	41.46493
72.0	0.0024058	190.7853	335.5955	0.0497	0.0110061	0.0001376	0.7689586	41.46493
78.0	0.0022027	193.8011	347.9552	0.0490	0.0110061	0.0001376	0.7807625	41.46493
84.0	0.0019887	196.8606	360.4944	0.0482	0.0110061	0.0001376	0.7927356	41.46493
90.0	0.0017890	199.9634	373.2106	0.0475	0.0110061	0.0001376	0.8048778	41.46493
96.0	0.0015910	203.1087	386.1010	0.0468	0.0110061	0.0001376	0.8171886	41.46493
102.0	0.0013811	206.2959	399.1635	0.0461	0.0110061	0.0001376	0.8296677	41.46493
108.0	0.0011860	209.5244	412.2943	0.0454	0.0110061	0.0001376	0.8423148	41.46493
114.0	0.0009786	212.7933	425.5825	0.0447	0.0110061	0.0001376	0.8551273	41.46493
120.0	0.0007862	216.1022	439.0334	0.0440	0.0110061	0.0001376	0.8681049	41.46493
126.0	0.0005951	219.4494	452.6397	0.0434	0.0110061	0.0001376	0.8812335	41.46493
132.0	0.0003908	222.8295	466.3801	0.0427	0.0110061	0.0001376	0.8944869	41.46493
138.0	0.0002021	226.2204	480.1643	0.0421	0.0110061	0.0001376	0.9077748	41.46493
144.0	0.0000000	229.5123	493.5460	0.0415	0.0110061	0.0001376	0.9206574	41.46493

rod power delivered to the coolant 0.662 btu/sec 0.00070 mw

calculated fluid conditions at time = 0.0000 seconds
channel 1

assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0045582	158.0000	200.0000	0.0600	0.0000881	0.0001811	0.8384427	0.25230
6.0	0.0043372	163.8015	224.0727	0.0579	0.0000881	0.0001811	0.8694925	0.25230
12.0	0.0041224	170.3384	251.1969	0.0556	0.0000881	0.0001811	0.9044782	0.25230
18.0	0.0038940	177.6581	281.5688	0.0533	0.0000881	0.0001811	0.9436529	0.25230
24.0	0.0036916	185.5086	313.9695	0.0511	0.0000881	0.0001811	0.9850510	0.25230
30.0	0.0034947	193.7313	347.6691	0.0490	0.0000881	0.0001811	1.0275685	0.25230
36.0	0.0032801	202.1744	382.2721	0.0470	0.0000881	0.0001811	1.0712258	0.25230
42.0	0.0030927	210.7482	417.2691	0.0451	0.0000881	0.0001811	1.1155974	0.25230
48.0	0.0028848	219.4059	452.4629	0.0434	0.0000881	0.0001811	1.1604427	0.25230
54.0	0.0027048	228.0696	487.6811	0.0417	0.0000881	0.0001811	1.2053192	0.25230
60.0	0.0025280	236.7268	522.5975	0.0402	0.0000881	0.0001811	1.2498679	0.25230
66.0	0.0023265	245.3683	557.3025	0.0389	0.0000881	0.0001811	1.2941776	0.25230
72.0	0.0021549	253.9411	591.7312	0.0376	0.0000881	0.0001811	1.3381347	0.25230
78.0	0.0019850	262.4612	625.6397	0.0364	0.0000881	0.0001811	1.3811437	0.25230
84.0	0.0017865	270.9249	659.2259	0.0353	0.0000881	0.0001811	1.4236535	0.25230
90.0	0.0016193	279.2932	692.4333	0.0343	0.0000881	0.0001811	1.4656837	0.25230
96.0	0.0014532	287.5986	725.0926	0.0334	0.0000881	0.0001811	1.5070832	0.25230
102.0	0.0012553	295.8434	757.4252	0.0325	0.0000881	0.0001811	1.5480875	0.25230
108.0	0.0010908	303.9953	789.3934	0.0317	0.0000881	0.0001811	1.5886297	0.25230
114.0	0.0008923	312.0760	820.8374	0.0309	0.0000881	0.0001811	1.6284651	0.25230
120.0	0.0007286	320.0996	851.9364	0.0302	0.0000881	0.0001811	1.6678424	0.25230
126.0	0.0005651	328.0358	882.6969	0.0295	0.0000881	0.0001811	1.7067911	0.25230
132.0	0.0003647	335.8776	912.8916	0.0288	0.0000881	0.0001811	1.7451465	0.25230
138.0	0.0002013	343.6354	942.5015	0.0282	0.0000881	0.0001811	1.7829213	0.25230
144.0	0.0000000	351.0242	970.7032	0.0277	0.0000881	0.0001811	1.8188996	0.25230

calculated fluid conditions at time = 0.0000 seconds
channel 2
assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0044752	158.0000	200.0000	0.0600	0.0000797	0.0001811	0.8384427	0.22810
6.0	0.0042563	164.3948	226.5344	0.0576	0.0000797	0.0001811	0.8726677	0.22810
12.0	0.0040441	171.3741	255.4941	0.0553	0.0000797	0.0001811	0.9100208	0.22810
18.0	0.0038183	178.8283	286.4244	0.0530	0.0000797	0.0001811	0.9499159	0.22810
24.0	0.0036186	186.6448	318.6261	0.0508	0.0000797	0.0001811	0.9909259	0.22810
30.0	0.0034243	194.7445	351.8218	0.0487	0.0000797	0.0001811	1.0328077	0.22810
36.0	0.0032124	203.0295	385.7766	0.0468	0.0000797	0.0001811	1.0756473	0.22810
42.0	0.0030277	211.4412	420.0862	0.0449	0.0000797	0.0001811	1.1191870	0.22810
48.0	0.0028224	219.9394	454.6319	0.0432	0.0000797	0.0001811	1.1632065	0.22810
54.0	0.0026452	228.4543	489.2453	0.0417	0.0000797	0.0001811	1.2073124	0.22810
60.0	0.0024713	236.9793	523.6115	0.0402	0.0000797	0.0001811	1.2511626	0.22810
66.0	0.0022729	245.5014	557.8369	0.0389	0.0000797	0.0001811	1.2948599	0.22810
72.0	0.0021043	253.9681	591.8399	0.0376	0.0000797	0.0001811	1.3382735	0.22810
78.0	0.0019377	262.3932	625.3698	0.0364	0.0000797	0.0001811	1.3808021	0.22810
84.0	0.0017427	270.7736	658.6254	0.0354	0.0000797	0.0001811	1.4228933	0.22810
90.0	0.0015791	279.0700	691.5476	0.0343	0.0000797	0.0001811	1.4645626	0.22810
96.0	0.0014168	287.3106	723.9633	0.0334	0.0000797	0.0001811	1.5056510	0.22810
102.0	0.0012228	295.5006	756.0808	0.0325	0.0000797	0.0001811	1.5463826	0.22810
108.0	0.0010624	303.6060	787.8667	0.0317	0.0000797	0.0001811	1.5866936	0.22810
114.0	0.0008683	311.6430	819.1590	0.0309	0.0000797	0.0001811	1.6263399	0.22810
120.0	0.0007090	319.6300	850.1164	0.0302	0.0000797	0.0001811	1.6655379	0.22810
126.0	0.0005501	327.5361	880.7603	0.0295	0.0000797	0.0001811	1.7043389	0.22810
132.0	0.0003546	335.3473	910.8677	0.0289	0.0000797	0.0001811	1.7425645	0.22810
138.0	0.0001961	343.0883	940.4132	0.0283	0.0000797	0.0001811	1.7802572	0.22810
144.0	0.0000000	350.5607	968.9340	0.0277	0.0000797	0.0001811	1.8166426	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 3

assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0044719	158.0000	200.0000	0.0600	0.0000797	0.0001811	0.8384427	0.22810
6.0	0.0042531	164.5928	227.3562	0.0576	0.0000797	0.0001811	0.8737276	0.22810
12.0	0.0040413	171.7772	257.1668	0.0551	0.0000797	0.0001811	0.9121784	0.22810
18.0	0.0038159	179.3676	288.6624	0.0528	0.0000797	0.0001811	0.9528025	0.22810
24.0	0.0036166	187.2575	321.1373	0.0506	0.0000797	0.0001811	0.9940943	0.22810
30.0	0.0034228	195.3792	354.4229	0.0486	0.0000797	0.0001811	1.0360895	0.22810
36.0	0.0032111	203.6514	388.3255	0.0466	0.0000797	0.0001811	1.0788632	0.22810
42.0	0.0030267	212.0344	422.4977	0.0448	0.0000797	0.0001811	1.1222599	0.22810
48.0	0.0028216	220.4919	456.8778	0.0431	0.0000797	0.0001811	1.1660684	0.22810
54.0	0.0026447	228.9601	491.3010	0.0416	0.0000797	0.0001811	1.2099318	0.22810
60.0	0.0024709	237.4422	525.4706	0.0401	0.0000797	0.0001811	1.2535362	0.22810
66.0	0.0022725	245.9206	559.5205	0.0388	0.0000797	0.0001811	1.2970096	0.22810
72.0	0.0021041	254.3442	593.3502	0.0375	0.0000797	0.0001811	1.3402018	0.22810
78.0	0.0019376	262.7331	626.7186	0.0364	0.0000797	0.0001811	1.3825093	0.22810
84.0	0.0017426	271.0793	659.8385	0.0353	0.0000797	0.0001811	1.4244287	0.22810
90.0	0.0015791	279.3439	692.6347	0.0343	0.0000797	0.0001811	1.4659385	0.22810
96.0	0.0014168	287.5587	724.9359	0.0334	0.0000797	0.0001811	1.5068845	0.22810
102.0	0.0012228	295.7243	756.9581	0.0325	0.0000797	0.0001811	1.5474951	0.22810
108.0	0.0010624	303.8069	788.6546	0.0317	0.0000797	0.0001811	1.5876927	0.22810
114.0	0.0008683	311.8255	819.8665	0.0309	0.0000797	0.0001811	1.6272357	0.22810
120.0	0.0007091	319.7953	850.7571	0.0302	0.0000797	0.0001811	1.6663491	0.22810
126.0	0.0005502	327.6853	881.3382	0.0295	0.0000797	0.0001811	1.7050706	0.22810
132.0	0.0003546	335.4838	911.3885	0.0289	0.0000797	0.0001811	1.7432289	0.22810
138.0	0.0001961	343.2143	940.8943	0.0282	0.0000797	0.0001811	1.7808709	0.22810
144.0	0.0000000	350.6969	969.4539	0.0277	0.0000797	0.0001811	1.8173058	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 4
assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0044699	158.0000	200.0000	0.0600	0.0000797	0.0001811	0.8384427	0.22810
6.0	0.0042512	164.6657	227.6585	0.0576	0.0000797	0.0001811	0.8741175	0.22810
12.0	0.0040395	171.9563	257.9101	0.0551	0.0000797	0.0001811	0.9131372	0.22810
18.0	0.0038143	179.6418	289.7999	0.0527	0.0000797	0.0001811	0.9542696	0.22810
24.0	0.0036153	187.6031	322.5538	0.0505	0.0000797	0.0001811	0.9958814	0.22810
30.0	0.0034217	195.7674	356.0141	0.0485	0.0000797	0.0001811	1.0380971	0.22810
36.0	0.0032102	204.0567	389.9863	0.0465	0.0000797	0.0001811	1.0809586	0.22810
42.0	0.0030260	212.4409	424.1500	0.0447	0.0000797	0.0001811	1.1243653	0.22810
48.0	0.0028210	220.8858	458.4789	0.0431	0.0000797	0.0001811	1.1681086	0.22810
54.0	0.0026442	229.3319	492.8128	0.0415	0.0000797	0.0001811	1.2118582	0.22810
60.0	0.0024706	237.7916	526.8737	0.0401	0.0000797	0.0001811	1.2553276	0.22810
66.0	0.0022723	246.2440	560.8191	0.0387	0.0000797	0.0001811	1.2986675	0.22810
72.0	0.0021039	254.6398	594.5373	0.0375	0.0000797	0.0001811	1.3417174	0.22810
78.0	0.0019375	263.0048	627.7969	0.0364	0.0000797	0.0001811	1.3838741	0.22810
84.0	0.0017425	271.3276	660.8237	0.0353	0.0000797	0.0001811	1.4256757	0.22810
90.0	0.0015790	279.5698	693.5309	0.0343	0.0000797	0.0001811	1.4670728	0.22810
96.0	0.0014168	287.7663	725.7501	0.0334	0.0000797	0.0001811	1.5079170	0.22810
102.0	0.0012228	295.9146	757.7042	0.0325	0.0000797	0.0001811	1.5484413	0.22810
108.0	0.0010624	303.9806	789.3357	0.0317	0.0000797	0.0001811	1.5885564	0.22810
114.0	0.0008683	311.9860	820.4883	0.0309	0.0000797	0.0001811	1.6280231	0.22810
120.0	0.0007091	319.9432	851.3304	0.0302	0.0000797	0.0001811	1.6670751	0.22810
126.0	0.0005502	327.8211	881.8647	0.0295	0.0000797	0.0001811	1.7057373	0.22810
132.0	0.0003546	335.6105	911.8721	0.0288	0.0000797	0.0001811	1.7438459	0.22810
138.0	0.0001962	343.3332	941.3481	0.0282	0.0000797	0.0001811	1.7814498	0.22810
144.0	0.0000000	350.8197	969.9225	0.0277	0.0000797	0.0001811	1.8179036	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 5

assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0044685	158.0000	200.0000	0.0600	0.0000797	0.0001811	0.8384427	0.22810
6.0	0.0042499	164.7001	227.8011	0.0575	0.0000797	0.0001811	0.8743014	0.22810
12.0	0.0040383	172.0524	258.3087	0.0551	0.0000797	0.0001811	0.9136513	0.22810
18.0	0.0038132	179.8034	290.4706	0.0527	0.0000797	0.0001811	0.9551347	0.22810
24.0	0.0036143	187.8228	323.4542	0.0505	0.0000797	0.0001811	0.9970174	0.22810
30.0	0.0034209	196.0292	357.0869	0.0484	0.0000797	0.0001811	1.0394505	0.22810
36.0	0.0032095	204.3426	391.1581	0.0465	0.0000797	0.0001811	1.0824369	0.22810
42.0	0.0030254	212.7381	425.3582	0.0447	0.0000797	0.0001811	1.1259049	0.22810
48.0	0.0028206	221.1818	459.6823	0.0430	0.0000797	0.0001811	1.1696420	0.22810
54.0	0.0026439	229.6175	493.9736	0.0415	0.0000797	0.0001811	1.2133373	0.22810
60.0	0.0024704	238.0644	527.9696	0.0400	0.0000797	0.0001811	1.2567267	0.22810
66.0	0.0022721	246.4999	561.8468	0.0387	0.0000797	0.0001811	1.2999797	0.22810
72.0	0.0021038	254.8763	595.4872	0.0375	0.0000797	0.0001811	1.3429302	0.22810
78.0	0.0019374	263.2243	628.6679	0.0363	0.0000797	0.0001811	1.3849765	0.22810
84.0	0.0017425	271.5297	661.6259	0.0353	0.0000797	0.0001811	1.4266910	0.22810
90.0	0.0015790	279.7550	694.2658	0.0343	0.0000797	0.0001811	1.4680030	0.22810
96.0	0.0014168	287.9377	726.4225	0.0333	0.0000797	0.0001811	1.5087697	0.22810
102.0	0.0012228	296.0728	758.3245	0.0325	0.0000797	0.0001811	1.5492280	0.22810
108.0	0.0010624	304.1259	789.9056	0.0317	0.0000797	0.0001811	1.5892792	0.22810
114.0	0.0008683	312.1211	821.0121	0.0309	0.0000797	0.0001811	1.6286864	0.22810
120.0	0.0007091	320.0687	851.8167	0.0302	0.0000797	0.0001811	1.6676908	0.22810
126.0	0.0005502	327.9370	882.3141	0.0295	0.0000797	0.0001811	1.7063063	0.22810
132.0	0.0003546	335.7194	912.2877	0.0288	0.0000797	0.0001811	1.7443761	0.22810
138.0	0.0001962	343.4359	941.7400	0.0282	0.0000797	0.0001811	1.7819498	0.22810
144.0	0.0000000	350.9238	970.3197	0.0277	0.0000797	0.0001811	1.8184103	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 6
assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0044676	158.0000	200.0000	0.0600	0.0000797	0.0001811	0.8384427	0.22810
6.0	0.0042490	164.7193	227.8811	0.0575	0.0000797	0.0001811	0.8744047	0.22810
12.0	0.0040374	172.1079	258.5392	0.0550	0.0000797	0.0001811	0.9139485	0.22810
18.0	0.0038124	179.9017	290.8783	0.0526	0.0000797	0.0001811	0.9556607	0.22810
24.0	0.0036136	187.9628	324.0277	0.0504	0.0000797	0.0001811	0.9977410	0.22810
30.0	0.0034203	196.2023	357.7963	0.0484	0.0000797	0.0001811	1.0403456	0.22810
36.0	0.0032090	204.5374	391.9564	0.0464	0.0000797	0.0001811	1.0834441	0.22810
42.0	0.0030250	212.9454	426.2007	0.0446	0.0000797	0.0001811	1.1269784	0.22810
48.0	0.0028202	221.3918	460.5360	0.0430	0.0000797	0.0001811	1.1707298	0.22810
54.0	0.0026436	229.8228	494.8082	0.0414	0.0000797	0.0001811	1.2144008	0.22810
60.0	0.0024702	238.2626	528.7654	0.0400	0.0000797	0.0001811	1.2577428	0.22810
66.0	0.0022720	246.6871	562.5987	0.0387	0.0000797	0.0001811	1.3009397	0.22810
72.0	0.0021037	255.0504	596.1863	0.0374	0.0000797	0.0001811	1.3438227	0.22810
78.0	0.0019374	263.3866	629.3118	0.0363	0.0000797	0.0001811	1.3857915	0.22810
84.0	0.0017424	271.6797	662.2209	0.0352	0.0000797	0.0001811	1.4274442	0.22810
90.0	0.0015790	279.8928	694.8126	0.0343	0.0000797	0.0001811	1.4686951	0.22810
96.0	0.0014168	288.0656	726.9240	0.0333	0.0000797	0.0001811	1.5094057	0.22810
102.0	0.0012228	296.1910	758.7882	0.0325	0.0000797	0.0001811	1.5498161	0.22810
108.0	0.0010624	304.2348	790.3325	0.0316	0.0000797	0.0001811	1.5898207	0.22810
114.0	0.0008683	312.2226	821.4054	0.0309	0.0000797	0.0001811	1.6291843	0.22810
120.0	0.0007091	320.1631	852.1825	0.0302	0.0000797	0.0001811	1.6681540	0.22810
126.0	0.0005502	328.0244	882.6527	0.0295	0.0000797	0.0001811	1.7067351	0.22810
132.0	0.0003546	335.8016	912.6015	0.0288	0.0000797	0.0001811	1.7447765	0.22810
138.0	0.0001962	343.5135	942.0363	0.0282	0.0000797	0.0001811	1.7823278	0.22810
144.0	0.0000000	351.0016	970.6168	0.0277	0.0000797	0.0001811	1.8187894	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 7

assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0044671	158.0000	200.0000	0.0600	0.0000797	0.0001811	0.8384427	0.22810
6.0	0.0042485	164.7289	227.9208	0.0575	0.0000797	0.0001811	0.8744559	0.22810
12.0	0.0040370	172.1369	258.6593	0.0550	0.0000797	0.0001811	0.9141035	0.22810
18.0	0.0038119	179.9547	291.0983	0.0526	0.0000797	0.0001811	0.9559443	0.22810
24.0	0.0036132	188.0403	324.3454	0.0504	0.0000797	0.0001811	0.9981418	0.22810
30.0	0.0034199	196.3002	358.1976	0.0483	0.0000797	0.0001811	1.0408519	0.22810
36.0	0.0032087	204.6493	392.4152	0.0464	0.0000797	0.0001811	1.0840230	0.22810
42.0	0.0030248	213.0659	426.6907	0.0446	0.0000797	0.0001811	1.1276028	0.22810
48.0	0.0028200	221.5150	461.0367	0.0429	0.0000797	0.0001811	1.1713678	0.22810
54.0	0.0026435	229.9439	495.3006	0.0414	0.0000797	0.0001811	1.2150282	0.22810
60.0	0.0024701	238.3799	529.2367	0.0400	0.0000797	0.0001811	1.2583445	0.22810
66.0	0.0022719	246.7981	563.0448	0.0387	0.0000797	0.0001811	1.3015091	0.22810
72.0	0.0021037	255.1537	596.6013	0.0374	0.0000797	0.0001811	1.3443526	0.22810
78.0	0.0019373	263.4829	629.6942	0.0363	0.0000797	0.0001811	1.3862754	0.22810
84.0	0.0017424	271.7687	662.5741	0.0352	0.0000797	0.0001811	1.4278911	0.22810
90.0	0.0015790	279.9745	695.1369	0.0342	0.0000797	0.0001811	1.4691055	0.22810
96.0	0.0014168	288.1414	727.2211	0.0333	0.0000797	0.0001811	1.5097826	0.22810
102.0	0.0012228	296.2610	759.0627	0.0325	0.0000797	0.0001811	1.5501642	0.22810
108.0	0.0010625	304.2992	790.5850	0.0316	0.0000797	0.0001811	1.5901409	0.22810
114.0	0.0008683	312.2826	821.6378	0.0309	0.0000797	0.0001811	1.6294786	0.22810
120.0	0.0007091	320.2188	852.3986	0.0302	0.0000797	0.0001811	1.6684276	0.22810
126.0	0.0005502	328.0760	882.8526	0.0295	0.0000797	0.0001811	1.7069882	0.22810
132.0	0.0003547	335.8501	912.7867	0.0288	0.0000797	0.0001811	1.7450127	0.22810
138.0	0.0001962	343.5593	942.2110	0.0282	0.0000797	0.0001811	1.7825507	0.22810
144.0	0.0000000	351.0473	970.7914	0.0277	0.0000797	0.0001811	1.8190121	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 8
assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0044670	158.0000	200.0000	0.0600	0.0000797	0.0001811	0.8384427	0.22810
6.0	0.0042484	164.7308	227.9285	0.0575	0.0000797	0.0001811	0.8744658	0.22810
12.0	0.0040368	172.1441	258.6892	0.0550	0.0000797	0.0001811	0.9141420	0.22810
18.0	0.0038118	179.9685	291.1555	0.0526	0.0000797	0.0001811	0.9560182	0.22810
24.0	0.0036131	188.0606	324.4287	0.0504	0.0000797	0.0001811	0.9982469	0.22810
30.0	0.0034199	196.3257	358.3019	0.0483	0.0000797	0.0001811	1.0409834	0.22810
36.0	0.0032086	204.6779	392.5322	0.0464	0.0000797	0.0001811	1.0841706	0.22810
42.0	0.0030248	213.0959	426.8124	0.0446	0.0000797	0.0001811	1.1277579	0.22810
48.0	0.0028200	221.5446	461.1570	0.0429	0.0000797	0.0001811	1.1715211	0.22810
54.0	0.0026435	229.9719	495.4143	0.0414	0.0000797	0.0001811	1.2151731	0.22810
60.0	0.0024701	238.4059	529.3409	0.0400	0.0000797	0.0001811	1.2584776	0.22810
66.0	0.0022719	246.8215	563.1386	0.0386	0.0000797	0.0001811	1.3016289	0.22810
72.0	0.0021037	255.1743	596.6840	0.0374	0.0000797	0.0001811	1.3444582	0.22810
78.0	0.0019373	263.5011	629.7663	0.0363	0.0000797	0.0001811	1.3863667	0.22810
84.0	0.0017424	271.7845	662.6369	0.0352	0.0000797	0.0001811	1.4279707	0.22810
90.0	0.0015790	279.9882	695.1914	0.0342	0.0000797	0.0001811	1.4691745	0.22810
96.0	0.0014167	288.1535	727.2685	0.0333	0.0000797	0.0001811	1.5098426	0.22810
102.0	0.0012228	296.2716	759.1042	0.0325	0.0000797	0.0001811	1.5502169	0.22810
108.0	0.0010625	304.3084	790.6213	0.0316	0.0000797	0.0001811	1.5901869	0.22810
114.0	0.0008683	312.2908	821.6698	0.0309	0.0000797	0.0001811	1.6295191	0.22810
120.0	0.0007091	320.2262	852.4272	0.0302	0.0000797	0.0001811	1.6684638	0.22810
126.0	0.0005502	328.0825	882.8781	0.0295	0.0000797	0.0001811	1.7070204	0.22810
132.0	0.0003547	335.8561	912.8096	0.0288	0.0000797	0.0001811	1.7450420	0.22810
138.0	0.0001962	343.5649	942.2323	0.0282	0.0000797	0.0001811	1.7825778	0.22810
144.0	0.0000000	351.0534	970.8144	0.0277	0.0000797	0.0001811	1.8190414	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 211

assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0046757	158.0000	200.0000	0.0600	0.0000670	0.0001376	0.6370498	0.25230
6.0	0.0044558	160.0993	208.7106	0.0592	0.0000670	0.0001376	0.6455863	0.25230
12.0	0.0042385	162.3894	218.2133	0.0584	0.0000670	0.0001376	0.6548991	0.25230
18.0	0.0040133	165.0002	229.0464	0.0574	0.0000670	0.0001376	0.6655157	0.25230
24.0	0.0038017	167.8672	240.9425	0.0564	0.0000670	0.0001376	0.6771742	0.25230
30.0	0.0035931	170.9270	253.6389	0.0554	0.0000670	0.0001376	0.6896169	0.25230
36.0	0.0033762	174.1345	266.9482	0.0544	0.0000670	0.0001376	0.7026601	0.25230
42.0	0.0031736	177.4573	280.7355	0.0534	0.0000670	0.0001376	0.7161720	0.25230
48.0	0.0029623	180.8700	294.8964	0.0524	0.0000670	0.0001376	0.7300499	0.25230
54.0	0.0027654	184.3629	309.2740	0.0514	0.0000670	0.0001376	0.7439417	0.25230
60.0	0.0025713	187.9192	323.8492	0.0504	0.0000670	0.0001376	0.7579137	0.25230
66.0	0.0023673	191.5229	338.6183	0.0495	0.0000670	0.0001376	0.7720716	0.25230
72.0	0.0021784	195.1639	353.5407	0.0486	0.0000670	0.0001376	0.7863764	0.25230
78.0	0.0019918	198.8339	368.5814	0.0477	0.0000670	0.0001376	0.8007946	0.25230
84.0	0.0017944	202.5262	383.7141	0.0469	0.0000670	0.0001376	0.8153010	0.25230
90.0	0.0016124	206.2318	398.9007	0.0461	0.0000670	0.0001376	0.8298591	0.25230
96.0	0.0014324	209.9630	414.0773	0.0453	0.0000670	0.0001376	0.8445421	0.25230
102.0	0.0012407	213.7056	429.2910	0.0445	0.0000670	0.0001376	0.8592715	0.25230
108.0	0.0010647	217.4523	444.5217	0.0437	0.0000670	0.0001376	0.8740174	0.25230
114.0	0.0008763	221.2012	459.7609	0.0430	0.0000670	0.0001376	0.8887715	0.25230
120.0	0.0007039	224.9509	475.0039	0.0423	0.0000670	0.0001376	0.9035293	0.25230
126.0	0.0005332	228.6963	490.2288	0.0416	0.0000670	0.0001376	0.9182695	0.25230
132.0	0.0003490	232.4337	505.3560	0.0410	0.0000670	0.0001376	0.9329255	0.25230
138.0	0.0001814	236.1340	520.2169	0.0403	0.0000670	0.0001376	0.9473418	0.25230
144.0	0.0000000	239.5722	534.0250	0.0398	0.0000670	0.0001376	0.9607367	0.25230

calculated fluid conditions at time = 0.0000 seconds
channel 212
assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0046111	158.0000	200.0000	0.0600	0.0000605	0.0001376	0.6370498	0.22810
6.0	0.0043926	160.3003	209.5448	0.0591	0.0000605	0.0001376	0.6464038	0.22810
12.0	0.0041768	162.8176	219.9899	0.0582	0.0000605	0.0001376	0.6566402	0.22810
18.0	0.0039533	165.6128	231.5882	0.0572	0.0000605	0.0001376	0.6680068	0.22810
24.0	0.0037437	168.6457	244.1728	0.0562	0.0000605	0.0001376	0.6803399	0.22810
30.0	0.0035372	171.8678	257.5428	0.0551	0.0000605	0.0001376	0.6934427	0.22810
36.0	0.0033226	175.2388	271.5302	0.0541	0.0000605	0.0001376	0.7071506	0.22810
42.0	0.0031224	178.7261	286.0003	0.0530	0.0000605	0.0001376	0.7213316	0.22810
48.0	0.0029135	182.3043	300.8374	0.0519	0.0000605	0.0001376	0.7358542	0.22810
54.0	0.0027193	185.9669	315.8480	0.0509	0.0000605	0.0001376	0.7502437	0.22810
60.0	0.0025279	189.6829	331.0773	0.0500	0.0000605	0.0001376	0.7648427	0.22810
66.0	0.0023267	193.4394	346.4731	0.0490	0.0000605	0.0001376	0.7796013	0.22810
72.0	0.0021406	197.2257	361.9906	0.0481	0.0000605	0.0001376	0.7944766	0.22810
78.0	0.0019570	201.0320	377.5903	0.0472	0.0000605	0.0001376	0.8094307	0.22810
84.0	0.0017626	204.8516	393.2442	0.0464	0.0000605	0.0001376	0.8244367	0.22810
90.0	0.0015836	208.6856	408.8847	0.0455	0.0000605	0.0001376	0.8395148	0.22810
96.0	0.0014069	212.5282	424.5049	0.0447	0.0000605	0.0001376	0.8546377	0.22810
102.0	0.0012182	216.3697	440.1206	0.0439	0.0000605	0.0001376	0.8697564	0.22810
108.0	0.0010454	220.2064	455.7169	0.0432	0.0000605	0.0001376	0.8848562	0.22810
114.0	0.0008601	224.0360	471.2845	0.0425	0.0000605	0.0001376	0.8999283	0.22810
120.0	0.0006910	227.8575	486.8191	0.0418	0.0000605	0.0001376	0.9149684	0.22810
126.0	0.0005235	231.6697	502.2878	0.0411	0.0000605	0.0001376	0.9299491	0.22810
132.0	0.0003425	235.4832	517.6033	0.0405	0.0000605	0.0001376	0.9448063	0.22810
138.0	0.0001783	239.2466	532.7172	0.0398	0.0000605	0.0001376	0.9594680	0.22810
144.0	0.0000000	242.8170	547.0561	0.0393	0.0000605	0.0001376	0.9733779	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 213

assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0046050	158.0000	200.0000	0.0600	0.0000605	0.0001376	0.6370498	0.22810
6.0	0.0043865	160.3548	209.7710	0.0591	0.0000605	0.0001376	0.6466255	0.22810
12.0	0.0041709	162.9393	220.4951	0.0582	0.0000605	0.0001376	0.6571353	0.22810
18.0	0.0039476	165.7930	232.3360	0.0572	0.0000605	0.0001376	0.6687396	0.22810
24.0	0.0037382	168.8743	245.1215	0.0561	0.0000605	0.0001376	0.6812696	0.22810
30.0	0.0035320	172.1376	258.6622	0.0550	0.0000605	0.0001376	0.6945397	0.22810
36.0	0.0033176	175.5450	272.8008	0.0540	0.0000605	0.0001376	0.7083959	0.22810
42.0	0.0031177	179.0655	287.4089	0.0529	0.0000605	0.0001376	0.7227120	0.22810
48.0	0.0029091	182.6775	302.3668	0.0518	0.0000605	0.0001376	0.7373204	0.22810
54.0	0.0027152	186.3686	317.4942	0.0508	0.0000605	0.0001376	0.7518217	0.22810
60.0	0.0025241	190.1117	332.8347	0.0499	0.0000605	0.0001376	0.7665273	0.22810
66.0	0.0023232	193.8936	348.3346	0.0489	0.0000605	0.0001376	0.7813857	0.22810
72.0	0.0021374	197.7033	363.9481	0.0480	0.0000605	0.0001376	0.7963530	0.22810
78.0	0.0019542	201.5310	379.6352	0.0471	0.0000605	0.0001376	0.8113909	0.22810
84.0	0.0017600	205.3698	395.3681	0.0462	0.0000605	0.0001376	0.8264727	0.22810
90.0	0.0015814	209.2235	411.0710	0.0454	0.0000605	0.0001376	0.8416314	0.22810
96.0	0.0014049	213.0815	426.7543	0.0446	0.0000605	0.0001376	0.8568155	0.22810
102.0	0.0012165	216.9364	442.4244	0.0438	0.0000605	0.0001376	0.8719868	0.22810
108.0	0.0010440	220.7847	458.0679	0.0431	0.0000605	0.0001376	0.8871324	0.22810
114.0	0.0008589	224.6242	473.6758	0.0424	0.0000605	0.0001376	0.9022435	0.22810
120.0	0.0006900	228.4539	489.2436	0.0417	0.0000605	0.0001376	0.9173158	0.22810
126.0	0.0005228	232.2775	504.7288	0.0410	0.0000605	0.0001376	0.9323171	0.22810
132.0	0.0003421	236.0972	520.0690	0.0404	0.0000605	0.0001376	0.9471983	0.22810
138.0	0.0001781	239.8670	535.2087	0.0397	0.0000605	0.0001376	0.9618850	0.22810
144.0	0.0000000	243.4583	549.6317	0.0392	0.0000605	0.0001376	0.9758765	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 214
assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0046022	158.0000	200.0000	0.0600	0.0000605	0.0001376	0.6370498	0.22810
6.0	0.0043837	160.3742	209.8513	0.0591	0.0000605	0.0001376	0.6467042	0.22810
12.0	0.0041681	162.9898	220.7047	0.0581	0.0000605	0.0001376	0.6573407	0.22810
18.0	0.0039449	165.8750	232.6762	0.0571	0.0000605	0.0001376	0.6690730	0.22810
24.0	0.0037356	168.9841	245.5771	0.0561	0.0000605	0.0001376	0.6817162	0.22810
30.0	0.0035295	172.2710	259.2156	0.0550	0.0000605	0.0001376	0.6950821	0.22810
36.0	0.0033153	175.6982	273.4364	0.0539	0.0000605	0.0001376	0.7090188	0.22810
42.0	0.0031156	179.2355	288.1140	0.0528	0.0000605	0.0001376	0.7234031	0.22810
48.0	0.0029070	182.8631	303.1277	0.0518	0.0000605	0.0001376	0.7380497	0.22810
54.0	0.0027133	186.5665	318.3053	0.0508	0.0000605	0.0001376	0.7525992	0.22810
60.0	0.0025224	190.3206	333.6910	0.0498	0.0000605	0.0001376	0.7673482	0.22810
66.0	0.0023216	194.1124	349.2313	0.0489	0.0000605	0.0001376	0.7822453	0.22810
72.0	0.0021360	197.9309	364.8805	0.0479	0.0000605	0.0001376	0.7972469	0.22810
78.0	0.0019529	201.7662	380.5991	0.0471	0.0000605	0.0001376	0.8123149	0.22810
84.0	0.0017588	205.6116	396.3592	0.0462	0.0000605	0.0001376	0.8274228	0.22810
90.0	0.0015804	209.4721	412.0818	0.0454	0.0000605	0.0001376	0.8426101	0.22810
96.0	0.0014040	213.3351	427.7850	0.0446	0.0000605	0.0001376	0.8578135	0.22810
102.0	0.0012157	217.1941	443.4719	0.0438	0.0000605	0.0001376	0.8730010	0.22810
108.0	0.0010434	221.0458	459.1295	0.0430	0.0000605	0.0001376	0.8881602	0.22810
114.0	0.0008584	224.8881	474.7486	0.0423	0.0000605	0.0001376	0.9032821	0.22810
120.0	0.0006896	228.7200	490.3250	0.0416	0.0000605	0.0001376	0.9183628	0.22810
126.0	0.0005225	232.5470	505.8113	0.0410	0.0000605	0.0001376	0.9333671	0.22810
132.0	0.0003419	236.3682	521.1576	0.0403	0.0000605	0.0001376	0.9482543	0.22810
138.0	0.0001780	240.1399	536.3047	0.0397	0.0000605	0.0001376	0.9629482	0.22810
144.0	0.0000000	243.7407	550.7658	0.0391	0.0000605	0.0001376	0.9769766	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 215

assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0046005	158.0000	200.0000	0.0600	0.0000605	0.0001376	0.6370498	0.22810
6.0	0.0043820	160.3831	209.8884	0.0591	0.0000605	0.0001376	0.6467406	0.22810
12.0	0.0041665	163.0159	220.8127	0.0581	0.0000605	0.0001376	0.6574466	0.22810
18.0	0.0039433	165.9204	232.8646	0.0571	0.0000605	0.0001376	0.6692576	0.22810
24.0	0.0037341	169.0479	245.8420	0.0560	0.0000605	0.0001376	0.6819757	0.22810
30.0	0.0035281	172.3509	259.5475	0.0550	0.0000605	0.0001376	0.6954073	0.22810
36.0	0.0033139	175.7917	273.8246	0.0539	0.0000605	0.0001376	0.7093992	0.22810
42.0	0.0031143	179.3402	288.5486	0.0528	0.0000605	0.0001376	0.7238290	0.22810
48.0	0.0029058	182.9778	303.5977	0.0518	0.0000605	0.0001376	0.7385003	0.22810
54.0	0.0027122	186.6885	318.8051	0.0508	0.0000605	0.0001376	0.7530784	0.22810
60.0	0.0025214	190.4488	334.2163	0.0498	0.0000605	0.0001376	0.7678517	0.22810
66.0	0.0023207	194.2459	349.7781	0.0488	0.0000605	0.0001376	0.7827695	0.22810
72.0	0.0021352	198.0687	365.4454	0.0479	0.0000605	0.0001376	0.7977884	0.22810
78.0	0.0019521	201.9077	381.1790	0.0470	0.0000605	0.0001376	0.8128708	0.22810
84.0	0.0017582	205.7562	396.9516	0.0462	0.0000605	0.0001376	0.8279907	0.22810
90.0	0.0015798	209.6198	412.6821	0.0453	0.0000605	0.0001376	0.8431913	0.22810
96.0	0.0014035	213.4848	428.3935	0.0445	0.0000605	0.0001376	0.8584026	0.22810
102.0	0.0012153	217.3454	444.0868	0.0438	0.0000605	0.0001376	0.8735964	0.22810
108.0	0.0010430	221.1984	459.7496	0.0430	0.0000605	0.0001376	0.8887606	0.22810
114.0	0.0008581	225.0417	475.3726	0.0423	0.0000605	0.0001376	0.9038862	0.22810
120.0	0.0006894	228.8741	490.9516	0.0416	0.0000605	0.0001376	0.9189694	0.22810
126.0	0.0005224	232.7026	506.4362	0.0409	0.0000605	0.0001376	0.9339734	0.22810
132.0	0.0003417	236.5242	521.7840	0.0403	0.0000605	0.0001376	0.9488620	0.22810
138.0	0.0001779	240.2965	536.9339	0.0397	0.0000605	0.0001376	0.9635586	0.22810
144.0	0.0000000	243.9027	551.4166	0.0391	0.0000605	0.0001376	0.9776080	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 216
assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0045995	158.0000	200.0000	0.0600	0.0000605	0.0001376	0.6370498	0.22810
6.0	0.0043810	160.3882	209.9094	0.0591	0.0000605	0.0001376	0.6467612	0.22810
12.0	0.0041655	163.0307	220.8744	0.0581	0.0000605	0.0001376	0.6575070	0.22810
18.0	0.0039423	165.9472	232.9761	0.0571	0.0000605	0.0001376	0.6693669	0.22810
24.0	0.0037331	169.0869	246.0038	0.0560	0.0000605	0.0001376	0.6821343	0.22810
30.0	0.0035272	172.4010	259.7550	0.0549	0.0000605	0.0001376	0.6956108	0.22810
36.0	0.0033130	175.8512	274.0713	0.0539	0.0000605	0.0001376	0.7096409	0.22810
42.0	0.0031134	179.4074	288.8274	0.0528	0.0000605	0.0001376	0.7241022	0.22810
48.0	0.0029051	183.0517	303.9006	0.0517	0.0000605	0.0001376	0.7387907	0.22810
54.0	0.0027115	186.7672	319.1277	0.0507	0.0000605	0.0001376	0.7533876	0.22810
60.0	0.0025207	190.5314	334.5550	0.0498	0.0000605	0.0001376	0.7681764	0.22810
66.0	0.0023201	194.3317	350.1298	0.0488	0.0000605	0.0001376	0.7831066	0.22810
72.0	0.0021346	198.1570	365.8075	0.0479	0.0000605	0.0001376	0.7981355	0.22810
78.0	0.0019517	201.9980	381.5493	0.0470	0.0000605	0.0001376	0.8132258	0.22810
84.0	0.0017577	205.8482	397.3285	0.0461	0.0000605	0.0001376	0.8283519	0.22810
90.0	0.0015794	209.7134	413.0625	0.0453	0.0000605	0.0001376	0.8435595	0.22810
96.0	0.0014032	213.5793	428.7778	0.0445	0.0000605	0.0001376	0.8587746	0.22810
102.0	0.0012150	217.4406	444.4739	0.0437	0.0000605	0.0001376	0.8739711	0.22810
108.0	0.0010428	221.2941	460.1387	0.0430	0.0000605	0.0001376	0.8891373	0.22810
114.0	0.0008579	225.1377	475.7630	0.0423	0.0000605	0.0001376	0.9042643	0.22810
120.0	0.0006892	228.9703	491.3427	0.0416	0.0000605	0.0001376	0.9193480	0.22810
126.0	0.0005223	232.7996	506.8255	0.0409	0.0000605	0.0001376	0.9343510	0.22810
132.0	0.0003417	236.6212	522.1735	0.0403	0.0000605	0.0001376	0.9492398	0.22810
138.0	0.0001779	240.3938	537.3244	0.0397	0.0000605	0.0001376	0.9639375	0.22810
144.0	0.0000000	244.0031	551.8196	0.0391	0.0000605	0.0001376	0.9779989	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 217

assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0045989	158.0000	200.0000	0.0600	0.0000605	0.0001376	0.6370498	0.22810
6.0	0.0043804	160.3908	209.9203	0.0591	0.0000605	0.0001376	0.6467718	0.22810
12.0	0.0041649	163.0386	220.9071	0.0581	0.0000605	0.0001376	0.6575391	0.22810
18.0	0.0039417	165.9618	233.0364	0.0571	0.0000605	0.0001376	0.6694261	0.22810
24.0	0.0037326	169.1084	246.0928	0.0560	0.0000605	0.0001376	0.6822215	0.22810
30.0	0.0035266	172.4288	259.8705	0.0549	0.0000605	0.0001376	0.6957239	0.22810
36.0	0.0033125	175.8845	274.2095	0.0539	0.0000605	0.0001376	0.7097764	0.22810
42.0	0.0031130	179.4452	288.9844	0.0528	0.0000605	0.0001376	0.7242561	0.22810
48.0	0.0029046	183.0934	304.0714	0.0517	0.0000605	0.0001376	0.7389545	0.22810
54.0	0.0027111	186.8116	319.3097	0.0507	0.0000605	0.0001376	0.7535621	0.22810
60.0	0.0025204	190.5780	334.7458	0.0497	0.0000605	0.0001376	0.7683593	0.22810
66.0	0.0023198	194.3799	350.3275	0.0488	0.0000605	0.0001376	0.7832962	0.22810
72.0	0.0021344	198.2066	366.0106	0.0479	0.0000605	0.0001376	0.7983302	0.22810
78.0	0.0019514	202.0486	381.7565	0.0470	0.0000605	0.0001376	0.8134244	0.22810
84.0	0.0017575	205.8994	397.5387	0.0461	0.0000605	0.0001376	0.8285534	0.22810
90.0	0.0015792	209.7654	413.2740	0.0453	0.0000605	0.0001376	0.8437644	0.22810
96.0	0.0014030	213.6318	428.9910	0.0445	0.0000605	0.0001376	0.8589811	0.22810
102.0	0.0012148	217.4933	444.6882	0.0437	0.0000605	0.0001376	0.8741786	0.22810
108.0	0.0010427	221.3470	460.3538	0.0430	0.0000605	0.0001376	0.8893455	0.22810
114.0	0.0008578	225.1907	475.9785	0.0423	0.0000605	0.0001376	0.9044729	0.22810
120.0	0.0006892	229.0233	491.5582	0.0416	0.0000605	0.0001376	0.9195567	0.22810
126.0	0.0005222	232.8529	507.0398	0.0409	0.0000605	0.0001376	0.9345589	0.22810
132.0	0.0003416	236.6745	522.3876	0.0403	0.0000605	0.0001376	0.9494476	0.22810
138.0	0.0001779	240.4472	537.5390	0.0396	0.0000605	0.0001376	0.9641456	0.22810
144.0	0.0000000	244.0581	552.0407	0.0391	0.0000605	0.0001376	0.9782134	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 218
assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0045987	158.0000	200.0000	0.0600	0.0000605	0.0001376	0.6370498	0.22810
6.0	0.0043803	160.3913	209.9226	0.0591	0.0000605	0.0001376	0.6467741	0.22810
12.0	0.0041648	163.0407	220.9156	0.0581	0.0000605	0.0001376	0.6575475	0.22810
18.0	0.0039416	165.9657	233.0526	0.0571	0.0000605	0.0001376	0.6694419	0.22810
24.0	0.0037324	169.1141	246.1165	0.0560	0.0000605	0.0001376	0.6822447	0.22810
30.0	0.0035265	172.4361	259.9007	0.0549	0.0000605	0.0001376	0.6957536	0.22810
36.0	0.0033124	175.8930	274.2450	0.0538	0.0000605	0.0001376	0.7098112	0.22810
42.0	0.0031129	179.4547	289.0237	0.0528	0.0000605	0.0001376	0.7242946	0.22810
48.0	0.0029045	183.1036	304.1132	0.0517	0.0000605	0.0001376	0.7389945	0.22810
54.0	0.0027110	186.8222	319.3532	0.0507	0.0000605	0.0001376	0.7536037	0.22810
60.0	0.0025203	190.5889	334.7905	0.0497	0.0000605	0.0001376	0.7684022	0.22810
66.0	0.0023197	194.3910	350.3731	0.0488	0.0000605	0.0001376	0.7833399	0.22810
72.0	0.0021343	198.2179	366.0568	0.0479	0.0000605	0.0001376	0.7983745	0.22810
78.0	0.0019514	202.0600	381.8032	0.0470	0.0000605	0.0001376	0.8134692	0.22810
84.0	0.0017575	205.9110	397.5859	0.0461	0.0000605	0.0001376	0.8285987	0.22810
90.0	0.0015791	209.7771	413.3214	0.0453	0.0000605	0.0001376	0.8438103	0.22810
96.0	0.0014030	213.6436	429.0389	0.0445	0.0000605	0.0001376	0.8590274	0.22810
102.0	0.0012148	217.5052	444.7365	0.0437	0.0000605	0.0001376	0.8742253	0.22810
108.0	0.0010426	221.3590	460.4025	0.0430	0.0000605	0.0001376	0.8893927	0.22810
114.0	0.0008577	225.2028	476.0276	0.0423	0.0000605	0.0001376	0.9045204	0.22810
120.0	0.0006891	229.0355	491.6077	0.0416	0.0000605	0.0001376	0.9196046	0.22810
126.0	0.0005222	232.8653	507.0895	0.0409	0.0000605	0.0001376	0.9346071	0.22810
132.0	0.0003416	236.6870	522.4377	0.0403	0.0000605	0.0001376	0.9494961	0.22810
138.0	0.0001779	240.4598	537.5896	0.0396	0.0000605	0.0001376	0.9641947	0.22810
144.0	0.0000000	244.0714	552.0938	0.0391	0.0000605	0.0001376	0.9782649	0.22810

slab temperature summary time = 0.0000 seconds
(assembly no. - channel no.)

axial zone (inches)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
0.0 - 6.0	229.5280	229.5206	239.9246	239.9337	229.5305	229.5360	239.9498	239.9447	211.5967	211.1027
6.0 - 12.0	245.3897	245.3753	267.5076	267.5289	245.3948	245.4054	267.5659	267.5535	219.4828	218.4421
12.0 - 18.0	266.4127	266.3868	300.6395	300.6798	266.4217	266.4412	300.7489	300.7242	229.2418	227.3432
18.0 - 24.0	289.4494	289.4089	335.4198	335.4834	289.4627	289.4939	335.5912	335.5502	239.8415	236.8162
24.0 - 30.0	313.5123	313.4557	371.0447	371.1333	313.5298	313.5744	371.2822	371.2227	251.0321	246.6314
30.0 - 36.0	338.1917	338.1189	407.0681	407.1807	338.2125	338.2709	407.3686	407.2901	262.7091	256.7073
36.0 - 42.0	363.2338	363.1461	443.1398	443.2737	363.2567	363.3284	443.4963	443.4001	274.8048	267.0049
42.0 - 48.0	388.4955	388.3948	479.1612	479.3127	388.5195	388.6031	479.5634	479.4517	287.2616	277.5028
48.0 - 54.0	413.8204	413.7095	514.8843	515.0483	413.8445	413.9380	515.3190	515.1954	300.0068	288.1842
54.0 - 60.0	439.1161	438.9976	550.1741	550.3467	439.1392	439.2405	550.6319	550.4993	312.9677	299.0195
60.0 - 66.0	464.3675	464.2438	585.1152	585.2925	464.3892	464.4961	585.5855	585.4471	326.1610	309.9746
66.0 - 72.0	489.5072	489.3807	619.5573	619.7353	489.5269	489.6375	620.0297	619.8888	339.5860	321.0970
72.0 - 78.0	514.4735	514.3463	653.4874	653.6639	514.4911	514.6033	653.9568	653.8155	353.2192	332.4189
78.0 - 84.0	539.2795	539.1531	687.0132	687.1860	539.2949	539.4074	687.4733	687.3335	367.0366	343.9485
84.0 - 90.0	563.8701	563.7458	720.0061	720.1731	563.8833	563.9947	720.4513	720.3151	381.0108	355.6908
90.0 - 96.0	588.2188	588.0977	752.4945	752.6554	588.2300	588.3393	752.9243	752.7922	395.1118	367.6488
96.0 -102.0	612.3678	612.2502	784.6134	784.7676	612.3772	612.4839	785.0257	784.8983	409.3130	379.8224
102.0 -108.0	636.2914	636.1780	816.2568	816.4033	636.2990	636.4025	816.6488	816.5272	423.5998	392.2040
108.0 -114.0	659.9631	659.8541	847.4206	847.5599	659.9692	660.0691	847.7941	847.6779	437.9879	404.7763
114.0 -120.0	683.4015	683.2969	878.2518	878.3843	683.4064	683.5027	878.6070	878.4963	452.4708	417.5257
120.0 -126.0	706.5214	706.4215	908.6563	908.7813	706.5253	706.6175	908.9912	908.8865	467.0244	430.4808
126.0 -132.0	729.0514	728.9561	938.4794	938.5975	729.0545	729.1428	938.7963	938.6971	481.5728	443.5843
132.0 -138.0	750.1753	750.0840	967.7006	967.8128	750.1779	750.2627	968.0015	967.9072	495.7931	456.5053
138.0 -144.0	766.6734	766.5854	994.0220	994.1286	766.6756	766.7575	994.3075	994.2177	507.9483	467.5100

slab temperature summary time = 0.0000 seconds
(assembly no. - channel no.)

axial zone (inches)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
0.0 - 6.0	211.1304	211.1276	211.0970	211.5919	211.5899	211.0999	211.1334	211.1350	211.1044	211.5957
6.0 - 12.0	218.4070	218.4009	218.4299	219.4727	219.4683	218.4361	218.4132	218.4168	218.4458	219.4805
12.0 - 18.0	227.2317	227.2208	227.3217	229.2236	229.2157	227.3328	227.2425	227.2493	227.3503	229.2375
18.0 - 24.0	236.6006	236.5839	236.7836	239.8135	239.8017	236.8009	236.6167	236.6276	236.8276	239.8348
24.0 - 30.0	246.2751	246.2519	246.5871	250.9934	250.9779	246.6112	246.2965	246.3121	246.6479	251.0231
30.0 - 36.0	256.1685	256.1388	256.6513	262.6595	262.6406	256.6824	256.1952	256.2158	256.7292	262.6979
36.0 - 42.0	266.2397	266.2035	266.9378	274.7446	274.7231	266.9758	266.2712	266.2969	267.0324	274.7918
42.0 - 48.0	276.4674	276.4252	277.4254	287.1915	287.1681	277.4703	276.5034	276.5341	277.5360	287.2474
48.0 - 54.0	286.8384	286.7908	288.0978	299.9280	299.9037	288.1492	286.8785	286.9138	288.2230	299.9921
54.0 - 60.0	297.3310	297.2787	298.9256	312.8815	312.8569	298.9827	297.3746	297.4140	299.0635	312.9529
60.0 - 66.0	307.9104	307.8541	309.8743	326.0681	326.0437	309.9366	307.9571	308.0000	310.0234	326.1465
66.0 - 72.0	318.6167	318.5568	320.9908	339.4875	339.4637	321.0583	318.6665	318.7128	321.1506	339.5722
72.0 - 78.0	329.4959	329.4329	332.3078	353.1161	353.0934	332.3801	329.5487	329.5979	332.4771	353.2064
78.0 - 84.0	340.5638	340.4982	343.8335	366.9301	366.9088	343.9102	340.6193	340.6710	344.0110	367.0251
84.0 - 90.0	351.8324	351.7647	355.5728	380.9020	380.8825	355.6535	351.8905	351.9442	355.7573	381.0010
90.0 - 96.0	363.3126	363.2433	367.5287	395.0016	394.9841	367.6131	363.3731	363.4286	367.7191	395.1038
96.0 -102.0	375.0126	374.9423	379.7009	409.2024	409.1872	379.7887	375.0756	375.1323	379.8962	409.3070
102.0 -108.0	386.9351	386.8641	392.0820	423.4892	423.4761	392.1726	387.0002	387.0577	392.2808	423.5957
108.0 -114.0	399.0674	398.9963	404.6545	437.8778	437.8670	404.7474	399.1345	399.1924	404.8557	437.9858
114.0 -120.0	411.3828	411.3120	417.4044	452.3617	452.3531	417.4995	411.4517	411.5097	417.6076	452.4707
120.0 -126.0	423.9110	423.8403	430.3602	466.9167	466.9104	430.4575	423.9819	424.0400	430.5652	467.0264
126.0 -132.0	436.6085	436.5383	443.4647	481.4668	481.4629	443.5640	436.6814	436.7395	443.6709	481.5769
132.0 -138.0	449.1421	449.0724	456.3871	495.6891	495.6875	456.4882	449.2169	449.2747	456.5941	495.7993
138.0 -144.0	459.7821	459.7129	467.3930	507.8461	507.8466	467.4957	459.8587	459.9161	467.6007	507.9564

slab temperature summary time = 0.0000 seconds
(assembly no. - channel no.)

axial zone (inches)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(
0.0 - 6.0	215.1134	215.1105	231.8212	231.8145	231.8308	231.8267	215.1139	215.1110	
6.0 - 12.0	226.9620	226.9553	259.8799	259.8611	259.9081	259.8965	226.9615	226.9545	
12.0 - 18.0	240.7539	240.7413	290.5471	290.5098	290.6029	290.5789	240.7528	240.7396	
18.0 - 24.0	255.6110	255.5910	322.5199	322.4598	322.6092	322.5686	255.6100	255.5891	
24.0 - 30.0	271.1590	271.1305	355.4186	355.3332	355.5438	355.4840	271.1585	271.1290	
30.0 - 36.0	287.1876	287.1504	388.9469	388.8366	389.1066	389.0268	287.1881	287.1498	
36.0 - 42.0	303.5482	303.5028	422.7877	422.6550	422.9778	422.8790	303.5499	303.5033	
42.0 - 48.0	320.1252	320.0726	456.8608	456.7088	457.0765	456.9605	320.1283	320.0742	
48.0 - 54.0	336.7589	336.7000	490.9573	490.7906	491.1920	491.0623	336.7630	336.7025	
54.0 - 60.0	353.4591	353.3953	524.8699	524.6932	525.1174	524.9774	353.4638	353.3981	
60.0 - 66.0	370.1962	370.1285	558.6989	558.5153	558.9547	558.8071	370.2012	370.1313	
66.0 - 72.0	386.9279	386.8576	592.3063	592.1202	592.5650	592.4135	386.9328	386.8599	
72.0 - 78.0	403.6180	403.5461	625.5520	625.3667	625.8092	625.6567	403.6226	403.5477	
78.0 - 84.0	420.2530	420.1803	658.5842	658.4013	658.8379	658.6860	420.2571	420.1812	
84.0 - 90.0	436.7764	436.7038	691.2752	691.0971	691.5221	691.3733	436.7800	436.7040	
90.0 - 96.0	453.1848	453.1129	723.5443	723.3724	723.7827	723.6381	453.1879	453.1123	
96.0 -102.0	469.4976	469.4268	755.5604	755.3948	755.7904	755.6504	469.5003	469.4256	
102.0 -108.0	485.7074	485.6379	787.2269	787.0689	787.4469	787.3127	485.7096	485.6361	
108.0 -114.0	501.8081	501.7403	818.4645	818.3142	818.6740	818.5459	501.8098	501.7379	
114.0 -120.0	517.8038	517.7379	849.4152	849.2718	849.6154	849.4929	517.8053	517.7351	
120.0 -126.0	533.6556	533.5918	880.0157	879.8802	880.2054	880.0894	533.6569	533.5889	
126.0 -132.0	549.2814	549.2197	910.0729	909.9450	910.2525	910.1428	549.2827	549.2167	
132.0 -138.0	564.4970	564.4372	939.5636	939.4419	939.7349	939.6304	564.4986	564.4345	
138.0 -144.0	578.3877	578.3297	967.6608	967.5457	967.8235	967.7246	578.3897	578.3275	

calculated rod temperatures at time = 0.0000 seconds
rod no. 1
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	2.2	229.4	250.7
6.0 - 12.0	0.0000	1	2.3	259.5	281.6
12.0 - 18.0	0.0001	1	2.3	291.2	314.0
18.0 - 24.0	0.0001	1	2.3	324.1	347.3
24.0 - 30.0	0.0001	1	2.4	358.0	381.4
30.0 - 36.0	0.0001	1	2.4	392.6	416.0
36.0 - 42.0	0.0001	1	2.4	427.4	450.8
42.0 - 48.0	0.0001	1	2.5	462.5	485.6
48.0 - 54.0	0.0001	1	2.5	497.4	520.3
54.0 - 60.0	0.0001	1	2.5	532.1	554.7
60.0 - 66.0	0.0001	1	2.6	566.6	588.8
66.0 - 72.0	0.0001	1	2.6	600.7	622.6
72.0 - 78.0	0.0001	1	2.6	634.4	655.9
78.0 - 84.0	0.0001	1	2.7	667.7	688.9
84.0 - 90.0	0.0001	1	2.7	700.7	721.4
90.0 - 96.0	0.0001	1	2.7	733.1	753.4
96.0 - 102.0	0.0001	1	2.7	765.2	785.2
102.0 - 108.0	0.0001	1	2.8	796.9	816.5
108.0 - 114.0	0.0001	1	2.8	828.1	847.4
114.0 - 120.0	0.0001	1	2.8	859.0	877.9
120.0 - 126.0	0.0001	1	2.9	889.6	908.1
126.0 - 132.0	0.0001	1	2.9	919.6	937.7
132.0 - 138.0	0.0001	1	2.9	949.0	966.9
138.0 - 144.0	0.0001	1	2.9	977.3	994.6

calculated rod temperatures at time = 0.0000 seconds
rod no. 2
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	2.3	233.1	253.0
6.0 - 12.0	0.0000	1	2.3	265.4	285.5
12.0 - 18.0	0.0000	1	2.4	298.1	318.4
18.0 - 24.0	0.0000	1	2.4	331.3	351.8
24.0 - 30.0	0.0001	1	2.4	365.0	385.7
30.0 - 36.0	0.0001	1	2.5	399.3	420.0
36.0 - 42.0	0.0001	1	2.5	433.7	454.4
42.0 - 48.0	0.0001	1	2.6	468.2	488.9
48.0 - 54.0	0.0001	1	2.6	502.7	523.2
54.0 - 60.0	0.0001	1	2.6	536.9	557.2
60.0 - 66.0	0.0001	1	2.7	571.0	591.0
66.0 - 72.0	0.0001	1	2.7	604.7	624.5
72.0 - 78.0	0.0001	1	2.7	638.0	657.5
78.0 - 84.0	0.0001	1	2.8	671.0	690.3
84.0 - 90.0	0.0001	1	2.8	703.7	722.7
90.0 - 96.0	0.0001	1	2.8	735.8	754.5
96.0 - 102.0	0.0001	1	2.8	767.7	786.1
102.0 - 108.0	0.0001	1	2.9	799.2	817.3
108.0 - 114.0	0.0001	1	2.9	830.3	848.1
114.0 - 120.0	0.0001	1	2.9	861.0	878.5
120.0 - 126.0	0.0001	1	3.0	891.4	908.6
126.0 - 132.0	0.0001	1	3.0	921.2	938.2
132.0 - 138.0	0.0001	1	3.0	950.6	967.3
138.0 - 144.0	0.0000	1	3.0	979.0	995.1

calculated rod temperatures at time = 0.0000 seconds
rod no. 3
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	2.3	233.9	254.1
6.0 - 12.0	0.0000	1	2.3	267.2	287.6
12.0 - 18.0	0.0000	1	2.4	300.6	321.2
18.0 - 24.0	0.0001	1	2.4	334.1	354.9
24.0 - 30.0	0.0001	1	2.5	368.1	388.9
30.0 - 36.0	0.0001	1	2.5	402.3	423.2
36.0 - 42.0	0.0001	1	2.5	436.6	457.4
42.0 - 48.0	0.0001	1	2.6	471.0	491.7
48.0 - 54.0	0.0001	1	2.6	505.3	525.8
54.0 - 60.0	0.0001	1	2.6	539.3	559.7
60.0 - 66.0	0.0001	1	2.7	573.2	593.3
66.0 - 72.0	0.0001	1	2.7	606.7	626.5
72.0 - 78.0	0.0001	1	2.7	639.8	659.4
78.0 - 84.0	0.0001	1	2.8	672.7	692.0
84.0 - 90.0	0.0001	1	2.8	705.2	724.2
90.0 - 96.0	0.0001	1	2.8	737.2	755.9
96.0 - 102.0	0.0001	1	2.9	769.0	787.4
102.0 - 108.0	0.0001	1	2.9	800.4	818.5
108.0 - 114.0	0.0001	1	2.9	831.3	849.1
114.0 - 120.0	0.0001	1	2.9	862.0	879.5
120.0 - 126.0	0.0001	1	3.0	892.3	909.5

126.0 - 132.0	0.0001	1	3.0	922.1	939.0
132.0 - 138.0	0.0001	1	3.0	951.4	968.1
138.0 - 144.0	0.0000	1	3.0	979.8	996.0

calculated rod temperatures at time = 0.0000 seconds
rod no. 4
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	2.3	234.3	254.6
6.0 - 12.0	0.0000	1	2.3	268.1	288.7
12.0 - 18.0	0.0000	1	2.4	302.0	322.8
18.0 - 24.0	0.0001	1	2.4	335.9	356.9
24.0 - 30.0	0.0001	1	2.5	370.1	391.2
30.0 - 36.0	0.0001	1	2.5	404.4	425.5
36.0 - 42.0	0.0001	1	2.5	438.7	459.8
42.0 - 48.0	0.0001	1	2.6	473.1	494.0
48.0 - 54.0	0.0001	1	2.6	507.3	528.0
54.0 - 60.0	0.0001	1	2.6	541.2	561.6
60.0 - 66.0	0.0001	1	2.7	574.9	595.1
66.0 - 72.0	0.0001	1	2.7	608.3	628.2
72.0 - 78.0	0.0001	1	2.7	641.3	661.0
78.0 - 84.0	0.0001	1	2.8	674.0	693.4
84.0 - 90.0	0.0001	1	2.8	706.4	725.5
90.0 - 96.0	0.0001	1	2.8	738.4	757.1
96.0 - 102.0	0.0001	1	2.9	770.0	788.5
102.0 - 108.0	0.0001	1	2.9	801.3	819.5
108.0 - 114.0	0.0001	1	2.9	832.2	850.1
114.0 - 120.0	0.0001	1	2.9	862.8	880.4
120.0 - 126.0	0.0001	1	3.0	893.1	910.3
126.0 - 132.0	0.0001	1	3.0	922.8	939.8
132.0 - 138.0	0.0001	1	3.0	952.1	968.8
138.0 - 144.0	0.0000	1	3.0	980.5	996.8

calculated rod temperatures at time = 0.0000 seconds
rod no. 5
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	2.3	234.4	254.8
6.0 - 12.0	0.0000	1	2.3	268.6	289.4
12.0 - 18.0	0.0001	1	2.4	302.8	323.9
18.0 - 24.0	0.0001	1	2.4	337.0	358.3
24.0 - 30.0	0.0001	1	2.5	371.4	392.7
30.0 - 36.0	0.0001	1	2.5	405.9	427.2
36.0 - 42.0	0.0001	1	2.5	440.3	461.5
42.0 - 48.0	0.0001	1	2.6	474.6	495.7
48.0 - 54.0	0.0001	1	2.6	508.7	529.6
54.0 - 60.0	0.0001	1	2.6	542.6	563.2
60.0 - 66.0	0.0001	1	2.7	576.2	596.6
66.0 - 72.0	0.0001	1	2.7	609.5	629.5
72.0 - 78.0	0.0001	1	2.7	642.4	662.2
78.0 - 84.0	0.0001	1	2.8	675.1	694.6
84.0 - 90.0	0.0001	1	2.8	707.3	726.5
90.0 - 96.0	0.0001	1	2.8	739.2	758.1
96.0 - 102.0	0.0001	1	2.9	770.8	789.4

102.0 - 108.0	0.0001	1	2.9	802.1	820.3
108.0 - 114.0	0.0001	1	2.9	832.9	850.8
114.0 - 120.0	0.0001	1	2.9	863.4	881.1
120.0 - 126.0	0.0001	1	3.0	893.6	911.0
126.0 - 132.0	0.0001	1	3.0	923.3	940.4
132.0 - 138.0	0.0001	1	3.0	952.6	969.4
138.0 - 144.0	0.0000	1	3.0	981.0	997.4

calculated rod temperatures at time = 0.0000 seconds
rod no. 6
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) * fluid	clad
0.0 - 6.0	0.0000	1	2.3	234.5	255.0
6.0 - 12.0	0.0000	1	2.4	268.8	289.8
12.0 - 18.0	0.0001	1	2.4	303.2	324.5
18.0 - 24.0	0.0001	1	2.4	337.7	359.1
24.0 - 30.0	0.0001	1	2.5	372.2	393.8
30.0 - 36.0	0.0001	1	2.5	406.8	428.3
36.0 - 42.0	0.0001	1	2.5	441.2	462.6
42.0 - 48.0	0.0001	1	2.6	475.6	496.8
48.0 - 54.0	0.0001	1	2.6	509.7	530.7
54.0 - 60.0	0.0001	1	2.6	543.5	564.2
60.0 - 66.0	0.0001	1	2.7	577.1	597.5
66.0 - 72.0	0.0001	1	2.7	610.3	630.5
72.0 - 78.0	0.0001	1	2.7	643.1	663.0
78.0 - 84.0	0.0001	1	2.8	675.7	695.4
84.0 - 90.0	0.0001	1	2.8	708.0	727.3
90.0 - 96.0	0.0001	1	2.8	739.8	758.8
96.0 - 102.0	0.0001	1	2.9	771.4	790.0
102.0 - 108.0	0.0001	1	2.9	802.6	820.9
108.0 - 114.0	0.0001	1	2.9	833.3	851.4
114.0 - 120.0	0.0001	1	2.9	863.8	881.6
120.0 - 126.0	0.0001	1	3.0	894.0	911.5
126.0 - 132.0	0.0001	1	3.0	923.7	940.8
132.0 - 138.0	0.0001	1	3.0	952.9	969.8
138.0 - 144.0	0.0000	1	3.0	981.3	997.8

calculated rod temperatures at time = 0.0000 seconds
rod no. 7
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) * fluid	clad
0.0 - 6.0	0.0000	1	2.3	234.6	255.1
6.0 - 12.0	0.0000	1	2.4	269.0	289.9
12.0 - 18.0	0.0001	1	2.4	303.5	324.8
18.0 - 24.0	0.0001	1	2.4	338.0	359.5
24.0 - 30.0	0.0001	1	2.5	372.7	394.2
30.0 - 36.0	0.0001	1	2.5	407.3	428.8
36.0 - 42.0	0.0001	1	2.5	441.7	463.2
42.0 - 48.0	0.0001	1	2.6	476.1	497.4
48.0 - 54.0	0.0001	1	2.6	510.2	531.2
54.0 - 60.0	0.0001	1	2.6	543.9	564.7
60.0 - 66.0	0.0001	1	2.7	577.5	598.0
66.0 - 72.0	0.0001	1	2.7	610.7	630.9
72.0 - 78.0	0.0001	1	2.7	643.5	663.4

78.0 - 84.0	0.0001	1	2.8	676.1	695.7
84.0 - 90.0	0.0001	1	2.8	708.3	727.6
90.0 - 96.0	0.0001	1	2.8	740.1	759.1
96.0 - 102.0	0.0001	1	2.9	771.6	790.3
102.0 - 108.0	0.0001	1	2.9	802.8	821.1
108.0 - 114.0	0.0001	1	2.9	833.6	851.6
114.0 - 120.0	0.0001	1	2.9	864.1	881.8
120.0 - 126.0	0.0001	1	3.0	894.2	911.7
126.0 - 132.0	0.0001	1	3.0	923.9	941.0
132.0 - 138.0	0.0001	1	3.0	953.1	970.0
138.0 - 144.0	0.0000	1	3.0	981.5	998.0

calculated rod temperatures at time = 0.0000 seconds
rod no. 8
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	2.3	234.6	255.0
6.0 - 12.0	0.0000	1	2.4	269.0	289.9
12.0 - 18.0	0.0001	1	2.4	303.5	324.8
18.0 - 24.0	0.0001	1	2.4	338.0	359.5
24.0 - 30.0	0.0001	1	2.5	372.6	394.2
30.0 - 36.0	0.0001	1	2.5	407.2	428.7
36.0 - 42.0	0.0001	1	2.5	441.7	463.1
42.0 - 48.0	0.0001	1	2.6	476.0	497.3
48.0 - 54.0	0.0001	1	2.6	510.1	531.2
54.0 - 60.0	0.0001	1	2.6	543.9	564.7
60.0 - 66.0	0.0001	1	2.7	577.4	597.9
66.0 - 72.0	0.0001	1	2.7	610.6	630.8
72.0 - 78.0	0.0001	1	2.7	643.5	663.4
78.0 - 84.0	0.0001	1	2.8	676.0	695.7
84.0 - 90.0	0.0001	1	2.8	708.2	727.5
90.0 - 96.0	0.0001	1	2.8	740.0	759.0
96.0 - 102.0	0.0001	1	2.9	771.6	790.3
102.0 - 108.0	0.0001	1	2.9	802.8	821.1
108.0 - 114.0	0.0001	1	2.9	833.5	851.6
114.0 - 120.0	0.0001	1	2.9	864.0	881.8
120.0 - 126.0	0.0001	1	3.0	894.2	911.6
126.0 - 132.0	0.0001	1	3.0	923.8	941.0
132.0 - 138.0	0.0001	1	3.0	953.0	969.9
138.0 - 144.0	0.0000	1	3.0	981.5	998.0

calculated rod temperatures at time = 0.0000 seconds
rod no. 183
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	1.9	209.5	214.7
6.0 - 12.0	0.0000	1	1.9	219.3	224.7
12.0 - 18.0	0.0000	1	1.9	230.1	235.6
18.0 - 24.0	0.0000	1	1.9	241.7	247.4
24.0 - 30.0	0.0000	1	1.9	254.1	259.7
30.0 - 36.0	0.0000	1	1.9	267.0	272.7
36.0 - 42.0	0.0000	1	1.9	280.5	286.1
42.0 - 48.0	0.0000	1	1.9	294.3	299.8
48.0 - 54.0	0.0000	1	2.0	308.3	313.8

54.0 - 60.0	0.0000	1	2.0	322.6	328.0
60.0 - 66.0	0.0000	1	2.0	337.1	342.4
66.0 - 72.0	0.0000	1	2.0	351.7	357.0
72.0 - 78.0	0.0000	1	2.0	366.5	371.7
78.0 - 84.0	0.0000	1	2.0	381.5	386.5
84.0 - 90.0	0.0000	1	2.0	396.4	401.4
90.0 - 96.0	0.0000	1	2.0	411.5	416.3
96.0 - 102.0	0.0000	1	2.1	426.5	431.2
102.0 - 108.0	0.0000	1	2.1	441.6	446.2
108.0 - 114.0	0.0000	1	2.1	456.7	461.2
114.0 - 120.0	0.0000	1	2.1	471.8	476.2
120.0 - 126.0	0.0000	1	2.1	486.9	491.2
126.0 - 132.0	0.0000	1	2.1	502.0	506.2
132.0 - 138.0	0.0000	1	2.1	516.8	520.9
138.0 - 144.0	0.0000	1	2.1	530.7	534.7

calculated rod temperatures at time = 0.0000 seconds
rod no. 184
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) * fluid	clad
0.0 - 6.0	0.0000	1	1.9	210.5	215.3
6.0 - 12.0	0.0000	1	2.0	221.1	226.0
12.0 - 18.0	0.0000	1	2.0	232.5	237.3
18.0 - 24.0	0.0000	1	2.0	244.6	249.4
24.0 - 30.0	0.0000	1	2.0	257.4	262.1
30.0 - 36.0	0.0000	1	2.0	270.8	275.3
36.0 - 42.0	0.0000	1	2.0	284.6	289.0
42.0 - 48.0	0.0000	1	2.0	298.7	303.0
48.0 - 54.0	0.0000	1	2.0	313.1	317.2
54.0 - 60.0	0.0000	1	2.0	327.7	331.6
60.0 - 66.0	0.0000	1	2.1	342.6	346.2
66.0 - 72.0	0.0000	1	2.1	357.5	360.9
72.0 - 78.0	0.0000	1	2.1	372.6	375.8
78.0 - 84.0	0.0000	1	2.1	387.8	390.7
84.0 - 90.0	0.0000	1	2.1	403.0	405.7
90.0 - 96.0	0.0000	1	2.1	418.2	420.8
96.0 - 102.0	0.0000	1	2.1	433.5	435.8
102.0 - 108.0	0.0000	1	2.1	448.7	450.9
108.0 - 114.0	0.0000	1	2.2	464.0	465.9
114.0 - 120.0	0.0000	1	2.2	479.3	481.0
120.0 - 126.0	0.0000	1	2.2	494.5	496.0
126.0 - 132.0	0.0000	1	2.2	509.6	511.0
132.0 - 138.0	0.0000	1	2.2	524.6	525.8
138.0 - 144.0	0.0000	1	2.2	538.8	539.8

calculated rod temperatures at time = 0.0000 seconds
rod no. 185
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) * fluid	clad
0.0 - 6.0	0.0000	1	1.9	210.7	215.6
6.0 - 12.0	0.0000	1	2.0	221.7	226.6
12.0 - 18.0	0.0000	1	2.0	233.3	238.2
18.0 - 24.0	0.0000	1	2.0	245.6	250.5
24.0 - 30.0	0.0000	1	2.0	258.6	263.3

30.0 - 36.0	0.0000	1	2.0	272.1	276.7
36.0 - 42.0	0.0000	1	2.0	286.0	290.5
42.0 - 48.0	0.0000	1	2.0	300.3	304.6
48.0 - 54.0	0.0000	1	2.0	314.8	318.9
54.0 - 60.0	0.0000	1	2.0	329.5	333.4
60.0 - 66.0	0.0000	1	2.1	344.4	348.0
66.0 - 72.0	0.0000	1	2.1	359.4	362.9
72.0 - 78.0	0.0000	1	2.1	374.6	377.8
78.0 - 84.0	0.0000	1	2.1	389.8	392.8
84.0 - 90.0	0.0000	1	2.1	405.1	407.9
90.0 - 96.0	0.0000	1	2.1	420.4	422.9
96.0 - 102.0	0.0000	1	2.1	435.6	438.0
102.0 - 108.0	0.0000	1	2.1	450.9	453.1
108.0 - 114.0	0.0000	1	2.2	466.2	468.2
114.0 - 120.0	0.0000	1	2.2	481.5	483.3
120.0 - 126.0	0.0000	1	2.2	496.7	498.3
126.0 - 132.0	0.0000	1	2.2	511.9	513.3
132.0 - 138.0	0.0000	1	2.2	526.8	528.1
138.0 - 144.0	0.0000	1	2.2	541.2	542.2

calculated rod temperatures at time = 0.0000 seconds
rod no. 186
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) * fluid	clad
0.0 - 6.0	0.0000	1	1.9	210.8	215.7
6.0 - 12.0	0.0000	1	2.0	221.9	226.9
12.0 - 18.0	0.0000	1	2.0	233.7	238.7
18.0 - 24.0	0.0000	1	2.0	246.2	251.1
24.0 - 30.0	0.0000	1	2.0	259.2	264.1
30.0 - 36.0	0.0000	1	2.0	272.8	277.5
36.0 - 42.0	0.0000	1	2.0	286.8	291.4
42.0 - 48.0	0.0000	1	2.0	301.2	305.6
48.0 - 54.0	0.0000	1	2.0	315.7	319.9
54.0 - 60.0	0.0000	1	2.0	330.5	334.4
60.0 - 66.0	0.0000	1	2.1	345.4	349.2
66.0 - 72.0	0.0000	1	2.1	360.5	364.0
72.0 - 78.0	0.0000	1	2.1	375.7	379.0
78.0 - 84.0	0.0000	1	2.1	391.0	394.0
84.0 - 90.0	0.0000	1	2.1	406.2	409.1
90.0 - 96.0	0.0000	1	2.1	421.5	424.2
96.0 - 102.0	0.0000	1	2.1	436.8	439.3
102.0 - 108.0	0.0000	1	2.2	452.1	454.4
108.0 - 114.0	0.0000	1	2.2	467.4	469.5
114.0 - 120.0	0.0000	1	2.2	482.7	484.6
120.0 - 126.0	0.0000	1	2.2	497.9	499.6
126.0 - 132.0	0.0000	1	2.2	513.1	514.6
132.0 - 138.0	0.0000	1	2.2	528.0	529.4
138.0 - 144.0	0.0000	1	2.2	542.4	543.6

calculated rod temperatures at time = 0.0000 seconds
rod no. 187
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) * fluid	clad
0.0 - 6.0	0.0000	1	1.9	210.8	215.8

6.0 - 12.0	0.0000	1	2.0	222.0	227.1
12.0 - 18.0	0.0000	1	2.0	233.9	239.0
18.0 - 24.0	0.0000	1	2.0	246.5	251.5
24.0 - 30.0	0.0000	1	2.0	259.6	264.5
30.0 - 36.0	0.0000	1	2.0	273.3	278.1
36.0 - 42.0	0.0000	1	2.0	287.4	292.0
42.0 - 48.0	0.0000	1	2.0	301.8	306.2
48.0 - 54.0	0.0000	1	2.0	316.3	320.6
54.0 - 60.0	0.0000	1	2.0	331.1	335.2
60.0 - 66.0	0.0000	1	2.1	346.1	349.9
66.0 - 72.0	0.0000	1	2.1	361.2	364.8
72.0 - 78.0	0.0000	1	2.1	376.4	379.8
78.0 - 84.0	0.0000	1	2.1	391.7	394.8
84.0 - 90.0	0.0000	1	2.1	406.9	409.9
90.0 - 96.0	0.0000	1	2.1	422.2	425.0
96.0 - 102.0	0.0000	1	2.1	437.5	440.1
102.0 - 108.0	0.0000	1	2.2	452.8	455.2
108.0 - 114.0	0.0000	1	2.2	468.1	470.3
114.0 - 120.0	0.0000	1	2.2	483.4	485.4
120.0 - 126.0	0.0000	1	2.2	498.6	500.4
126.0 - 132.0	0.0000	1	2.2	513.8	515.4
132.0 - 138.0	0.0000	1	2.2	528.8	530.2
138.0 - 144.0	0.0000	1	2.2	543.2	544.4

calculated rod temperatures at time = 0.0000 seconds
rod no. 188
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) * fluid	clad
0.0 - 6.0	0.0000	1	1.9	210.9	215.9
6.0 - 12.0	0.0000	1	2.0	222.1	227.2
12.0 - 18.0	0.0000	1	2.0	234.1	239.1
18.0 - 24.0	0.0000	1	2.0	246.7	251.7
24.0 - 30.0	0.0000	1	2.0	259.9	264.8
30.0 - 36.0	0.0000	1	2.0	273.6	278.4
36.0 - 42.0	0.0000	1	2.0	287.7	292.4
42.0 - 48.0	0.0000	1	2.0	302.1	306.6
48.0 - 54.0	0.0000	1	2.0	316.7	321.0
54.0 - 60.0	0.0000	1	2.0	331.5	335.6
60.0 - 66.0	0.0000	1	2.1	346.5	350.4
66.0 - 72.0	0.0000	1	2.1	361.6	365.3
72.0 - 78.0	0.0000	1	2.1	376.8	380.3
78.0 - 84.0	0.0000	1	2.1	392.1	395.3
84.0 - 90.0	0.0000	1	2.1	407.4	410.4
90.0 - 96.0	0.0000	1	2.1	422.7	425.5
96.0 - 102.0	0.0000	1	2.1	438.0	440.6
102.0 - 108.0	0.0000	1	2.2	453.3	455.7
108.0 - 114.0	0.0000	1	2.2	468.6	470.8
114.0 - 120.0	0.0000	1	2.2	483.8	485.9
120.0 - 126.0	0.0000	1	2.2	499.1	501.0
126.0 - 132.0	0.0000	1	2.2	514.2	515.9
132.0 - 138.0	0.0000	1	2.2	529.2	530.7
138.0 - 144.0	0.0000	1	2.2	543.6	545.0

calculated rod temperatures at time = 0.0000 seconds
rod no. 189
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

* fuel temperatures(f.)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fluid	clad
0.0 - 6.0	0.0000	1	1.9	210.9	215.9
6.0 - 12.0	0.0000	1	2.0	222.2	227.2
12.0 - 18.0	0.0000	1	2.0	234.1	239.2
18.0 - 24.0	0.0000	1	2.0	246.8	251.8
24.0 - 30.0	0.0000	1	2.0	260.0	265.0
30.0 - 36.0	0.0000	1	2.0	273.7	278.6
36.0 - 42.0	0.0000	1	2.0	287.9	292.5
42.0 - 48.0	0.0000	1	2.0	302.3	306.8
48.0 - 54.0	0.0000	1	2.0	316.9	321.2
54.0 - 60.0	0.0000	1	2.0	331.7	335.8
60.0 - 66.0	0.0000	1	2.1	346.7	350.6
66.0 - 72.0	0.0000	1	2.1	361.8	365.5
72.0 - 78.0	0.0000	1	2.1	377.0	380.5
78.0 - 84.0	0.0000	1	2.1	392.3	395.5
84.0 - 90.0	0.0000	1	2.1	407.6	410.6
90.0 - 96.0	0.0000	1	2.1	422.9	425.7
96.0 - 102.0	0.0000	1	2.1	438.2	440.8
102.0 - 108.0	0.0000	1	2.2	453.5	455.9
108.0 - 114.0	0.0000	1	2.2	468.8	471.0
114.0 - 120.0	0.0000	1	2.2	484.0	486.1
120.0 - 126.0	0.0000	1	2.2	499.3	501.2
126.0 - 132.0	0.0000	1	2.2	514.4	516.2
132.0 - 138.0	0.0000	1	2.2	529.4	531.0
138.0 - 144.0	0.0000	1	2.2	543.8	545.2

calculated rod temperatures at time = 0.0000 seconds
rod no. 190
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	1.9	210.9	215.9
6.0 - 12.0	0.0000	1	2.0	222.2	227.2
12.0 - 18.0	0.0000	1	2.0	234.1	239.2
18.0 - 24.0	0.0000	1	2.0	246.8	251.8
24.0 - 30.0	0.0000	1	2.0	260.0	265.0
30.0 - 36.0	0.0000	1	2.0	273.7	278.6
36.0 - 42.0	0.0000	1	2.0	287.9	292.5
42.0 - 48.0	0.0000	1	2.0	302.3	306.8
48.0 - 54.0	0.0000	1	2.0	316.9	321.2
54.0 - 60.0	0.0000	1	2.0	331.7	335.8
60.0 - 66.0	0.0000	1	2.1	346.7	350.6
66.0 - 72.0	0.0000	1	2.1	361.8	365.5
72.0 - 78.0	0.0000	1	2.1	377.0	380.5
78.0 - 84.0	0.0000	1	2.1	392.3	395.5
84.0 - 90.0	0.0000	1	2.1	407.6	410.6
90.0 - 96.0	0.0000	1	2.1	422.8	425.7
96.0 - 102.0	0.0000	1	2.1	438.1	440.8
102.0 - 108.0	0.0000	1	2.2	453.4	455.9
108.0 - 114.0	0.0000	1	2.2	468.7	471.0
114.0 - 120.0	0.0000	1	2.2	484.0	486.1
120.0 - 126.0	0.0000	1	2.2	499.3	501.2
126.0 - 132.0	0.0000	1	2.2	514.4	516.2
132.0 - 138.0	0.0000	1	2.2	529.4	531.0
138.0 - 144.0	0.0000	1	2.2	543.8	545.2

iterations = 11

```
 input transient time completed


 common dumped to tape 8
1***** computational time summary *****


     subroutine energy...................     0.67  sec
     subroutine moment...................     0.28  sec
     subroutine reheat...................     1.63  sec
     subroutine recirc (pressure loop)....    0.50  sec
     subroutine result...................     1.48  sec
     subroutine setup....................     0.49  sec
     other subroutines...................    18.79  sec

     total cpu time......................    23.84  sec
```

```
1
    CCCCC        00000     BBBBBBBBB    RRRRRRRRR       AAAAA
   CCCCCCC      0000000    BBBBBBBBBB   RRRRRRRRRR     AAAAAAA
  CCCCCCCCC    000000000   BBBBBBBBBBB  RRRRRRRRRRR   AAAAAAAAA
 CCCCCCCCCCC  00000000000  BBBB  BBBBB  RRRR  RRRRR  AAAAAAAAAAA
 CCCCC CCCCC  00000 00000  BBBB   BBBB  RRRR   RRRR  AAAAA AAAAA
 CCCC   CCCC  0000   0000  BBBB  BBBB   RRRR  RRRR   AAAA   AAAA
 CCCC         0000   0000  BBBBBBBBB    RRRRRRRRR    AAAA   AAAA
 CCCC         0000   0000  BBBBBBBB     RRRRRRRR     AAAAAAAAAAA
 CCCC         0000   0000  BBBBBBBBB    RRRR RRRR    AAAAAAAAAAA
 CCCC   CCCC  0000   0000  BBBB  BBBB   RRRR  RRRR   AAAAAAAAAAA    FFFFF
 CCCCC CCCCC  0000   0000  BBBB   BBBB  RRRR   RRRR  AAAA   AAAA  FF     FF
 CCCCCCCCCCC  00000 00000  BBBB  BBBBB  RRRR   RRRR  AAAA   AAAA  F       F
  CCCCCCCCC    000000000   BBBBBBBBBBB  RRRR   RRRR  AAAA   AAAA  FFFFFFFFF            FFFFFFFFFFFFF       SSSSSSSSSS
   CCCCCCC      0000000    BBBBBBBBBB   RRRR   RRRR  AAAA   AAAA  FF  F   FSS          FFFFFFFFFFFFF      SSSSSS SSSSS
    CCCCC        00000     BBBBBBBBB    RRRR   RRRR  AAAA   AAAA  FF  F   FSSS         FFFFF F  FFFF     SSSSSSS   SSSS
                                                                  FF  F   FSS S        FFF  F   FFFF     SSSSSSSSS   SS
                                                                 SFF  F   FS  SS       FFF  FF FFFFF    SSSSSSSSSSS SSS
                                                                SSFF  F   FS   SS      FF  FFFFFFFFF    SSS SSSS SSSSSSS
                                                               SSSFF  F   FSSSSSSS     FF  FFFFFFFFF    SSS SSS   SSSSSS
                                                              SSSSFF  F   F SSSSS      FFFFFFF          SS  SSS   SSSSSS
                                                             SSS SFF  F   SSSSSSSSS    FFFFFFF          SSS  SS
                                                            SSS  SFF  F  SS SSSSS SS   FFFFFFF          SSSSSSS
                                                            SSSSSSFF  F SSS  SSS  SSS  FFFFFFF          SSSSSSS
                                                            SSSSSSSF  F SS *  S  * SS  FFFFFFF          SSS SSS
                                                            SSSS SSS  F  S         S   FFFF FFFFFFFF    SS  SSSS
                                                            SSS    SS F   SS     SS   FFFF  FFFFFFF    SSSSSS SS
                                                             SSSSSSSSSS   F SS SS      FFFFF   FFFFF    SS SS  SSS
                                                   S          SSSSSSS SS  F   S        FFFFFF   FFFF     S  SSSSSSS
                                                    SSS         SSSSS   SS F   S        FFFFFF   FFFF      SS  SSSSSS
                                                       S         SSSS    SSS   S        F FFFFFF   FF       SS  SSSSSS
                                                        SS         SSSS    SS           F  FFFFFFFFFF        S SSSSSSSS
                                                      SS           FSSSSSSS SSS         FF FFFFFFFFFF         SSSSSS  SS
                                                     SS            FFSSSSSS   SS        FF  FFF                SSSSSS SSS
                                                     SSSSS         FFSSSSS     SS       FFF FFF                 SSSS  SSSS
                                                       S  SSS      FF SSSSS     SS      FFF FFF                  SSSS  SSS
                                                        SS  SSS    FF  SSSSS     SS     FF   FF                   SSSS SSS
                                                          SS SSS   FF  FSSSSSS   SS     FF   FF                    SSS SSS
                                                             S SSS  FF  F SSSSSS   SS    FF  FFF                     SS  SSS
                                                             S SSS  FF  F  SSSSSS  SS    FFFFFFF           SSSSSS   SSSSSSS
                                                            SS SS   FF  F   SSSSSSSSS    FFFFFFF           SSSSSS   SSSSSSS
                                                         S   SS   SFF  F   FSSSSS SS    FFFFFFF           SSS SSS SSSSSSSS
                                                        SS  SSSSSSSFF  F   FSSSSS SS    FFF FFF            SS  SSSSSSSSSSS
                                                       S   SSSSSSSSFF  F   FSSSSS SS    FF FFFF            SSS  SSSSSSS SSS
                                                       SS     SSSSSFF  F   FSSS  SS     F   FFF             SSS  SSSS   SS
      COBRA-SFS (SPENT FUEL STORAGE) CODE              SSS     SSSFF  F   FSSSSSS       FFF FFF             SSSSSSSSS  SS
 FOR MULTIASSEMBLY SPENT FUEL CASK ANALYSIS                SSSS    FF  F   FSSSSS       FFFFFFF              SSSSSSSSS S
                                                              SSSSFF  F   FSSSS        FFFFFFF               SSSSSSSSS
                                                                  FF  F   F
 WRITTEN AT PACIFIC NORTHWEST LABORATORY 1982-1986                FF  F  FF
 CREATION DATE FOR THIS VERSION (Cycle 3             ) 09-25-97    FFFFFFF

 CONTACT:  T.E. MICHENER (509) 375-2162
           D.R. RECTOR   (509) 372-4530
           J.M. CUTA     (509) 375-3673

 Calculation No. 2013-11284 Rev. 0, May 2015 Case                    date: 11/04/13 time: 14:56:07


data from iterative solution using the recirculation module
time =      0.0000    dt =0.1000E+11
```

KMAYSelected.O

iteration no.	sweep no.	peak clad temp(f)	peak clad level	peak clad rod	peak clad ass.	total flow (lbm/s)	pressure drop(psi)	error total energy	error flow	error fluid energy	error rod energy
1	1	855.6	25	105	1	0.338E-01	0.0049091	-0.0044	1.7862	0.0263	0.0172
2	1	878.6	25	105	1	0.338E-01	0.0049366	0.0000	0.0183	0.0028	0.0032
3	1	875.9	25	105	1	0.338E-01	0.0049385	0.0004	0.0032	0.0007	0.0005
4	1	875.9	25	105	1	0.338E-01	0.0049384	0.0004	0.0008	0.0005	0.0001

cobra-sfs code results
case 1 Calculation No. 2013-11284 Rev. 0, May 2015 Case date: 11/04/13 time: 14:56:08

assembly average results for assembly 1 time = 0.00000

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0049985	162.0970	217.0000	0.0585	0.0132377	0.0001655	0.7862574	41.46493
6.0	0.0047720	169.4425	247.4794	0.0559	0.0132377	0.0001655	0.8221344	41.46493
12.0	0.0045509	176.5898	277.1362	0.0536	0.0132377	0.0001655	0.8569948	41.46493
18.0	0.0043173	183.6586	306.3877	0.0516	0.0132377	0.0001655	0.8910977	41.46493
24.0	0.0041050	190.6682	335.1155	0.0497	0.0132377	0.0001655	0.9242866	41.46493
30.0	0.0038964	197.6244	363.6245	0.0480	0.0132377	0.0001655	0.9571132	41.46493
36.0	0.0036716	204.5262	391.9108	0.0465	0.0132377	0.0001655	0.9897099	41.46493
42.0	0.0034688	211.3741	419.8136	0.0450	0.0132377	0.0001655	1.0220960	41.46493
48.0	0.0032478	218.1696	447.4376	0.0436	0.0132377	0.0001655	1.0542655	41.46493
54.0	0.0030492	224.9122	474.8462	0.0423	0.0132377	0.0001655	1.0861943	41.46493
60.0	0.0028523	231.6017	502.0150	0.0411	0.0132377	0.0001655	1.1177823	41.46493
66.0	0.0026348	238.2406	528.6770	0.0400	0.0132377	0.0001655	1.1489842	41.46493
72.0	0.0024407	244.8304	555.1420	0.0390	0.0132377	0.0001655	1.1798821	41.46493
78.0	0.0022477	251.3703	581.4070	0.0380	0.0132377	0.0001655	1.2105389	41.46493
84.0	0.0020315	257.8610	607.3851	0.0371	0.0132377	0.0001655	1.2407199	41.46493
90.0	0.0018396	264.3050	632.9564	0.0362	0.0132377	0.0001655	1.2704040	41.46493
96.0	0.0016480	270.7028	658.3444	0.0354	0.0132377	0.0001655	1.2997850	41.46493
102.0	0.0014306	277.0539	683.5472	0.0346	0.0132377	0.0001655	1.3289478	41.46493
108.0	0.0012390	283.3592	708.4673	0.0339	0.0132377	0.0001655	1.3577783	41.46493
114.0	0.0010205	289.6213	733.0248	0.0332	0.0132377	0.0001655	1.3862836	41.46493
120.0	0.0008286	295.8406	757.4140	0.0325	0.0132377	0.0001655	1.4145611	41.46493
126.0	0.0006364	302.0165	781.6332	0.0319	0.0132377	0.0001655	1.4426409	41.46493
132.0	0.0004153	308.1444	805.5986	0.0313	0.0132377	0.0001655	1.4703703	41.46493
138.0	0.0002223	314.2100	829.1086	0.0307	0.0132377	0.0001655	1.4976296	41.46493
144.0	0.0000000	320.0770	851.8490	0.0302	0.0132377	0.0001655	1.5239469	41.46493

rod power delivered to the coolant 2.017 btu/sec 0.00213 mw

assembly average results for assembly 2 time = 0.00000

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0049084	162.0970	217.0000	0.0585	0.0102702	0.0001284	0.6100027	41.46493
6.0	0.0046854	164.8533	228.4369	0.0575	0.0102702	0.0001284	0.6204586	41.46493
12.0	0.0044651	167.5379	239.5765	0.0566	0.0102702	0.0001284	0.6306389	41.46493
18.0	0.0042375	170.2369	250.7755	0.0557	0.0102702	0.0001284	0.6408735	41.46493
24.0	0.0040219	172.9632	262.0878	0.0548	0.0102702	0.0001284	0.6512128	41.46493
30.0	0.0038085	175.7217	273.5340	0.0539	0.0102702	0.0001284	0.6616751	41.46493

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36.0	0.0035873	178.5129	285.1159	0.0531	0.0102702	0.0001284	0.6722615	41.46493
42.0	0.0033783	181.3367	296.8329	0.0522	0.0102702	0.0001284	0.6829437	41.46493
48.0	0.0031609	184.1936	308.5802	0.0514	0.0102702	0.0001284	0.6935276	41.46493
54.0	0.0029559	187.0844	320.4279	0.0507	0.0102702	0.0001284	0.7041271	41.46493
60.0	0.0027528	190.0085	332.4121	0.0499	0.0102702	0.0001284	0.7148372	41.46493
66.0	0.0025406	192.9654	344.5302	0.0492	0.0102702	0.0001284	0.7256656	41.46493
72.0	0.0023411	195.9544	356.7805	0.0484	0.0102702	0.0001284	0.7366108	41.46493
78.0	0.0021433	198.9754	369.1616	0.0477	0.0102702	0.0001284	0.7476718	41.46493
84.0	0.0019357	202.0279	381.6719	0.0470	0.0102702	0.0001284	0.7588477	41.46493
90.0	0.0017411	205.1115	394.3096	0.0463	0.0102702	0.0001284	0.7701399	41.46493
96.0	0.0015479	208.2258	407.0153	0.0456	0.0102702	0.0001284	0.7815504	41.46493
102.0	0.0013444	211.3706	419.7990	0.0450	0.0102702	0.0001284	0.7930797	41.46493
108.0	0.0011541	214.5457	432.7060	0.0443	0.0102702	0.0001284	0.8047238	41.46493
114.0	0.0009528	217.7502	445.7325	0.0437	0.0102702	0.0001284	0.8164763	41.46493
120.0	0.0007651	220.9835	458.8761	0.0431	0.0102702	0.0001284	0.8283353	41.46493
126.0	0.0005786	224.2452	472.1350	0.0424	0.0102702	0.0001284	0.8402963	41.46493
132.0	0.0003804	227.5288	485.4830	0.0418	0.0102702	0.0001284	0.8523260	41.46493
138.0	0.0001961	230.8143	498.8386	0.0413	0.0102702	0.0001284	0.8643410	41.46493
144.0	0.0000000	233.9851	511.5869	0.0407	0.0102702	0.0001284	0.8759039	41.46493

rod power delivered to the coolant 0.640 btu/sec 0.00068 mw

assembly average results for assembly 3 time = 0.00000

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0049083	162.0970	217.0000	0.0585	0.0102702	0.0001284	0.6100027	41.46493
6.0	0.0046854	164.8533	228.4371	0.0575	0.0102702	0.0001284	0.6204588	41.46493
12.0	0.0044650	167.5381	239.5771	0.0566	0.0102702	0.0001284	0.6306394	41.46493
18.0	0.0042374	170.2372	250.7766	0.0557	0.0102702	0.0001284	0.6408746	41.46493
24.0	0.0040218	172.9636	262.0897	0.0548	0.0102702	0.0001284	0.6512146	41.46493
30.0	0.0038085	175.7224	273.5370	0.0539	0.0102702	0.0001284	0.6616781	41.46493
36.0	0.0035872	178.5140	285.1202	0.0531	0.0102702	0.0001284	0.6722657	41.46493
42.0	0.0033782	181.3381	296.8388	0.0522	0.0102702	0.0001284	0.6829501	41.46493
48.0	0.0031608	184.1954	308.5878	0.0514	0.0102702	0.0001284	0.6935353	41.46493
54.0	0.0029558	187.0867	320.4375	0.0507	0.0102702	0.0001284	0.7041364	41.46493
60.0	0.0027527	190.0114	332.4239	0.0499	0.0102702	0.0001284	0.7148486	41.46493
66.0	0.0025406	192.9688	344.5444	0.0491	0.0102702	0.0001284	0.7256793	41.46493
72.0	0.0023410	195.9585	356.7970	0.0484	0.0102702	0.0001284	0.7366267	41.46493
78.0	0.0021432	198.9801	369.1807	0.0477	0.0102702	0.0001284	0.7476902	41.46493
84.0	0.0019356	202.0332	381.6935	0.0470	0.0102702	0.0001284	0.7588685	41.46493
90.0	0.0017410	205.1174	394.3337	0.0463	0.0102702	0.0001284	0.7701631	41.46493
96.0	0.0015479	208.2323	407.0418	0.0456	0.0102702	0.0001284	0.7815760	41.46493
102.0	0.0013443	211.3777	419.8281	0.0450	0.0102702	0.0001284	0.7931078	41.46493
108.0	0.0011540	214.5535	432.7377	0.0443	0.0102702	0.0001284	0.8047543	41.46493
114.0	0.0009528	217.7586	445.7667	0.0437	0.0102702	0.0001284	0.8165092	41.46493
120.0	0.0007651	220.9926	458.9129	0.0431	0.0102702	0.0001284	0.8283705	41.46493
126.0	0.0005786	224.2549	472.1744	0.0424	0.0102702	0.0001284	0.8403340	41.46493
132.0	0.0003804	227.5392	485.5250	0.0418	0.0102702	0.0001284	0.8523661	41.46493
138.0	0.0001961	230.8252	498.8831	0.0413	0.0102702	0.0001284	0.8643835	41.46493
144.0	0.0000000	233.9966	511.6331	0.0407	0.0102702	0.0001284	0.8759482	41.46493

rod power delivered to the coolant 0.640 btu/sec 0.00068 mw

calculated fluid conditions at time = 0.0000 seconds
channel 1
assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0044713	162.0970	217.0000	0.0585	0.0000805	0.0001655	0.7862574	0.25230

6.0	0.0042552	166.8071	236.5441	0.0568	0.0000805	0.0001655	0.8092945	0.25230
12.0	0.0040441	172.0300	258.2159	0.0551	0.0000805	0.0001655	0.8348397	0.25230
18.0	0.0038213	177.8486	282.3595	0.0533	0.0000805	0.0001655	0.8632985	0.25230
24.0	0.0036202	184.0536	308.0066	0.0515	0.0000805	0.0001655	0.8933233	0.25230
30.0	0.0034237	190.5335	334.5636	0.0498	0.0000805	0.0001655	0.9239430	0.25230
36.0	0.0032131	197.1766	361.7892	0.0481	0.0000805	0.0001655	0.9553337	0.25230
42.0	0.0030249	203.9028	389.3557	0.0466	0.0000805	0.0001655	0.9871174	0.25230
48.0	0.0028206	210.6746	416.9699	0.0451	0.0000805	0.0001655	1.0191511	0.25230
54.0	0.0026394	217.4736	444.6082	0.0437	0.0000805	0.0001655	1.0513353	0.25230
60.0	0.0024612	224.2648	472.2148	0.0424	0.0000805	0.0001655	1.0834825	0.25230
66.0	0.0022641	231.0103	499.6352	0.0412	0.0000805	0.0001655	1.1154130	0.25230
72.0	0.0020911	237.7465	526.6929	0.0401	0.0000805	0.0001655	1.1469824	0.25230
78.0	0.0019204	244.4542	553.6312	0.0390	0.0000805	0.0001655	1.1784133	0.25230
84.0	0.0017283	251.1120	580.3696	0.0380	0.0000805	0.0001655	1.2096109	0.25230
90.0	0.0015614	257.7058	606.7692	0.0371	0.0000805	0.0001655	1.2403449	0.25230
96.0	0.0013960	264.2706	632.8198	0.0362	0.0000805	0.0001655	1.2704766	0.25230
102.0	0.0012067	270.7929	658.7018	0.0354	0.0000805	0.0001655	1.3004134	0.25230
108.0	0.0010436	277.2554	684.3470	0.0346	0.0000805	0.0001655	1.3300761	0.25230
114.0	0.0008552	283.6566	709.6338	0.0338	0.0000805	0.0001655	1.3593466	0.25230
120.0	0.0006940	290.0281	734.6201	0.0331	0.0000805	0.0001655	1.3883047	0.25230
126.0	0.0005336	296.3581	759.4435	0.0324	0.0000805	0.0001655	1.4170739	0.25230
132.0	0.0003460	302.6233	784.0127	0.0318	0.0000805	0.0001655	1.4455487	0.25230
138.0	0.0001870	308.7866	808.0876	0.0312	0.0000805	0.0001655	1.4734356	0.25230
144.0	0.0000000	314.6346	830.7543	0.0307	0.0000805	0.0001655	1.4996638	0.25230

calculated fluid conditions at time = 0.0000 seconds
channel 2
assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0044040	162.0970	217.0000	0.0585	0.0000728	0.0001655	0.7862574	0.22810
6.0	0.0041897	167.2269	238.2859	0.0567	0.0000728	0.0001655	0.8113477	0.22810
12.0	0.0039808	172.7899	261.3690	0.0548	0.0000728	0.0001655	0.8385563	0.22810
18.0	0.0037603	178.7181	285.9673	0.0530	0.0000728	0.0001655	0.8675510	0.22810
24.0	0.0035615	184.9089	311.5118	0.0512	0.0000728	0.0001655	0.8973647	0.22810
30.0	0.0033673	191.3078	337.7370	0.0496	0.0000728	0.0001655	0.9276019	0.22810
36.0	0.0031590	197.8443	364.5257	0.0480	0.0000728	0.0001655	0.9584888	0.22810
42.0	0.0029731	204.4564	391.6246	0.0464	0.0000728	0.0001655	0.9897335	0.22810
48.0	0.0027712	211.1180	418.7724	0.0450	0.0000728	0.0001655	1.0212501	0.22810
54.0	0.0025924	217.8105	445.9776	0.0437	0.0000728	0.0001655	1.0529299	0.22810
60.0	0.0024166	224.5031	473.1833	0.0424	0.0000728	0.0001655	1.0846103	0.22810
66.0	0.0022220	231.1585	500.2351	0.0412	0.0000728	0.0001655	1.1161120	0.22810
72.0	0.0020516	237.8127	526.9587	0.0401	0.0000728	0.0001655	1.1472924	0.22810
78.0	0.0018836	244.4461	553.5990	0.0390	0.0000728	0.0001655	1.1783757	0.22810
84.0	0.0016943	251.0381	580.0727	0.0380	0.0000728	0.0001655	1.2092646	0.22810
90.0	0.0015302	257.5715	606.2361	0.0371	0.0000728	0.0001655	1.2397283	0.22810
96.0	0.0013678	264.0807	632.0665	0.0362	0.0000728	0.0001655	1.2696053	0.22810
102.0	0.0011815	270.5539	657.7536	0.0354	0.0000728	0.0001655	1.2993166	0.22810
108.0	0.0010217	276.9735	683.2283	0.0346	0.0000728	0.0001655	1.3287821	0.22810
114.0	0.0008367	283.3349	708.3720	0.0339	0.0000728	0.0001655	1.3578841	0.22810
120.0	0.0006790	289.6713	733.2207	0.0332	0.0000728	0.0001655	1.3866828	0.22810
126.0	0.0005222	295.9711	757.9261	0.0325	0.0000728	0.0001655	1.4153153	0.22810
132.0	0.0003383	302.2118	782.3992	0.0318	0.0000728	0.0001655	1.4436787	0.22810
138.0	0.0001831	308.3591	806.4304	0.0312	0.0000728	0.0001655	1.4715181	0.22810
144.0	0.0000000	314.2881	829.4114	0.0307	0.0000728	0.0001655	1.4981098	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 3
assembly 1

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distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0044008	162.0970	217.0000	0.0585	0.0000728	0.0001655	0.7862574	0.22810
6.0	0.0041867	167.3759	238.9040	0.0566	0.0000728	0.0001655	0.8120763	0.22810
12.0	0.0039781	173.0948	262.6339	0.0547	0.0000728	0.0001655	0.8400473	0.22810
18.0	0.0037579	179.1274	287.6657	0.0529	0.0000728	0.0001655	0.8695530	0.22810
24.0	0.0035594	185.3756	313.4245	0.0511	0.0000728	0.0001655	0.8995700	0.22810
30.0	0.0033656	191.7945	339.7314	0.0494	0.0000728	0.0001655	0.9299014	0.22810
36.0	0.0031575	198.3267	366.5029	0.0478	0.0000728	0.0001655	0.9607685	0.22810
42.0	0.0029719	204.9194	393.5221	0.0463	0.0000728	0.0001655	0.9919212	0.22810
48.0	0.0027702	211.5566	420.5554	0.0449	0.0000728	0.0001655	1.0233264	0.22810
54.0	0.0025915	218.2198	447.6413	0.0436	0.0000728	0.0001655	1.0548673	0.22810
60.0	0.0024159	224.8810	474.7194	0.0423	0.0000728	0.0001655	1.0863991	0.22810
66.0	0.0022215	231.5075	501.6365	0.0411	0.0000728	0.0001655	1.1177471	0.22810
72.0	0.0020512	238.1328	528.2443	0.0400	0.0000728	0.0001655	1.1487925	0.22810
78.0	0.0018832	244.7386	554.7734	0.0390	0.0000728	0.0001655	1.1797460	0.22810
84.0	0.0016940	251.3041	581.1410	0.0380	0.0000728	0.0001655	1.2105110	0.22810
90.0	0.0015300	257.8147	607.2013	0.0370	0.0000728	0.0001655	1.2408447	0.22810
96.0	0.0013676	264.3024	632.9460	0.0362	0.0000728	0.0001655	1.2706226	0.22810
102.0	0.0011814	270.7556	658.5539	0.0354	0.0000728	0.0001655	1.3002422	0.22810
108.0	0.0010216	277.1565	683.9542	0.0346	0.0000728	0.0001655	1.3296218	0.22810
114.0	0.0008366	283.5024	709.0291	0.0338	0.0000728	0.0001655	1.3586457	0.22810
120.0	0.0006789	289.8241	733.8199	0.0331	0.0000728	0.0001655	1.3873773	0.22810
126.0	0.0005221	296.1102	758.4715	0.0325	0.0000728	0.0001655	1.4159475	0.22810
132.0	0.0003383	302.3382	782.8951	0.0318	0.0000728	0.0001655	1.4442534	0.22810
138.0	0.0001831	308.4771	806.8879	0.0312	0.0000728	0.0001655	1.4720474	0.22810
144.0	0.0000000	314.4172	829.9116	0.0307	0.0000728	0.0001655	1.4986887	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 4
assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0043988	162.0970	217.0000	0.0585	0.0000728	0.0001655	0.7862574	0.22810
6.0	0.0041848	167.4328	239.1403	0.0566	0.0000728	0.0001655	0.8123547	0.22810
12.0	0.0039762	173.2341	263.2118	0.0547	0.0000728	0.0001655	0.8407286	0.22810
18.0	0.0037562	179.3399	288.5473	0.0528	0.0000728	0.0001655	0.8705922	0.22810
24.0	0.0035579	185.6427	314.5192	0.0510	0.0000728	0.0001655	0.9008322	0.22810
30.0	0.0033643	192.0949	340.9627	0.0494	0.0000728	0.0001655	0.9313211	0.22810
36.0	0.0031564	198.6427	367.7979	0.0478	0.0000728	0.0001655	0.9622616	0.22810
42.0	0.0029710	205.2370	394.8236	0.0463	0.0000728	0.0001655	0.9934218	0.22810
48.0	0.0027694	211.8690	421.8252	0.0449	0.0000728	0.0001655	1.0248050	0.22810
54.0	0.0025909	218.5204	448.8633	0.0435	0.0000728	0.0001655	1.0562903	0.22810
60.0	0.0024154	225.1655	475.8762	0.0423	0.0000728	0.0001655	1.0877462	0.22810
66.0	0.0022210	231.7760	502.7149	0.0411	0.0000728	0.0001655	1.1190054	0.22810
72.0	0.0020508	238.3841	529.2533	0.0400	0.0000728	0.0001655	1.1499698	0.22810
78.0	0.0018830	244.9723	555.7122	0.0389	0.0000728	0.0001655	1.1808414	0.22810
84.0	0.0016938	251.5201	582.0084	0.0379	0.0000728	0.0001655	1.2115231	0.22810
90.0	0.0015299	258.0156	607.9984	0.0370	0.0000728	0.0001655	1.2417667	0.22810
96.0	0.0013675	264.4885	633.6847	0.0362	0.0000728	0.0001655	1.2714770	0.22810
102.0	0.0011813	270.9278	659.2373	0.0353	0.0000728	0.0001655	1.3010327	0.22810
108.0	0.0010215	277.3152	684.5842	0.0346	0.0000728	0.0001655	1.3303505	0.22810
114.0	0.0008365	283.6503	709.6091	0.0338	0.0000728	0.0001655	1.3593180	0.22810
120.0	0.0006789	289.9614	734.3586	0.0331	0.0000728	0.0001655	1.3880016	0.22810
126.0	0.0005221	296.2377	758.9714	0.0325	0.0000728	0.0001655	1.4165268	0.22810
132.0	0.0003383	302.4562	783.3577	0.0318	0.0000728	0.0001655	1.4447896	0.22810
138.0	0.0001831	308.5886	807.3202	0.0312	0.0000728	0.0001655	1.4725476	0.22810
144.0	0.0000000	314.5330	830.3603	0.0307	0.0000728	0.0001655	1.4992078	0.22810

calculated fluid conditions at time = 0.0000 seconds

channel 5
assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0043974	162.0970	217.0000	0.0585	0.0000728	0.0001655	0.7862574	0.22810
6.0	0.0041834	167.4605	239.2553	0.0566	0.0000728	0.0001655	0.8124903	0.22810
12.0	0.0039749	173.3105	263.5292	0.0547	0.0000728	0.0001655	0.8411027	0.22810
18.0	0.0037549	179.4672	289.0757	0.0528	0.0000728	0.0001655	0.8712150	0.22810
24.0	0.0035568	185.8143	315.2224	0.0510	0.0000728	0.0001655	0.9016429	0.22810
30.0	0.0033633	192.2986	341.7974	0.0493	0.0000728	0.0001655	0.9322835	0.22810
36.0	0.0031555	198.8661	368.7133	0.0477	0.0000728	0.0001655	0.9633171	0.22810
42.0	0.0029702	205.4689	395.7740	0.0462	0.0000728	0.0001655	0.9945176	0.22810
48.0	0.0027687	212.1030	422.7765	0.0448	0.0000728	0.0001655	1.0259128	0.22810
54.0	0.0025904	218.7502	449.7976	0.0435	0.0000728	0.0001655	1.0573783	0.22810
60.0	0.0024150	225.3865	476.7746	0.0422	0.0000728	0.0001655	1.0887923	0.22810
66.0	0.0022207	231.9873	503.5635	0.0410	0.0000728	0.0001655	1.1199955	0.22810
72.0	0.0020506	238.5840	530.0562	0.0399	0.0000728	0.0001655	1.1509066	0.22810
78.0	0.0018828	245.1601	556.4664	0.0389	0.0000728	0.0001655	1.1817213	0.22810
84.0	0.0016936	251.6949	582.7104	0.0379	0.0000728	0.0001655	1.2123421	0.22810
90.0	0.0015297	258.1795	608.6487	0.0370	0.0000728	0.0001655	1.2425189	0.22810
96.0	0.0013674	264.6415	634.2916	0.0361	0.0000728	0.0001655	1.2721790	0.22810
102.0	0.0011812	271.0702	659.8025	0.0353	0.0000728	0.0001655	1.3016865	0.22810
108.0	0.0010215	277.4473	685.1084	0.0345	0.0000728	0.0001655	1.3309568	0.22810
114.0	0.0008365	283.7742	710.0948	0.0338	0.0000728	0.0001655	1.3598808	0.22810
120.0	0.0006789	290.0772	734.8125	0.0331	0.0000728	0.0001655	1.3885276	0.22810
126.0	0.0005221	296.3458	759.3953	0.0324	0.0000728	0.0001655	1.4170181	0.22810
132.0	0.0003382	302.5568	783.7521	0.0318	0.0000728	0.0001655	1.4452466	0.22810
138.0	0.0001831	308.6839	807.6897	0.0312	0.0000728	0.0001655	1.4729752	0.22810
144.0	0.0000000	314.6300	830.7363	0.0307	0.0000728	0.0001655	1.4996429	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 6
assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0043964	162.0970	217.0000	0.0585	0.0000728	0.0001655	0.7862574	0.22810
6.0	0.0041824	167.4764	239.3211	0.0566	0.0000728	0.0001655	0.8125679	0.22810
12.0	0.0039740	173.3555	263.7156	0.0546	0.0000728	0.0001655	0.8413224	0.22810
18.0	0.0037541	179.5455	289.4004	0.0527	0.0000728	0.0001655	0.8715977	0.22810
24.0	0.0035560	185.9243	315.6732	0.0510	0.0000728	0.0001655	0.9021627	0.22810
30.0	0.0033626	192.4337	342.3513	0.0493	0.0000728	0.0001655	0.9329222	0.22810
36.0	0.0031549	199.0184	369.3375	0.0477	0.0000728	0.0001655	0.9640368	0.22810
42.0	0.0029697	205.6304	396.4360	0.0462	0.0000728	0.0001655	0.9952808	0.22810
48.0	0.0027683	212.2687	423.4501	0.0448	0.0000728	0.0001655	1.0266972	0.22810
54.0	0.0025900	218.9150	450.4677	0.0434	0.0000728	0.0001655	1.0581585	0.22810
60.0	0.0024147	225.5465	477.4249	0.0422	0.0000728	0.0001655	1.0895496	0.22810
66.0	0.0022204	232.1414	504.1825	0.0410	0.0000728	0.0001655	1.1207178	0.22810
72.0	0.0020504	238.7307	530.6455	0.0399	0.0000728	0.0001655	1.1515941	0.22810
78.0	0.0018826	245.2986	557.0224	0.0389	0.0000728	0.0001655	1.1823701	0.22810
84.0	0.0016935	251.8242	583.2298	0.0379	0.0000728	0.0001655	1.2129482	0.22810
90.0	0.0015296	258.3011	609.1314	0.0370	0.0000728	0.0001655	1.2430772	0.22810
96.0	0.0013673	264.7553	634.7434	0.0361	0.0000728	0.0001655	1.2727015	0.22810
102.0	0.0011812	271.1765	660.2243	0.0353	0.0000728	0.0001655	1.3021743	0.22810
108.0	0.0010214	277.5460	685.5002	0.0345	0.0000728	0.0001655	1.3314100	0.22810
114.0	0.0008365	283.8669	710.4585	0.0338	0.0000728	0.0001655	1.3603023	0.22810
120.0	0.0006788	290.1640	735.1530	0.0331	0.0000728	0.0001655	1.3889223	0.22810
126.0	0.0005221	296.4270	759.7138	0.0324	0.0000728	0.0001655	1.4173872	0.22810
132.0	0.0003382	302.6325	784.0489	0.0318	0.0000728	0.0001655	1.4455907	0.22810
138.0	0.0001831	308.7557	807.9676	0.0312	0.0000728	0.0001655	1.4732969	0.22810
144.0	0.0000000	314.7021	831.0158	0.0306	0.0000728	0.0001655	1.4999664	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 7
assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0043959	162.0970	217.0000	0.0585	0.0000728	0.0001655	0.7862574	0.22810
6.0	0.0041819	167.4843	239.3541	0.0566	0.0000728	0.0001655	0.8126068	0.22810
12.0	0.0039734	173.3791	263.8138	0.0546	0.0000728	0.0001655	0.8414381	0.22810
18.0	0.0037536	179.5880	289.5767	0.0527	0.0000728	0.0001655	0.8718056	0.22810
24.0	0.0035556	185.9855	315.9242	0.0509	0.0000728	0.0001655	0.9024521	0.22810
30.0	0.0033622	192.5105	342.6658	0.0493	0.0000728	0.0001655	0.9332848	0.22810
36.0	0.0031545	199.1061	369.6973	0.0477	0.0000728	0.0001655	0.9644515	0.22810
42.0	0.0029694	205.7245	396.8217	0.0462	0.0000728	0.0001655	0.9957256	0.22810
48.0	0.0027680	212.3661	423.8459	0.0448	0.0000728	0.0001655	1.0271581	0.22810
54.0	0.0025898	219.0125	450.8637	0.0434	0.0000728	0.0001655	1.0586197	0.22810
60.0	0.0024145	225.6414	477.8107	0.0422	0.0000728	0.0001655	1.0899988	0.22810
66.0	0.0022203	232.2331	504.5508	0.0410	0.0000728	0.0001655	1.1211475	0.22810
72.0	0.0020502	238.8181	530.9964	0.0399	0.0000728	0.0001655	1.1520036	0.22810
78.0	0.0018825	245.3811	557.3538	0.0389	0.0000728	0.0001655	1.1827567	0.22810
84.0	0.0016934	251.9012	583.5391	0.0379	0.0000728	0.0001655	1.2133091	0.22810
90.0	0.0015296	258.3735	609.4187	0.0370	0.0000728	0.0001655	1.2434095	0.22810
96.0	0.0013673	264.8230	635.0120	0.0361	0.0000728	0.0001655	1.2730123	0.22810
102.0	0.0011811	271.2396	660.4747	0.0353	0.0000728	0.0001655	1.3024640	0.22810
108.0	0.0010214	277.6046	685.7325	0.0345	0.0000728	0.0001655	1.3316787	0.22810
114.0	0.0008364	283.9218	710.6738	0.0338	0.0000728	0.0001655	1.3605519	0.22810
120.0	0.0006788	290.2154	735.3544	0.0331	0.0000728	0.0001655	1.3891556	0.22810
126.0	0.0005221	296.4750	759.9019	0.0324	0.0000728	0.0001655	1.4176052	0.22810
132.0	0.0003382	302.6771	784.2239	0.0318	0.0000728	0.0001655	1.4457934	0.22810
138.0	0.0001831	308.7978	808.1312	0.0312	0.0000728	0.0001655	1.4734861	0.22810
144.0	0.0000000	314.7443	831.1794	0.0306	0.0000728	0.0001655	1.5001556	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 8
assembly 1

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0043957	162.0970	217.0000	0.0585	0.0000728	0.0001655	0.7862574	0.22810
6.0	0.0041817	167.4860	239.3609	0.0566	0.0000728	0.0001655	0.8126148	0.22810
12.0	0.0039733	173.3851	263.8388	0.0546	0.0000728	0.0001655	0.8414676	0.22810
18.0	0.0037534	179.5993	289.6237	0.0527	0.0000728	0.0001655	0.8718609	0.22810
24.0	0.0035555	186.0020	315.9917	0.0509	0.0000728	0.0001655	0.9025299	0.22810
30.0	0.0033621	192.5310	342.7501	0.0493	0.0000728	0.0001655	0.9333819	0.22810
36.0	0.0031544	199.1293	369.7924	0.0477	0.0000728	0.0001655	0.9645613	0.22810
42.0	0.0029693	205.7490	396.9219	0.0462	0.0000728	0.0001655	0.9958412	0.22810
48.0	0.0027679	212.3908	423.9464	0.0448	0.0000728	0.0001655	1.0272751	0.22810
54.0	0.0025897	219.0365	450.9614	0.0434	0.0000728	0.0001655	1.0587335	0.22810
60.0	0.0024145	225.6641	477.9027	0.0422	0.0000728	0.0001655	1.0901060	0.22810
66.0	0.0022202	232.2542	504.6354	0.0410	0.0000728	0.0001655	1.1212462	0.22810
72.0	0.0020502	238.8374	531.0738	0.0399	0.0000728	0.0001655	1.1520938	0.22810
78.0	0.0018825	245.3984	557.4235	0.0389	0.0000728	0.0001655	1.1828380	0.22810
84.0	0.0016934	251.9166	583.6009	0.0379	0.0000728	0.0001655	1.2133812	0.22810
90.0	0.0015296	258.3872	609.4732	0.0370	0.0000728	0.0001655	1.2434725	0.22810
96.0	0.0013673	264.8351	635.0601	0.0361	0.0000728	0.0001655	1.2730679	0.22810
102.0	0.0011811	271.2503	660.5169	0.0353	0.0000728	0.0001655	1.3025128	0.22810
108.0	0.0010214	277.6138	685.7692	0.0345	0.0000728	0.0001655	1.3317211	0.22810
114.0	0.0008364	283.9300	710.7058	0.0338	0.0000728	0.0001655	1.3605889	0.22810
120.0	0.0006788	290.2225	735.3823	0.0331	0.0000728	0.0001655	1.3891880	0.22810
126.0	0.0005221	296.4812	759.9263	0.0324	0.0000728	0.0001655	1.4176335	0.22810
132.0	0.0003382	302.6825	784.2450	0.0318	0.0000728	0.0001655	1.4458179	0.22810

138.0	0.0001831	308.8026	808.1497	0.0312	0.0000728	0.0001655	1.4735076	0.22810
144.0	0.0000000	314.7493	831.1988	0.0306	0.0000728	0.0001655	1.5001781	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 211
assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0045779	162.0970	217.0000	0.0585	0.0000625	0.0001284	0.6100027	0.25230
6.0	0.0043637	164.2454	225.9145	0.0577	0.0000625	0.0001284	0.6181550	0.25230
12.0	0.0041518	166.5531	235.4900	0.0569	0.0000625	0.0001284	0.6269117	0.25230
18.0	0.0039330	169.1589	246.3024	0.0560	0.0000625	0.0001284	0.6367996	0.25230
24.0	0.0037266	171.9873	258.0386	0.0551	0.0000625	0.0001284	0.6475322	0.25230
30.0	0.0035229	174.9789	270.4518	0.0541	0.0000625	0.0001284	0.6588840	0.25230
36.0	0.0033120	178.0868	283.3478	0.0532	0.0000625	0.0001284	0.6706773	0.25230
42.0	0.0031140	181.2787	296.5919	0.0522	0.0000625	0.0001284	0.6827890	0.25230
48.0	0.0029081	184.5402	310.0007	0.0513	0.0000625	0.0001284	0.6948515	0.25230
54.0	0.0027152	187.8575	323.5961	0.0504	0.0000625	0.0001284	0.7070129	0.25230
60.0	0.0025248	191.2176	337.3670	0.0496	0.0000625	0.0001284	0.7193312	0.25230
66.0	0.0023259	194.6113	351.2759	0.0487	0.0000625	0.0001284	0.7317730	0.25230
72.0	0.0021402	198.0319	365.2946	0.0479	0.0000625	0.0001284	0.7443129	0.25230
78.0	0.0019567	201.4749	379.4053	0.0471	0.0000625	0.0001284	0.7569353	0.25230
84.0	0.0017639	204.9359	393.5896	0.0463	0.0000625	0.0001284	0.7696235	0.25230
90.0	0.0015846	208.4155	407.7866	0.0456	0.0000625	0.0001284	0.7823923	0.25230
96.0	0.0014074	211.9132	422.0049	0.0449	0.0000625	0.0001284	0.7952377	0.25230
102.0	0.0012199	215.4219	436.2678	0.0441	0.0000625	0.0001284	0.8081233	0.25230
108.0	0.0010463	218.9401	450.5696	0.0434	0.0000625	0.0001284	0.8210441	0.25230
114.0	0.0008619	222.4665	464.9046	0.0428	0.0000625	0.0001284	0.8339948	0.25230
120.0	0.0006918	226.0003	479.2697	0.0421	0.0000625	0.0001284	0.8469728	0.25230
126.0	0.0005232	229.5396	493.6569	0.0415	0.0000625	0.0001284	0.8599707	0.25230
132.0	0.0003430	233.0812	507.9566	0.0409	0.0000625	0.0001284	0.8729038	0.25230
138.0	0.0001775	236.5896	522.0464	0.0403	0.0000625	0.0001284	0.8856581	0.25230
144.0	0.0000000	239.8409	535.1039	0.0397	0.0000625	0.0001284	0.8974781	0.25230

calculated fluid conditions at time = 0.0000 seconds
channel 212
assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0045226	162.0970	217.0000	0.0585	0.0000565	0.0001284	0.6100027	0.22810
6.0	0.0043096	164.4199	226.6388	0.0576	0.0000565	0.0001284	0.6188173	0.22810
12.0	0.0040992	166.9303	237.0551	0.0568	0.0000565	0.0001284	0.6283429	0.22810
18.0	0.0038820	169.6835	248.4794	0.0558	0.0000565	0.0001284	0.6387904	0.22810
24.0	0.0036773	172.6331	260.7183	0.0549	0.0000565	0.0001284	0.6499828	0.22810
30.0	0.0034756	175.7357	273.5921	0.0539	0.0000565	0.0001284	0.6617558	0.22810
36.0	0.0032666	178.9517	286.9365	0.0529	0.0000565	0.0001284	0.6739591	0.22810
42.0	0.0030706	182.2507	300.6178	0.0520	0.0000565	0.0001284	0.6864583	0.22810
48.0	0.0028669	185.6225	314.4363	0.0510	0.0000565	0.0001284	0.6988192	0.22810
54.0	0.0026763	189.0442	328.4597	0.0501	0.0000565	0.0001284	0.7113634	0.22810
60.0	0.0024882	192.5042	342.6403	0.0493	0.0000565	0.0001284	0.7240482	0.22810
66.0	0.0022915	195.9930	356.9385	0.0484	0.0000565	0.0001284	0.7368383	0.22810
72.0	0.0021083	199.5030	371.3237	0.0476	0.0000565	0.0001284	0.7497061	0.22810
78.0	0.0019273	203.0298	385.7779	0.0468	0.0000565	0.0001284	0.7626357	0.22810
84.0	0.0017369	206.5687	400.2792	0.0460	0.0000565	0.0001284	0.7756099	0.22810
90.0	0.0015603	210.1280	414.7478	0.0452	0.0000565	0.0001284	0.7886813	0.22810
96.0	0.0013856	213.6935	429.2420	0.0445	0.0000565	0.0001284	0.8017760	0.22810
102.0	0.0012007	217.2639	443.7559	0.0438	0.0000565	0.0001284	0.8148883	0.22810
108.0	0.0010298	220.8381	458.2851	0.0431	0.0000565	0.0001284	0.8280145	0.22810
114.0	0.0008481	224.4147	472.8239	0.0424	0.0000565	0.0001284	0.8411494	0.22810

120.0	0.0006807	227.9930	487.3700	0.0418	0.0000565	0.0001284	0.8542909	0.22810
126.0	0.0005149	231.5744	501.9051	0.0411	0.0000565	0.0001284	0.8674258	0.22810
132.0	0.0003374	235.1654	516.3270	0.0405	0.0000565	0.0001284	0.8804809	0.22810
138.0	0.0001747	238.7178	530.5937	0.0399	0.0000565	0.0001284	0.8933954	0.22810
144.0	0.0000000	242.0867	544.1235	0.0394	0.0000565	0.0001284	0.9056428	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 213
assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0045177	162.0970	217.0000	0.0585	0.0000565	0.0001284	0.6100027	0.22810
6.0	0.0043047	164.4734	226.8606	0.0576	0.0000565	0.0001284	0.6190202	0.22810
12.0	0.0040945	167.0484	237.5454	0.0567	0.0000565	0.0001284	0.6287914	0.22810
18.0	0.0038775	169.8548	249.1901	0.0558	0.0000565	0.0001284	0.6394403	0.22810
24.0	0.0036730	172.8450	261.5976	0.0548	0.0000565	0.0001284	0.6507869	0.22810
30.0	0.0034715	175.9794	274.6032	0.0538	0.0000565	0.0001284	0.6626804	0.22810
36.0	0.0032627	179.2214	288.0555	0.0528	0.0000565	0.0001284	0.6749825	0.22810
42.0	0.0030670	182.5449	301.8232	0.0519	0.0000565	0.0001284	0.6875366	0.22810
48.0	0.0028635	185.9360	315.7215	0.0510	0.0000565	0.0001284	0.6999688	0.22810
54.0	0.0026731	189.3757	329.8185	0.0501	0.0000565	0.0001284	0.7125789	0.22810
60.0	0.0024853	192.8521	344.0659	0.0492	0.0000565	0.0001284	0.7253235	0.22810
66.0	0.0022888	196.3556	358.4245	0.0483	0.0000565	0.0001284	0.7381675	0.22810
72.0	0.0021059	199.8788	372.8638	0.0475	0.0000565	0.0001284	0.7510838	0.22810
78.0	0.0019251	203.4174	387.3663	0.0467	0.0000565	0.0001284	0.7640565	0.22810
84.0	0.0017350	206.9685	401.9046	0.0459	0.0000565	0.0001284	0.7770784	0.22810
90.0	0.0015585	210.5371	416.4111	0.0451	0.0000565	0.0001284	0.7901840	0.22810
96.0	0.0013841	214.1107	430.9380	0.0444	0.0000565	0.0001284	0.8033082	0.22810
102.0	0.0011994	217.6882	445.4806	0.0437	0.0000565	0.0001284	0.8164465	0.22810
108.0	0.0010287	221.2684	460.0343	0.0430	0.0000565	0.0001284	0.8295949	0.22810
114.0	0.0008472	224.8500	474.5933	0.0423	0.0000565	0.0001284	0.8427480	0.22810
120.0	0.0006800	228.4323	489.1557	0.0417	0.0000565	0.0001284	0.8559042	0.22810
126.0	0.0005143	232.0203	503.6959	0.0410	0.0000565	0.0001284	0.8690469	0.22810
132.0	0.0003371	235.6140	518.1286	0.0404	0.0000565	0.0001284	0.8821117	0.22810
138.0	0.0001746	239.1707	532.4124	0.0398	0.0000565	0.0001284	0.8950416	0.22810
144.0	0.0000000	242.5588	546.0194	0.0393	0.0000565	0.0001284	0.9073590	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 214
assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0045153	162.0970	217.0000	0.0585	0.0000565	0.0001284	0.6100027	0.22810
6.0	0.0043024	164.4936	226.9444	0.0576	0.0000565	0.0001284	0.6190968	0.22810
12.0	0.0040921	167.1003	237.7606	0.0567	0.0000565	0.0001284	0.6289881	0.22810
18.0	0.0038752	169.9373	249.5324	0.0558	0.0000565	0.0001284	0.6397533	0.22810
24.0	0.0036709	172.9529	262.0454	0.0548	0.0000565	0.0001284	0.6511964	0.22810
30.0	0.0034694	176.1074	275.1343	0.0538	0.0000565	0.0001284	0.6631661	0.22810
36.0	0.0032608	179.3650	288.6515	0.0528	0.0000565	0.0001284	0.6755275	0.22810
42.0	0.0030652	182.7016	302.4654	0.0518	0.0000565	0.0001284	0.6881110	0.22810
48.0	0.0028618	186.1024	316.4032	0.0509	0.0000565	0.0001284	0.7005786	0.22810
54.0	0.0026715	189.5500	330.5326	0.0500	0.0000565	0.0001284	0.7132177	0.22810
60.0	0.0024839	193.0329	344.8068	0.0491	0.0000565	0.0001284	0.7259862	0.22810
66.0	0.0022875	196.5417	359.1872	0.0483	0.0000565	0.0001284	0.7388498	0.22810
72.0	0.0021047	200.0693	373.6446	0.0474	0.0000565	0.0001284	0.7517822	0.22810
78.0	0.0019241	203.6115	388.1618	0.0466	0.0000565	0.0001284	0.7647682	0.22810
84.0	0.0017340	207.1666	402.7096	0.0459	0.0000565	0.0001284	0.7778056	0.22810
90.0	0.0015577	210.7374	417.2252	0.0451	0.0000565	0.0001284	0.7909195	0.22810
96.0	0.0013834	214.3128	431.7593	0.0444	0.0000565	0.0001284	0.8040502	0.22810

102.0	0.0011988	217.8917	446.3077	0.0436	0.0000565	0.0001284	0.8171937	0.22810
108.0	0.0010282	221.4729	460.8656	0.0430	0.0000565	0.0001284	0.8303459	0.22810
114.0	0.0008468	225.0551	475.4273	0.0423	0.0000565	0.0001284	0.8435014	0.22810
120.0	0.0006796	228.6378	489.9909	0.0416	0.0000565	0.0001284	0.8566587	0.22810
126.0	0.0005141	232.2272	504.5269	0.0410	0.0000565	0.0001284	0.8697992	0.22810
132.0	0.0003369	235.8207	518.9588	0.0404	0.0000565	0.0001284	0.8828632	0.22810
138.0	0.0001745	239.3782	533.2459	0.0398	0.0000565	0.0001284	0.8957962	0.22810
144.0	0.0000000	242.7748	546.8869	0.0393	0.0000565	0.0001284	0.9081443	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 215
assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0045139	162.0970	217.0000	0.0585	0.0000565	0.0001284	0.6100027	0.22810
6.0	0.0043009	164.5035	226.9854	0.0576	0.0000565	0.0001284	0.6191343	0.22810
12.0	0.0040907	167.1284	237.8770	0.0567	0.0000565	0.0001284	0.6290946	0.22810
18.0	0.0038738	169.9851	249.7308	0.0557	0.0000565	0.0001284	0.6399348	0.22810
24.0	0.0036695	173.0185	262.3175	0.0548	0.0000565	0.0001284	0.6514452	0.22810
30.0	0.0034682	176.1875	275.4670	0.0538	0.0000565	0.0001284	0.6634703	0.22810
36.0	0.0032596	179.4566	289.0317	0.0528	0.0000565	0.0001284	0.6758752	0.22810
42.0	0.0030641	182.8024	302.8785	0.0518	0.0000565	0.0001284	0.6884805	0.22810
48.0	0.0028608	186.2098	316.8434	0.0509	0.0000565	0.0001284	0.7009724	0.22810
54.0	0.0026706	189.6624	330.9933	0.0500	0.0000565	0.0001284	0.7136298	0.22810
60.0	0.0024830	193.1490	345.2828	0.0491	0.0000565	0.0001284	0.7264120	0.22810
66.0	0.0022868	196.6606	359.6746	0.0482	0.0000565	0.0001284	0.7392858	0.22810
72.0	0.0021040	200.1902	374.1403	0.0474	0.0000565	0.0001284	0.7522256	0.22810
78.0	0.0019235	203.7339	388.6634	0.0466	0.0000565	0.0001284	0.7652169	0.22810
84.0	0.0017335	207.2905	403.2136	0.0458	0.0000565	0.0001284	0.7782609	0.22810
90.0	0.0015572	210.8619	417.7313	0.0451	0.0000565	0.0001284	0.7913767	0.22810
96.0	0.0013830	214.4376	432.2665	0.0443	0.0000565	0.0001284	0.8045084	0.22810
102.0	0.0011984	218.0165	446.8152	0.0436	0.0000565	0.0001284	0.8176522	0.22810
108.0	0.0010279	221.5977	461.3728	0.0429	0.0000565	0.0001284	0.8308041	0.22810
114.0	0.0008465	225.1796	475.9333	0.0423	0.0000565	0.0001284	0.8439586	0.22810
120.0	0.0006794	228.7618	490.4950	0.0416	0.0000565	0.0001284	0.8571142	0.22810
126.0	0.0005140	232.3515	505.0263	0.0410	0.0000565	0.0001284	0.8702512	0.22810
132.0	0.0003368	235.9444	519.4553	0.0404	0.0000565	0.0001284	0.8833126	0.22810
138.0	0.0001744	239.5017	533.7420	0.0398	0.0000565	0.0001284	0.8962452	0.22810
144.0	0.0000000	242.9030	547.4017	0.0393	0.0000565	0.0001284	0.9086103	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 216
assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0045129	162.0970	217.0000	0.0585	0.0000565	0.0001284	0.6100027	0.22810
6.0	0.0042999	164.5093	227.0094	0.0576	0.0000565	0.0001284	0.6191562	0.22810
12.0	0.0040898	167.1449	237.9458	0.0567	0.0000565	0.0001284	0.6291575	0.22810
18.0	0.0038729	170.0143	249.8518	0.0557	0.0000565	0.0001284	0.6400455	0.22810
24.0	0.0036686	173.0597	262.4884	0.0547	0.0000565	0.0001284	0.6516016	0.22810
30.0	0.0034673	176.2391	275.6807	0.0537	0.0000565	0.0001284	0.6636658	0.22810
36.0	0.0032589	179.5164	289.2798	0.0528	0.0000565	0.0001284	0.6761021	0.22810
42.0	0.0030634	182.8687	303.1503	0.0518	0.0000565	0.0001284	0.6887237	0.22810
48.0	0.0028601	186.2808	317.1346	0.0509	0.0000565	0.0001284	0.7012329	0.22810
54.0	0.0026700	189.7369	331.2986	0.0500	0.0000565	0.0001284	0.7139029	0.22810
60.0	0.0024824	193.2259	345.5981	0.0491	0.0000565	0.0001284	0.7266941	0.22810
66.0	0.0022862	196.7392	359.9969	0.0482	0.0000565	0.0001284	0.7395741	0.22810
72.0	0.0021035	200.2700	374.4671	0.0474	0.0000565	0.0001284	0.7525180	0.22810
78.0	0.0019231	203.8143	388.9931	0.0466	0.0000565	0.0001284	0.7655117	0.22810

84.0	0.0017331	207.3717	403.5436	0.0458	0.0000565	0.0001284	0.7785591	0.22810
90.0	0.0015569	210.9431	418.0614	0.0451	0.0000565	0.0001284	0.7916750	0.22810
96.0	0.0013827	214.5187	432.5962	0.0443	0.0000565	0.0001284	0.8048062	0.22810
102.0	0.0011982	218.0974	447.1440	0.0436	0.0000565	0.0001284	0.8179492	0.22810
108.0	0.0010277	221.6782	461.7002	0.0429	0.0000565	0.0001284	0.8310998	0.22810
114.0	0.0008463	225.2597	476.2589	0.0422	0.0000565	0.0001284	0.8442527	0.22810
120.0	0.0006793	228.8414	490.8185	0.0416	0.0000565	0.0001284	0.8574064	0.22810
126.0	0.0005139	232.4311	505.3459	0.0410	0.0000565	0.0001284	0.8705405	0.22810
132.0	0.0003368	236.0233	519.7721	0.0404	0.0000565	0.0001284	0.8835994	0.22810
138.0	0.0001744	239.5803	534.0574	0.0398	0.0000565	0.0001284	0.8965307	0.22810
144.0	0.0000000	242.9841	547.7275	0.0392	0.0000565	0.0001284	0.9089052	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 217
assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0045124	162.0970	217.0000	0.0585	0.0000565	0.0001284	0.6100027	0.22810
6.0	0.0042994	164.5123	227.0219	0.0576	0.0000565	0.0001284	0.6191677	0.22810
12.0	0.0040892	167.1539	237.9828	0.0567	0.0000565	0.0001284	0.6291913	0.22810
18.0	0.0038724	170.0303	249.9183	0.0557	0.0000565	0.0001284	0.6401063	0.22810
24.0	0.0036681	173.0827	262.5839	0.0547	0.0000565	0.0001284	0.6516888	0.22810
30.0	0.0034669	176.2682	275.8015	0.0537	0.0000565	0.0001284	0.6637763	0.22810
36.0	0.0032584	179.5505	289.4210	0.0527	0.0000565	0.0001284	0.6762313	0.22810
42.0	0.0030630	182.9066	303.3058	0.0518	0.0000565	0.0001284	0.6888628	0.22810
48.0	0.0028597	186.3216	317.3015	0.0509	0.0000565	0.0001284	0.7013822	0.22810
54.0	0.0026696	189.7796	331.4737	0.0499	0.0000565	0.0001284	0.7140595	0.22810
60.0	0.0024821	193.2700	345.7789	0.0491	0.0000565	0.0001284	0.7268558	0.22810
66.0	0.0022860	196.7842	360.1813	0.0482	0.0000565	0.0001284	0.7397390	0.22810
72.0	0.0021033	200.3155	374.6537	0.0474	0.0000565	0.0001284	0.7526849	0.22810
78.0	0.0019228	203.8601	389.1807	0.0466	0.0000565	0.0001284	0.7656796	0.22810
84.0	0.0017329	207.4178	403.7309	0.0458	0.0000565	0.0001284	0.7787283	0.22810
90.0	0.0015567	210.9891	418.2482	0.0450	0.0000565	0.0001284	0.7918438	0.22810
96.0	0.0013826	214.5644	432.7822	0.0443	0.0000565	0.0001284	0.8049743	0.22810
102.0	0.0011980	218.1429	447.3290	0.0436	0.0000565	0.0001284	0.8181164	0.22810
108.0	0.0010276	221.7235	461.8840	0.0429	0.0000565	0.0001284	0.8312659	0.22810
114.0	0.0008463	225.3046	476.4413	0.0422	0.0000565	0.0001284	0.8444176	0.22810
120.0	0.0006792	228.8859	490.9994	0.0416	0.0000565	0.0001284	0.8575699	0.22810
126.0	0.0005138	232.4755	505.5243	0.0410	0.0000565	0.0001284	0.8707020	0.22810
132.0	0.0003367	236.0672	519.9487	0.0404	0.0000565	0.0001284	0.8837593	0.22810
138.0	0.0001744	239.6239	534.2327	0.0398	0.0000565	0.0001284	0.8966894	0.22810
144.0	0.0000000	243.0291	547.9079	0.0392	0.0000565	0.0001284	0.9090685	0.22810

calculated fluid conditions at time = 0.0000 seconds
channel 218
assembly 2

distance (in.)	delta-p (psi)	enthalpy (btu/lb)	temperature (deg-f)	density (lb/cu-ft)	flow (lb/sec)	mass flux (mlb/hr-ft2)	velocity (ft/sec)	area (sq-in)
0.0	0.0045122	162.0970	217.0000	0.0585	0.0000565	0.0001284	0.6100027	0.22810
6.0	0.0042993	164.5130	227.0248	0.0576	0.0000565	0.0001284	0.6191703	0.22810
12.0	0.0040891	167.1563	237.9930	0.0567	0.0000565	0.0001284	0.6292006	0.22810
18.0	0.0038723	170.0348	249.9371	0.0557	0.0000565	0.0001284	0.6401234	0.22810
24.0	0.0036680	173.0892	262.6108	0.0547	0.0000565	0.0001284	0.6517134	0.22810
30.0	0.0034668	176.2763	275.8352	0.0537	0.0000565	0.0001284	0.6638071	0.22810
36.0	0.0032583	179.5598	289.4599	0.0527	0.0000565	0.0001284	0.6762668	0.22810
42.0	0.0030629	182.9169	303.3478	0.0518	0.0000565	0.0001284	0.6889003	0.22810
48.0	0.0028596	186.3324	317.3457	0.0508	0.0000565	0.0001284	0.7014218	0.22810
54.0	0.0026696	189.7907	331.5192	0.0499	0.0000565	0.0001284	0.7141002	0.22810
60.0	0.0024820	193.2812	345.8247	0.0491	0.0000565	0.0001284	0.7268968	0.22810

66.0	0.0022859	196.7954	360.2271	0.0482	0.0000565	0.0001284	0.7397800	0.22810
72.0	0.0021032	200.3266	374.6992	0.0474	0.0000565	0.0001284	0.7527256	0.22810
78.0	0.0019228	203.8711	389.2257	0.0466	0.0000565	0.0001284	0.7657198	0.22810
84.0	0.0017328	207.4287	403.7751	0.0458	0.0000565	0.0001284	0.7787682	0.22810
90.0	0.0015567	210.9997	418.2916	0.0450	0.0000565	0.0001284	0.7918830	0.22810
96.0	0.0013825	214.5749	432.8249	0.0443	0.0000565	0.0001284	0.8050129	0.22810
102.0	0.0011980	218.1533	447.3711	0.0436	0.0000565	0.0001284	0.8181544	0.22810
108.0	0.0010276	221.7336	461.9254	0.0429	0.0000565	0.0001284	0.8313033	0.22810
114.0	0.0008462	225.3146	476.4822	0.0422	0.0000565	0.0001284	0.8444545	0.22810
120.0	0.0006792	228.8958	491.0397	0.0416	0.0000565	0.0001284	0.8576063	0.22810
126.0	0.0005138	232.4854	505.5639	0.0410	0.0000565	0.0001284	0.8707379	0.22810
132.0	0.0003367	236.0770	519.9878	0.0404	0.0000565	0.0001284	0.8837947	0.22810
138.0	0.0001744	239.6336	534.2716	0.0398	0.0000565	0.0001284	0.8967246	0.22810
144.0	0.0000000	243.0392	547.9486	0.0392	0.0000565	0.0001284	0.9091053	0.22810

slab temperature summary time = 0.0000 seconds
(assembly no. - channel no.)

axial zone (inches)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
0.0 - 6.0	241.9850	241.9809	248.8142	248.8203	241.9860	241.9890	248.8308	248.8277	229.3750	229.1004
6.0 - 12.0	255.1232	255.1149	270.4795	270.4936	255.1252	255.1314	270.5179	270.5102	237.6093	236.9825
12.0 - 18.0	272.9195	272.9040	296.5808	296.6073	272.9228	272.9346	296.6523	296.6369	247.7868	246.6074
18.0 - 24.0	292.1328	292.1083	323.9142	323.9555	292.1375	292.1566	324.0250	323.9996	258.7183	256.8244
24.0 - 30.0	312.2474	312.2128	351.8957	351.9529	312.2534	312.2809	352.0484	352.0117	270.1707	267.4189
30.0 - 36.0	332.7469	332.7019	380.2075	380.2802	332.7538	332.7901	380.4007	380.3522	281.9997	278.2678
36.0 - 42.0	353.4743	353.4193	408.5942	408.6811	353.4818	353.5268	408.8239	408.7643	294.1261	289.3171
42.0 - 48.0	374.2926	374.2283	436.8806	436.9799	374.3000	374.3534	437.1429	437.0728	306.4491	300.5092
48.0 - 54.0	395.1910	395.1183	465.0694	465.1792	395.1980	395.2591	465.3591	465.2797	318.9423	311.7879
54.0 - 60.0	416.1162	416.0364	493.0617	493.1796	416.1223	416.1903	493.3724	493.2855	331.6350	323.2039
60.0 - 66.0	437.0011	436.9155	520.7079	520.8315	437.0061	437.0799	521.0341	520.9412	344.5094	334.7677
66.0 - 72.0	457.8068	457.7162	548.0359	548.1641	457.8106	457.8895	548.3748	548.2769	357.5483	346.4788
72.0 - 78.0	478.5620	478.4676	575.1249	575.2561	478.5647	478.6477	575.4724	575.3707	370.7362	358.3351
78.0 - 84.0	499.2285	499.1315	601.9074	602.0399	499.2301	499.3161	602.2587	602.1548	384.0570	370.3357
84.0 - 90.0	519.7505	519.6519	628.2865	628.4187	519.7511	519.8392	628.6381	628.5332	397.4830	382.4776
90.0 - 96.0	540.1425	540.0428	654.3798	654.5117	540.1422	540.2319	654.7312	654.6255	410.9798	394.7488
96.0 -102.0	560.4354	560.3354	680.2297	680.3602	560.4345	560.5250	680.5781	680.4727	424.5549	407.1200
102.0 -108.0	580.6075	580.5079	705.7671	705.8949	580.6058	580.6964	706.1091	706.0049	438.2283	419.5987
108.0 -114.0	600.6279	600.5294	730.9165	731.0414	600.6256	600.7157	731.2516	731.1491	451.9959	432.2211
114.0 -120.0	620.5174	620.4201	755.8201	755.9423	620.5147	620.6041	756.1483	756.0475	465.8516	444.9894
120.0 -126.0	640.2942	640.1986	780.5073	780.6262	640.2915	640.3798	780.8274	780.7287	479.7856	457.9022
126.0 -132.0	659.5120	659.4185	804.8711	804.9860	659.5090	659.5957	805.1807	805.0849	493.6931	470.8706
132.0 -138.0	677.7287	677.6375	828.5951	828.7060	677.7256	677.8104	828.8944	828.8016	507.2859	483.6096
138.0 -144.0	691.5853	691.4963	849.6370	849.7445	691.5821	691.6651	849.9275	849.8372	518.8163	494.3118

slab temperature summary time = 0.0000 seconds
(assembly no. - channel no.)

axial zone (inches)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
0.0 - 6.0	229.1445	229.1420	229.0952	229.3709	229.3691	229.0980	229.1476	229.1489	229.1020	229.3743
6.0 - 12.0	236.9742	236.9690	236.9715	237.6005	237.5963	236.9773	236.9806	236.9835	236.9860	237.6073
12.0 - 18.0	246.5513	246.5419	246.5879	247.7709	247.7633	246.5983	246.5622	246.5678	246.6139	247.7828
18.0 - 24.0	256.7086	256.6942	256.7952	258.6941	258.6826	256.8111	256.7246	256.7335	256.8347	258.7120
24.0 - 30.0	267.2270	267.2072	267.3797	270.1377	270.1224	267.4015	267.2481	267.2609	267.4336	270.1619
30.0 - 36.0	277.9785	277.9531	278.2187	281.9580	281.9391	278.2468	278.0045	278.0213	278.2873	281.9886

36.0 - 42.0	288.9084	288.8778	289.2588	294.0760	294.0542	289.2929	288.9390	288.9599	289.3414	294.1129
42.0 - 48.0	299.9618	299.9263	300.4428	306.3915	306.3676	300.4826	299.9964	300.0213	300.5384	306.4344
48.0 - 54.0	311.0811	311.0411	311.7140	318.8774	318.8518	311.7593	311.1193	311.1479	311.8217	318.9263
54.0 - 60.0	322.3143	322.2700	323.1231	331.5635	331.5368	323.1738	322.3560	322.3883	323.2425	331.6182
60.0 - 66.0	333.6756	333.6274	334.6808	344.4320	344.4047	334.7366	333.7206	333.7563	334.8109	344.4923
66.0 - 72.0	345.1667	345.1151	346.3865	357.4657	357.4384	346.4471	345.2147	345.2535	346.5264	357.5313
72.0 - 78.0	356.7881	356.7335	358.2381	370.6489	370.6222	358.3032	356.8389	356.8805	358.3870	370.7196
78.0 - 84.0	368.5416	368.4844	370.2348	383.9659	383.9401	370.3041	368.5950	368.6392	370.3917	384.0412
84.0 - 90.0	380.4282	380.3687	382.3734	397.3889	397.3644	382.4466	380.4841	380.5304	382.5374	397.4684
90.0 - 96.0	392.4425	392.3814	394.6422	410.8836	410.8607	394.7189	392.5007	392.5488	394.8122	410.9666
96.0 -102.0	404.5586	404.4962	407.0117	424.4566	424.4355	407.0913	404.6186	404.6681	407.1865	424.5432
102.0 -108.0	416.7703	416.7069	419.4888	438.1286	438.1094	419.5716	416.8325	416.8833	419.6685	438.2184
108.0 -114.0	429.1255	429.0611	432.1100	451.8952	451.8783	432.1958	429.1898	429.2417	432.2940	451.9881
114.0 -120.0	441.6296	441.5646	444.8777	465.7504	465.7358	444.9662	441.6960	441.7487	445.0653	465.8459
120.0 -126.0	454.2837	454.2185	457.7902	479.6843	479.6725	457.8816	454.3525	454.4057	457.9812	479.7823
126.0 -132.0	466.9989	466.9335	470.7587	493.5922	493.5831	470.8526	467.0697	467.1233	470.9523	493.6922
132.0 -138.0	479.4881	479.4228	483.4982	507.1860	507.1795	483.5943	479.5608	479.6145	483.6938	507.2874
138.0 -144.0	489.9305	489.8655	494.2012	518.7172	518.7129	494.2989	490.0048	490.0585	494.3978	518.8197

slab temperature summary time = 0.0000 seconds
(assembly no. - channel no.)

axial zone (inches)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(
0.0 - 6.0	231.3081	231.3061	242.7569	242.7521	242.7639	242.7612	231.3071	231.3049	
6.0 - 12.0	242.5822	242.5775	265.0717	265.0585	265.0922	265.0844	242.5787	242.5730	
12.0 - 18.0	255.5929	255.5839	289.4940	289.4684	289.5331	289.5171	255.5867	255.5760	
18.0 - 24.0	269.4232	269.4087	314.8232	314.7829	314.8839	314.8576	269.4145	269.3977	
24.0 - 30.0	283.8249	283.8044	340.7965	340.7403	340.8801	340.8420	283.8142	283.7910	
30.0 - 36.0	298.5707	298.5441	367.2169	367.1450	367.3222	367.2718	298.5585	298.5288	
36.0 - 42.0	313.5321	313.4996	393.8661	393.7797	393.9908	393.9286	313.5194	313.4835	
42.0 - 48.0	328.5482	328.5101	420.5584	420.4593	420.6996	420.6264	328.5350	328.4934	
48.0 - 54.0	343.6681	343.6249	447.3235	447.2130	447.4791	447.3957	343.6548	343.6079	
54.0 - 60.0	358.8549	358.8072	474.0870	473.9676	474.2535	474.1616	358.8416	358.7901	
60.0 - 66.0	374.0695	374.0180	500.6988	500.5727	500.8730	500.7745	374.0563	374.0009	
66.0 - 72.0	389.2865	389.2317	527.0897	526.9580	527.2707	527.1662	389.2737	389.2148	
72.0 - 78.0	404.5017	404.4443	553.4137	553.2779	553.5995	553.4904	404.4893	404.4277	
78.0 - 84.0	419.6932	419.6338	579.5838	579.4459	579.7716	579.6596	419.6813	419.6177	
84.0 - 90.0	434.8013	434.7405	605.4830	605.3446	605.6711	605.5575	434.7899	434.7248	
90.0 - 96.0	449.8613	449.7995	631.1417	631.0028	631.3302	631.2152	449.8506	449.7844	
96.0 -102.0	464.8866	464.8241	656.6718	656.5335	656.8593	656.7440	464.8765	464.8096	
102.0 -108.0	479.8728	479.8101	681.9927	681.8565	682.1773	682.0629	479.8634	479.7962	
108.0 -114.0	494.8130	494.7503	707.0119	706.8785	707.1929	707.0801	494.8043	494.7371	
114.0 -120.0	509.7117	509.6494	731.8007	731.6696	731.9786	731.8672	509.7039	509.6370	
120.0 -126.0	524.5595	524.4979	756.4478	756.3197	756.6218	756.5125	524.5528	524.4867	
126.0 -132.0	539.2153	539.1546	780.8150	780.6908	780.9840	780.8776	539.2098	539.1445	
132.0 -138.0	553.5689	553.5092	804.6858	804.5658	804.8493	804.7462	553.5645	553.5002	
138.0 -144.0	566.6441	566.5854	827.2059	827.0895	827.3649	827.2646	566.6407	566.5775	

calculated rod temperatures at time = 0.0000 seconds
rod no. 1
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) * fluid	clad

0.0 - 6.0	0.0000	1	2.1	240.5	256.6
6.0 - 12.0	0.0000	1	2.1	264.4	281.1
12.0 - 18.0	0.0000	1	2.2	289.5	306.8
18.0 - 24.0	0.0000	1	2.2	315.6	333.2
24.0 - 30.0	0.0000	1	2.2	342.3	360.1
30.0 - 36.0	0.0000	1	2.2	369.6	387.5
36.0 - 42.0	0.0000	1	2.3	397.1	414.9
42.0 - 48.0	0.0000	1	2.3	424.6	442.4
48.0 - 54.0	0.0000	1	2.3	452.2	469.8
54.0 - 60.0	0.0000	1	2.3	479.7	497.1
60.0 - 66.0	0.0000	1	2.4	506.9	524.2
66.0 - 72.0	0.0000	1	2.4	533.9	550.9
72.0 - 78.0	0.0000	1	2.4	560.7	577.5
78.0 - 84.0	0.0000	1	2.5	587.3	603.8
84.0 - 90.0	0.0000	1	2.5	613.5	629.8
90.0 - 96.0	0.0000	1	2.5	639.4	655.5
96.0 - 102.0	0.0000	1	2.5	665.2	681.0
102.0 - 108.0	0.0000	1	2.5	690.7	706.2
108.0 - 114.0	0.0000	1	2.6	715.8	731.1
114.0 - 120.0	0.0000	1	2.6	740.6	755.8
120.0 - 126.0	0.0000	1	2.6	765.3	780.2
126.0 - 132.0	0.0000	1	2.6	789.8	804.5
132.0 - 138.0	0.0000	1	2.6	813.7	828.2
138.0 - 144.0	0.0000	1	2.7	836.5	850.6

calculated rod temperatures at time = 0.0000 seconds
rod no. 2
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) * fluid	clad
0.0 - 6.0	0.0000	1	2.2	243.2	258.3
6.0 - 12.0	0.0000	1	2.2	268.8	284.1
12.0 - 18.0	0.0000	1	2.2	294.8	310.2
18.0 - 24.0	0.0000	1	2.3	321.0	336.7
24.0 - 30.0	0.0000	1	2.3	347.7	363.5
30.0 - 36.0	0.0000	1	2.3	374.8	390.6
36.0 - 42.0	0.0000	1	2.4	402.0	417.8
42.0 - 48.0	0.0000	1	2.4	429.2	445.0
48.0 - 54.0	0.0000	1	2.4	456.4	472.2
54.0 - 60.0	0.0000	1	2.4	483.6	499.3
60.0 - 66.0	0.0000	1	2.5	510.5	526.1
66.0 - 72.0	0.0000	1	2.5	537.2	552.6
72.0 - 78.0	0.0000	1	2.5	563.7	579.0
78.0 - 84.0	0.0000	1	2.5	590.1	605.2
84.0 - 90.0	0.0000	1	2.6	616.1	631.0
90.0 - 96.0	0.0000	1	2.6	641.8	656.5
96.0 - 102.0	0.0000	1	2.6	667.4	681.9
102.0 - 108.0	0.0000	1	2.6	692.7	707.1
108.0 - 114.0	0.0000	1	2.7	717.7	731.9
114.0 - 120.0	0.0000	1	2.7	742.4	756.4
120.0 - 126.0	0.0000	1	2.7	766.9	780.8
126.0 - 132.0	0.0000	1	2.7	791.3	805.0
132.0 - 138.0	0.0000	1	2.7	815.1	828.6
138.0 - 144.0	0.0000	1	2.8	838.0	851.2

calculated rod temperatures at time = 0.0000 seconds
rod no. 3

assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) * fluid	clad
0.0 - 6.0	0.0000	1	2.2	243.8	259.1
6.0 - 12.0	0.0000	1	2.2	270.2	285.7
12.0 - 18.0	0.0000	1	2.3	296.7	312.3
18.0 - 24.0	0.0000	1	2.3	323.2	339.1
24.0 - 30.0	0.0000	1	2.3	350.1	366.0
30.0 - 36.0	0.0000	1	2.3	377.2	393.1
36.0 - 42.0	0.0000	1	2.4	404.3	420.3
42.0 - 48.0	0.0000	1	2.4	431.5	447.4
48.0 - 54.0	0.0000	1	2.4	458.6	474.4
54.0 - 60.0	0.0000	1	2.4	485.6	501.3
60.0 - 66.0	0.0000	1	2.5	512.4	528.0
66.0 - 72.0	0.0000	1	2.5	538.9	554.4
72.0 - 78.0	0.0000	1	2.5	565.4	580.6
78.0 - 84.0	0.0000	1	2.5	591.6	606.7
84.0 - 90.0	0.0000	1	2.6	617.4	632.4
90.0 - 96.0	0.0000	1	2.6	643.1	657.8
96.0 - 102.0	0.0000	1	2.6	668.5	683.1
102.0 - 108.0	0.0000	1	2.6	693.8	708.2
108.0 - 114.0	0.0000	1	2.7	718.6	732.9
114.0 - 120.0	0.0000	1	2.7	743.3	757.4
120.0 - 126.0	0.0000	1	2.7	767.8	781.7
126.0 - 132.0	0.0000	1	2.7	792.1	805.8
132.0 - 138.0	0.0000	1	2.7	815.9	829.4
138.0 - 144.0	0.0000	1	2.8	838.8	852.0

calculated rod temperatures at time = 0.0000 seconds
rod no. 4
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) * fluid	clad
0.0 - 6.0	0.0000	1	2.2	244.1	259.5
6.0 - 12.0	0.0000	1	2.2	270.9	286.6
12.0 - 18.0	0.0000	1	2.3	297.8	313.6
18.0 - 24.0	0.0000	1	2.3	324.6	340.6
24.0 - 30.0	0.0000	1	2.3	351.7	367.7
30.0 - 36.0	0.0000	1	2.3	378.8	395.0
36.0 - 42.0	0.0000	1	2.4	406.0	422.1
42.0 - 48.0	0.0000	1	2.4	433.1	449.2
48.0 - 54.0	0.0000	1	2.4	460.2	476.1
54.0 - 60.0	0.0000	1	2.4	487.1	503.0
60.0 - 66.0	0.0000	1	2.5	513.8	529.5
66.0 - 72.0	0.0000	1	2.5	540.3	555.8
72.0 - 78.0	0.0000	1	2.5	566.6	582.0
78.0 - 84.0	0.0000	1	2.5	592.7	607.9
84.0 - 90.0	0.0000	1	2.6	618.5	633.5
90.0 - 96.0	0.0000	1	2.6	644.1	658.9
96.0 - 102.0	0.0000	1	2.6	669.5	684.2
102.0 - 108.0	0.0000	1	2.6	694.6	709.1
108.0 - 114.0	0.0000	1	2.7	719.5	733.8
114.0 - 120.0	0.0000	1	2.7	744.1	758.2
120.0 - 126.0	0.0000	1	2.7	768.5	782.5
126.0 - 132.0	0.0000	1	2.7	792.7	806.5

132.0 - 138.0	0.0000	1	2.7	816.5	830.0
138.0 - 144.0	0.0000	1	2.8	839.5	852.8

calculated rod temperatures at time = 0.0000 seconds
rod no. 5
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) * fluid	clad
0.0 - 6.0	0.0000	1	2.2	244.3	259.7
6.0 - 12.0	0.0000	1	2.2	271.3	287.1
12.0 - 18.0	0.0000	1	2.3	298.4	314.4
18.0 - 24.0	0.0000	1	2.3	325.5	341.7
24.0 - 30.0	0.0000	1	2.3	352.7	369.0
30.0 - 36.0	0.0000	1	2.3	380.0	396.3
36.0 - 42.0	0.0000	1	2.4	407.2	423.5
42.0 - 48.0	0.0000	1	2.4	434.3	450.5
48.0 - 54.0	0.0000	1	2.4	461.4	477.5
54.0 - 60.0	0.0000	1	2.4	488.3	504.3
60.0 - 66.0	0.0000	1	2.5	514.9	530.7
66.0 - 72.0	0.0000	1	2.5	541.3	557.0
72.0 - 78.0	0.0000	1	2.5	567.6	583.1
78.0 - 84.0	0.0000	1	2.5	593.6	608.9
84.0 - 90.0	0.0000	1	2.6	619.4	634.5
90.0 - 96.0	0.0000	1	2.6	644.9	659.8
96.0 - 102.0	0.0000	1	2.6	670.2	685.0
102.0 - 108.0	0.0000	1	2.6	695.3	709.9
108.0 - 114.0	0.0000	1	2.7	720.1	734.5
114.0 - 120.0	0.0000	1	2.7	744.6	758.8
120.0 - 126.0	0.0000	1	2.7	769.0	783.1
126.0 - 132.0	0.0000	1	2.7	793.2	807.1
132.0 - 138.0	0.0000	1	2.7	817.0	830.6
138.0 - 144.0	0.0000	1	2.8	840.0	853.3

calculated rod temperatures at time = 0.0000 seconds
rod no. 6
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) * fluid	clad
0.0 - 6.0	0.0000	1	2.2	244.3	259.8
6.0 - 12.0	0.0000	1	2.2	271.5	287.4
12.0 - 18.0	0.0000	1	2.3	298.8	315.0
18.0 - 24.0	0.0000	1	2.3	326.0	342.4
24.0 - 30.0	0.0000	1	2.3	353.3	369.8
30.0 - 36.0	0.0000	1	2.3	380.7	397.2
36.0 - 42.0	0.0000	1	2.4	408.0	424.4
42.0 - 48.0	0.0000	1	2.4	435.1	451.4
48.0 - 54.0	0.0000	1	2.4	462.1	478.4
54.0 - 60.0	0.0000	1	2.4	489.0	505.1
60.0 - 66.0	0.0000	1	2.5	515.6	531.6
66.0 - 72.0	0.0000	1	2.5	542.0	557.8
72.0 - 78.0	0.0000	1	2.5	568.2	583.8
78.0 - 84.0	0.0000	1	2.5	594.2	609.6
84.0 - 90.0	0.0000	1	2.6	619.9	635.1

90.0 - 96.0	0.0000	1	2.6	645.4	660.4
96.0 - 102.0	0.0000	1	2.6	670.7	685.5
102.0 - 108.0	0.0000	1	2.6	695.8	710.4
108.0 - 114.0	0.0000	1	2.7	720.5	735.0
114.0 - 120.0	0.0000	1	2.7	745.0	759.3
120.0 - 126.0	0.0000	1	2.7	769.4	783.5
126.0 - 132.0	0.0000	1	2.7	793.6	807.5
132.0 - 138.0	0.0000	1	2.7	817.3	831.0
138.0 - 144.0	0.0000	1	2.8	840.3	853.7

calculated rod temperatures at time = 0.0000 seconds
rod no. 7
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	2.2	244.4	259.9
6.0 - 12.0	0.0000	1	2.2	271.6	287.5
12.0 - 18.0	0.0000	1	2.3	299.0	315.2
18.0 - 24.0	0.0000	1	2.3	326.3	342.7
24.0 - 30.0	0.0000	1	2.3	353.7	370.1
30.0 - 36.0	0.0000	1	2.3	381.1	397.6
36.0 - 42.0	0.0000	1	2.4	408.4	424.8
42.0 - 48.0	0.0000	1	2.4	435.5	451.9
48.0 - 54.0	0.0000	1	2.4	462.5	478.8
54.0 - 60.0	0.0000	1	2.4	489.4	505.5
60.0 - 66.0	0.0000	1	2.5	516.0	531.9
66.0 - 72.0	0.0000	1	2.5	542.3	558.1
72.0 - 78.0	0.0000	1	2.5	568.5	584.1
78.0 - 84.0	0.0000	1	2.5	594.5	609.9
84.0 - 90.0	0.0000	1	2.6	620.2	635.4
90.0 - 96.0	0.0000	1	2.6	645.6	660.7
96.0 - 102.0	0.0000	1	2.6	670.9	685.8
102.0 - 108.0	0.0000	1	2.6	696.0	710.6
108.0 - 114.0	0.0000	1	2.7	720.7	735.2
114.0 - 120.0	0.0000	1	2.7	745.2	759.5
120.0 - 126.0	0.0000	1	2.7	769.6	783.7
126.0 - 132.0	0.0000	1	2.7	793.7	807.6
132.0 - 138.0	0.0000	1	2.7	817.5	831.1
138.0 - 144.0	0.0000	1	2.8	840.4	853.9

calculated rod temperatures at time = 0.0000 seconds
rod no. 8
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	2.2	244.4	259.9
6.0 - 12.0	0.0000	1	2.2	271.6	287.5
12.0 - 18.0	0.0000	1	2.3	299.0	315.2
18.0 - 24.0	0.0000	1	2.3	326.3	342.6
24.0 - 30.0	0.0000	1	2.3	353.6	370.1
30.0 - 36.0	0.0000	1	2.3	381.1	397.5
36.0 - 42.0	0.0000	1	2.4	408.3	424.8
42.0 - 48.0	0.0000	1	2.4	435.5	451.8

48.0 - 54.0	0.0000	1	2.4	462.5	478.8
54.0 - 60.0	0.0000	1	2.4	489.4	505.5
60.0 - 66.0	0.0000	1	2.5	516.0	531.9
66.0 - 72.0	0.0000	1	2.5	542.3	558.1
72.0 - 78.0	0.0000	1	2.5	568.5	584.1
78.0 - 84.0	0.0000	1	2.5	594.5	609.9
84.0 - 90.0	0.0000	1	2.6	620.2	635.4
90.0 - 96.0	0.0000	1	2.6	645.6	660.6
96.0 - 102.0	0.0000	1	2.6	670.9	685.8
102.0 - 108.0	0.0000	1	2.6	695.9	710.6
108.0 - 114.0	0.0000	1	2.7	720.7	735.1
114.0 - 120.0	0.0000	1	2.7	745.2	759.5
120.0 - 126.0	0.0000	1	2.7	769.6	783.7
126.0 - 132.0	0.0000	1	2.7	793.7	807.6
132.0 - 138.0	0.0000	1	2.7	817.4	831.1
138.0 - 144.0	0.0000	1	2.8	840.4	853.9

calculated rod temperatures at time = 0.0000 seconds
rod no. 183
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	1.8	226.8	232.2
6.0 - 12.0	0.0000	1	1.8	236.8	242.4
12.0 - 18.0	0.0000	1	1.8	247.7	253.4
18.0 - 24.0	0.0000	1	1.8	259.3	265.1
24.0 - 30.0	0.0000	1	1.8	271.5	277.4
30.0 - 36.0	0.0000	1	1.9	284.2	290.0
36.0 - 42.0	0.0000	1	1.9	297.1	303.0
42.0 - 48.0	0.0000	1	1.9	310.3	316.1
48.0 - 54.0	0.0000	1	1.9	323.7	329.3
54.0 - 60.0	0.0000	1	1.9	337.2	342.8
60.0 - 66.0	0.0000	1	1.9	350.9	356.4
66.0 - 72.0	0.0000	1	1.9	364.7	370.2
72.0 - 78.0	0.0000	1	1.9	378.7	384.0
78.0 - 84.0	0.0000	1	1.9	392.7	397.9
84.0 - 90.0	0.0000	1	2.0	406.7	411.9
90.0 - 96.0	0.0000	1	2.0	420.8	425.9
96.0 - 102.0	0.0000	1	2.0	434.9	439.9
102.0 - 108.0	0.0000	1	2.0	449.1	454.0
108.0 - 114.0	0.0000	1	2.0	463.3	468.2
114.0 - 120.0	0.0000	1	2.0	477.6	482.3
120.0 - 126.0	0.0000	1	2.0	491.9	496.6
126.0 - 132.0	0.0000	1	2.0	506.1	510.7
132.0 - 138.0	0.0000	1	2.0	520.2	524.7
138.0 - 144.0	0.0000	1	2.1	533.4	537.8

calculated rod temperatures at time = 0.0000 seconds
rod no. 184
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	1.9	227.8	232.8

6.0 - 12.0	0.0000	1	1.9	238.6	243.6
12.0 - 18.0	0.0000	1	1.9	250.0	255.0
18.0 - 24.0	0.0000	1	1.9	261.9	266.9
24.0 - 30.0	0.0000	1	1.9	274.4	279.4
30.0 - 36.0	0.0000	1	1.9	287.4	292.2
36.0 - 42.0	0.0000	1	1.9	300.6	305.3
42.0 - 48.0	0.0000	1	1.9	314.0	318.6
48.0 - 54.0	0.0000	1	2.0	327.6	332.0
54.0 - 60.0	0.0000	1	2.0	341.3	345.6
60.0 - 66.0	0.0000	1	2.0	355.2	359.3
66.0 - 72.0	0.0000	1	2.0	369.2	373.2
72.0 - 78.0	0.0000	1	2.0	383.3	387.1
78.0 - 84.0	0.0000	1	2.0	397.5	401.1
84.0 - 90.0	0.0000	1	2.0	411.6	415.1
90.0 - 96.0	0.0000	1	2.0	425.8	429.2
96.0 - 102.0	0.0000	1	2.1	440.1	443.3
102.0 - 108.0	0.0000	1	2.1	454.4	457.4
108.0 - 114.0	0.0000	1	2.1	468.7	471.6
114.0 - 120.0	0.0000	1	2.1	483.0	485.8
120.0 - 126.0	0.0000	1	2.1	497.4	500.0
126.0 - 132.0	0.0000	1	2.1	511.6	514.2
132.0 - 138.0	0.0000	1	2.1	525.8	528.2
138.0 - 144.0	0.0000	1	2.1	539.3	541.4

calculated rod temperatures at time = 0.0000 seconds
rod no. 185
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	* fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	1.9	228.0	233.1
6.0 - 12.0	0.0000	1	1.9	239.1	244.2
12.0 - 18.0	0.0000	1	1.9	250.7	255.8
18.0 - 24.0	0.0000	1	1.9	262.9	268.0
24.0 - 30.0	0.0000	1	1.9	275.5	280.5
30.0 - 36.0	0.0000	1	1.9	288.6	293.5
36.0 - 42.0	0.0000	1	1.9	301.9	306.7
42.0 - 48.0	0.0000	1	1.9	315.3	320.0
48.0 - 54.0	0.0000	1	2.0	329.0	333.5
54.0 - 60.0	0.0000	1	2.0	342.8	347.1
60.0 - 66.0	0.0000	1	2.0	356.7	360.9
66.0 - 72.0	0.0000	1	2.0	370.8	374.8
72.0 - 78.0	0.0000	1	2.0	384.9	388.7
78.0 - 84.0	0.0000	1	2.0	399.1	402.7
84.0 - 90.0	0.0000	1	2.0	413.3	416.8
90.0 - 96.0	0.0000	1	2.0	427.5	430.8
96.0 - 102.0	0.0000	1	2.1	441.7	445.0
102.0 - 108.0	0.0000	1	2.1	456.0	459.1
108.0 - 114.0	0.0000	1	2.1	470.3	473.3
114.0 - 120.0	0.0000	1	2.1	484.7	487.5
120.0 - 126.0	0.0000	1	2.1	499.0	501.7
126.0 - 132.0	0.0000	1	2.1	513.3	515.9
132.0 - 138.0	0.0000	1	2.1	527.5	529.9
138.0 - 144.0	0.0000	1	2.1	541.0	543.3

calculated rod temperatures at time = 0.0000 seconds
rod no. 186
assembly 2 (fuel type 1 - cylinder)

rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	1.9	228.1	233.2
6.0 - 12.0	0.0000	1	1.9	239.4	244.5
12.0 - 18.0	0.0000	1	1.9	251.2	256.3
18.0 - 24.0	0.0000	1	1.9	263.4	268.6
24.0 - 30.0	0.0000	1	1.9	276.2	281.3
30.0 - 36.0	0.0000	1	1.9	289.3	294.3
36.0 - 42.0	0.0000	1	1.9	302.7	307.5
42.0 - 48.0	0.0000	1	1.9	316.1	320.9
48.0 - 54.0	0.0000	1	2.0	329.8	334.4
54.0 - 60.0	0.0000	1	2.0	343.7	348.1
60.0 - 66.0	0.0000	1	2.0	357.6	361.9
66.0 - 72.0	0.0000	1	2.0	371.7	375.8
72.0 - 78.0	0.0000	1	2.0	385.8	389.7
78.0 - 84.0	0.0000	1	2.0	400.0	403.8
84.0 - 90.0	0.0000	1	2.0	414.2	417.8
90.0 - 96.0	0.0000	1	2.0	428.4	431.9
96.0 - 102.0	0.0000	1	2.1	442.7	446.0
102.0 - 108.0	0.0000	1	2.1	457.0	460.1
108.0 - 114.0	0.0000	1	2.1	471.3	474.3
114.0 - 120.0	0.0000	1	2.1	485.6	488.5
120.0 - 126.0	0.0000	1	2.1	500.0	502.7
126.0 - 132.0	0.0000	1	2.1	514.3	516.9
132.0 - 138.0	0.0000	1	2.1	528.4	530.9
138.0 - 144.0	0.0000	1	2.1	542.0	544.4

calculated rod temperatures at time = 0.0000 seconds
rod no. 187
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	1.9	228.2	233.3
6.0 - 12.0	0.0000	1	1.9	239.5	244.7
12.0 - 18.0	0.0000	1	1.9	251.4	256.6
18.0 - 24.0	0.0000	1	1.9	263.8	269.0
24.0 - 30.0	0.0000	1	1.9	276.6	281.7
30.0 - 36.0	0.0000	1	1.9	289.8	294.8
36.0 - 42.0	0.0000	1	1.9	303.2	308.1
42.0 - 48.0	0.0000	1	1.9	316.7	321.5
48.0 - 54.0	0.0000	1	2.0	330.4	335.0
54.0 - 60.0	0.0000	1	2.0	344.2	348.7
60.0 - 66.0	0.0000	1	2.0	358.2	362.5
66.0 - 72.0	0.0000	1	2.0	372.3	376.4
72.0 - 78.0	0.0000	1	2.0	386.4	390.4
78.0 - 84.0	0.0000	1	2.0	400.6	404.4
84.0 - 90.0	0.0000	1	2.0	414.8	418.5
90.0 - 96.0	0.0000	1	2.0	429.0	432.5
96.0 - 102.0	0.0000	1	2.1	443.3	446.7
102.0 - 108.0	0.0000	1	2.1	457.6	460.8
108.0 - 114.0	0.0000	1	2.1	471.9	475.0
114.0 - 120.0	0.0000	1	2.1	486.2	489.2
120.0 - 126.0	0.0000	1	2.1	500.6	503.4
126.0 - 132.0	0.0000	1	2.1	514.8	517.6
132.0 - 138.0	0.0000	1	2.1	529.0	531.6

138.0 - 144.0	0.0000	1	2.1	542.6	545.1

calculated rod temperatures at time = 0.0000 seconds
rod no. 188
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	1.9	228.2	233.3
6.0 - 12.0	0.0000	1	1.9	239.6	244.8
12.0 - 18.0	0.0000	1	1.9	251.5	256.8
18.0 - 24.0	0.0000	1	1.9	264.0	269.2
24.0 - 30.0	0.0000	1	1.9	276.8	282.0
30.0 - 36.0	0.0000	1	1.9	290.0	295.2
36.0 - 42.0	0.0000	1	1.9	303.5	308.5
42.0 - 48.0	0.0000	1	2.0	317.0	321.9
48.0 - 54.0	0.0000	1	2.0	330.7	335.4
54.0 - 60.0	0.0000	1	2.0	344.6	349.1
60.0 - 66.0	0.0000	1	2.0	358.6	363.0
66.0 - 72.0	0.0000	1	2.0	372.7	376.9
72.0 - 78.0	0.0000	1	2.0	386.8	390.8
78.0 - 84.0	0.0000	1	2.0	401.0	404.9
84.0 - 90.0	0.0000	1	2.0	415.2	418.9
90.0 - 96.0	0.0000	1	2.0	429.4	433.0
96.0 - 102.0	0.0000	1	2.1	443.7	447.1
102.0 - 108.0	0.0000	1	2.1	457.9	461.2
108.0 - 114.0	0.0000	1	2.1	472.3	475.4
114.0 - 120.0	0.0000	1	2.1	486.6	489.6
120.0 - 126.0	0.0000	1	2.1	500.9	503.8
126.0 - 132.0	0.0000	1	2.1	515.2	518.0
132.0 - 138.0	0.0000	1	2.1	529.3	532.0
138.0 - 144.0	0.0000	1	2.1	543.0	545.5

calculated rod temperatures at time = 0.0000 seconds
rod no. 189
assembly 2 (fuel type 1 - cylinder)
rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.422)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2)	fuel temperatures(f.) fluid	clad
0.0 - 6.0	0.0000	1	1.9	228.2	233.3
6.0 - 12.0	0.0000	1	1.9	239.6	244.9
12.0 - 18.0	0.0000	1	1.9	251.6	256.9
18.0 - 24.0	0.0000	1	1.9	264.1	269.4
24.0 - 30.0	0.0000	1	1.9	277.0	282.2
30.0 - 36.0	0.0000	1	1.9	290.2	295.3
36.0 - 42.0	0.0000	1	1.9	303.6	308.6
42.0 - 48.0	0.0000	1	2.0	317.2	322.1
48.0 - 54.0	0.0000	1	2.0	330.9	335.6
54.0 - 60.0	0.0000	1	2.0	344.8	349.3
60.0 - 66.0	0.0000	1	2.0	358.8	363.2
66.0 - 72.0	0.0000	1	2.0	372.8	377.1
72.0 - 78.0	0.0000	1	2.0	387.0	391.0
78.0 - 84.0	0.0000	1	2.0	401.2	405.1
84.0 - 90.0	0.0000	1	2.0	415.4	419.1
90.0 - 96.0	0.0000	1	2.0	429.6	433.2

```
 96.0 - 102.0    0.0000    1              2.1      443.8    447.3
102.0 - 108.0    0.0000    1              2.1      458.1    461.4
108.0 - 114.0    0.0000    1              2.1      472.4    475.6
114.0 - 120.0    0.0000    1              2.1      486.8    489.8
120.0 - 126.0    0.0000    1              2.1      501.1    504.0
126.0 - 132.0    0.0000    1              2.1      515.4    518.2
132.0 - 138.0    0.0000    1              2.1      529.5    532.2
138.0 - 144.0    0.0000    1              2.1      543.1    545.7


calculated rod temperatures at time =      0.0000 seconds
rod no.  190
assembly   2                    (fuel type  1 - cylinder)
rod o.d. - 0.422 (in.)     zone-(fuel dia.(in.)) -  1-(0.422)

                                                *   fuel temperatures(f.)
                                                *
  axial zone  heat flux   type          hsurf  *   fluid    clad
     (in.)   (mbtu/hr-ft2)         (b/h-f-ft2) *
  0.0 -   6.0    0.0000    1              1.9      228.2    233.3
  6.0 -  12.0    0.0000    1              1.9      239.6    244.9
 12.0 -  18.0    0.0000    1              1.9      251.6    256.9
 18.0 -  24.0    0.0000    1              1.9      264.1    269.4
 24.0 -  30.0    0.0000    1              1.9      277.0    282.2
 30.0 -  36.0    0.0000    1              1.9      290.2    295.3
 36.0 -  42.0    0.0000    1              1.9      303.6    308.6
 42.0 -  48.0    0.0000    1              2.0      317.2    322.1
 48.0 -  54.0    0.0000    1              2.0      330.9    335.6
 54.0 -  60.0    0.0000    1              2.0      344.8    349.3
 60.0 -  66.0    0.0000    1              2.0      358.8    363.1
 66.0 -  72.0    0.0000    1              2.0      372.8    377.1
 72.0 -  78.0    0.0000    1              2.0      387.0    391.0
 78.0 -  84.0    0.0000    1              2.0      401.2    405.1
 84.0 -  90.0    0.0000    1              2.0      415.3    419.1
 90.0 -  96.0    0.0000    1              2.0      429.6    433.2
 96.0 - 102.0    0.0000    1              2.1      443.8    447.3
102.0 - 108.0    0.0000    1              2.1      458.1    461.4
108.0 - 114.0    0.0000    1              2.1      472.4    475.6
114.0 - 120.0    0.0000    1              2.1      486.8    489.8
120.0 - 126.0    0.0000    1              2.1      501.1    504.0
126.0 - 132.0    0.0000    1              2.1      515.3    518.2
132.0 - 138.0    0.0000    1              2.1      529.5    532.2
138.0 - 144.0    0.0000    1              2.1      543.1    545.7


iterations =    4


 input transient time completed


common dumped to tape 8
1***** computational time summary *****


    subroutine energy...................     0.06  sec
    subroutine moment...................     0.05  sec
    subroutine reheat...................     0.50  sec
    subroutine recirc (pressure loop)....    0.27  sec
    subroutine result...................     1.15  sec
    subroutine setup....................     0.28  sec
    other subroutines...................    18.12  sec

    total cpu time......................    20.43  sec
```

ATTACHMENT 10

Fuel Handling Area Lighting and Electrical Equipment Heat Loss Calculation

Prepared By: _____ Date: 10/24/13

Reviewed By: _____ Date: 10/24/13

1. Purpose and Scope

   The purpose of this attachment is to calculate the total heat loss due to lighting and electrical equipment in the Fuel Handling Area.

2. Design Inputs

   2.1. Drawing E-860-1 Rev. A, Lighting Drawing List, Specifications & Legend

   2.2. Drawing E-864 Rev. BC, Lighting Reactor and Auxiliary Building Mezzanine Floor El. 606'-0"

   2.3. Drawing E-867 Rev. AV, Lighting Reactor and Auxiliary Building Operating Floor El. 626'-0"

   2.4. DCR 1776 (0), Provide New SFP and Rx Cavity Lighting

   2.5. The total heat loss from lighting in any area of a power station can be estimated as being equal to the input power to all luminaires in that area. (Ref. 7.1)

   2.6. The lamp watts of a fluorescent luminaire should be multiplied by 1.2 to account for the heat loss from ballasts. (Ref. 7.1)

   2.7. The lamp watts of a high intensity discharge luminaire should be multiplied by 1.4 to account for the heat loss from ballasts. (Ref. 7.1)

3. Assumptions

   3.1. It is assumed that all installed lighting fixtures are operational and identified on lighting drawings provided in Section 2 of this Attachment.

   3.2. It is assumed that the elevator will not be operational and no power will be supplied while the plant is shutdown.

   3.3. It is assumed that areas shown surrounded by dotted lines on the drawings are isolated areas where lighting fixtures and electrical equipment in the area will not contribute heat losses to the Fuel Handling Area.

   3.4. For purposes of calculating heat losses in a conservative manner, it is assumed that all Lighting Panelboards are 42 circuit panels.

   3.5. It is assumed that the lighting drawings listed in Section 2 of this Attachment show all existing power/lighting panels and transformers currently existing in those areas.

4. Methodology and Acceptance Criteria

   Lighting drawings specified in Section 2 of this Attachment provide the lighting fixture types and quantitiesinstalled in the Fuel handling Area. Quantities of, and Watts per fixture are used to calculate the total heat loss due to the lighting loads.

5. Calculations

5.1. Lighting Loads

Table 1: Heat Loss for Lighting Loads

Reference Drawing	Light Fixture	Type	Watts/ Fixture	Quantity	Total Heat Loss (Watts)
E-864	300D	Incandescent	300	9	2700
E-864	200C	Incandescent	200	7	1400
E-864	100P	Fluorescent	120[1]	8	960
E-864	50CA[3]	Fluorescent	60[1]	4	240
E-864	25DA	Fluorescent	30[1]	1	30
E-867	1000AA	Incandescent	1000	21	21000
E-867	100P	Fluorescent	120[1]	15	1800
E-867	1000A	Mercury	1400[2]	17	23800
E-867	500E	Incandescent	500	3	1500
E-867	50CA[3]	Fluorescent	60[1]	10	600
E-867	200T	Fluorescent	240[1]	1	240
E-867	200C	Incandescent	200	4	800
E-867	400B	Incandescent	400	3	1200
			TOTAL	**103**	**56270**

[1]The lamp watts of fluorescent luminaires are multiplied by 1.2 to account for the heat loss from ballasts. (Ref. 7.1)
[2] The lamp watts of high intensity discharge (Mercury) luminaires are multiplied by 1.4 to account for the heat loss from ballasts. (Ref. 7.1)
[3] It is assumed that all emergency lighting fixtures are Type 50CA per Note 8 on Drawing E-867 Rev. AV.

5.2. Electrical Equipment Loads

Table 2: Heat Loss for Panels

Drawing	Equipment	Description	# of Ckts[4]	Total Heat Loss (Watts)	Basis
E-867	Spent Pool Control Panel	Control Panel	N/A	Negligible	Note 5
E-867	RPB13	Lighting Panel	42	500	Ref. 7.1
E-867	RPA15	Lighting Panel	42	500	Ref. 7.1
			TOTAL	**1000**	

[4] Number of circuits is estimated based on assumption 3.4
[5] It is assumed that the heat loss due to the Spent Fuel Pool Control Panel is negligible compared to the surrounding lighting loads in the area.

6. Results

The heat loss contribution due to Lighting in the Fuel Handling Area is calculated to be 56.27 KW. The heat loss contribution due to panels in the Fuel Handling Area is calculated to be 1.0 KW. The overall heat loss contribution due to lighting and electrical equipment in the Fuel Handling Building is 57.27 KW.

7. References

7.1. Rubin, Ira M. (1979). "Heat Losses from Electrical Equipment in Generating Stations". IEEE Transactions on Power Apparatus and Systems, vol. PAS-98 (4). pp. 1149-1152

7.2. W. N. White, A. Pahwa, and C. Cruz, "Heat Loss from Electrical and Control Equipment in Industrial Plants: Part I – Methods and Scope," ASHRAE NA-04-9-2a, January 1, 2004.

7.3. W. N. White, A. Pahwa, and C. Cruz, "Heat Loss from Electrical and Control Equipment in Industrial Plants: Part II – Results and Comparisons," ASHRAE NA-04-9-2b, January 1, 2004.

Outside air temperatures are computed in this attachment using the methodology provided in Section 3.1.5 of the main body. For convenience, the methodology is reproduced here:

$$t_{db,h} = t_{db,des} - f(DR)$$

where:

$t_{db,h}$ = hourly dry-bulb temperature, °F
$t_{db,des}$ = design dry-bulb temperature = 69.6°F for October, 86.0°F for July (Input 4.9)
f = hourly daily range fraction (see table below)
DR = daily range of dry-bulb temperature = 14.9°F for October, 16.9°F for July (Input 4.9)

The hourly daily range fraction (f) is taken from Table 6 of Chapter 14 of ASHRAE 2009 [Ref. 2.13] and given in the table below.

Fraction of Daily Temperature Range [Ref. 2.13]

Time, h	Fraction	Time, h	Fraction	Time, h	Fraction
1	0.88	9	0.55	17	0.14
2	0.92	10	0.38	18	0.24
3	0.95	11	0.23	19	0.39
4	0.98	12	0.13	20	0.50
5	1.00	13	0.05	21	0.59
6	0.98	14	0.00	22	0.68
7	0.91	15	0.00	23	0.75
8	0.74	16	0.06	24	0.82

Based on these inputs and methodology, the following outside air temperatures are computed:

Outside Air Temperature in October

Hour of Day	Outside Temperature (°F)	Hour of Day	Outside Temperature (°F)
0	57.4	13	68.9
1	56.5	14	69.6
2	55.9	15	69.6
3	55.4	16	68.7
4	55.0	17	67.5
5	54.7	18	66.0
6	55.0	19	63.8
7	56.0	20	62.2
8	58.6	21	60.8
9	61.4	22	59.5
10	63.9	23	58.4
11	66.2	24	57.4
12	67.7		

Outside Air Temperature in July

Hour of Day	Outside Temperature (°F)	Hour of Day	Outside Temperature (°F)
0	72.1	13	85.2
1	71.1	14	86.0
2	70.5	15	86.0
3	69.9	16	85.0
4	69.4	17	83.6
5	69.1	18	81.9
6	69.4	19	79.4
7	70.6	20	77.6
8	73.5	21	76.0
9	76.7	22	74.5
10	79.6	23	73.3
11	82.1	24	72.1
12	83.8		

Attachment 12, Sheet 1: Spent Fuel Pool Heat Loads: Load Locations

The pool map showing the racks and empty cells is in Reference 2.20

Rack #	Length (Numbers)	Width (Letters)	Empty Cells	Total Assemblies	Cycle 32 Assemblies	Other Assemblies	Edge Cells
1	9	10	4	86	10	76	18
2	9	10	3	87	16	71	9
3	9	10	0	90	14	76	18
4	9	10	6	84	16	68	9
5	9	10	1	89	13	76	9
6	9	10	1	89	8	81	18
7	9	10	22	68	10	58	9
8	9	10	3	87	5	82	18
9	9	10	51	39	13	26	27
10	9	10	2	88	4	84	26
11	9	10	0	90	12	78	18
		Sum	93				

Racks 1-8	South Pool	680	92	588
Racks 9-11	North Pool	217	29	188
	Total	897	121	776
	% in South	75.8%	76.0%	75.8%
	% in North	24.2%	24.0%	24.2%

Heat Load for Others on 10/30/14	1.93	MBTU/hr	Att 12, Sh. 2
Heat Load per Other Assembly on 10/30/14	2487	BTU/hr	
Edge Cells in the South Pool	108	Assemblies	
Total Heat of Edge Assemblies in South Pool	268608	BTU/hr	
Average Heat Load per Assembly on 10/30/14	3266	BTU/hr	Att 12, Sh. 2

Heat Load for Others on 5/18/2015	1.8	MBTU/hr	Att 12, Sh. 2
Heat Load per Other Assembly on 5/18/2015	2320	BTU/hr	
Edge Cells in the South Pool	108	Assemblies	
Total Heat of Edge Assemblies in South Pool	250515	BTU/hr	
Average Heat Load per Assembly on 5/18/2015	2809	BTU/hr	Att 12, Sh. 2

Attachment 12, Sheet 2: Spent Fuel Pool Heat Loads: Loads as a Function of Time

Date	Time	Cycle 32 Discharge Assemblies Only	Total Spent Fuel Pool Heat Load (MBTU/hr)	Non-Cycle 32 Heat Load (MBTU/hr)	South Pool Heat Load (MBTU/hr)	North Pool Heat Load (MBTU/hr)	Maximum Single Assembly Heat (BTU/hr)	Max of the 13 Bounding Arrangements (BTU/hr, see Fig. 3.10)	Average Assembly Heat (BTU/hr)
		Ref. 2.17	Ref. 2.17	Ref. 2.17	Using Ratios developed on Att 12, Pg. 1	Using Ratios developed on Att 12, Pg. 1	= 1.449 * Cycle 32 Total / 121 per Ref. 2.17	= 1.386 * Cycle 32 Total / 121 per Ref. 2.20	= Total Pool Heat / 897 per Att 12, Pg. 1
5/8/2013	0:00	32.25	34.88	2.63	26.44	8.44	386,200	369,409	38,885
5/8/2013	8:00	28.23	30.85	2.62	23.38	7.47	338,060	323,362	34,392
5/8/2013	16:00	26.62	29.24	2.62	22.16	7.08	318,780	304,920	32,598
5/9/2013	0:00	25.39	28.01	2.62	21.23	6.78	304,050	290,831	31,226
5/9/2013	8:00	24.36	26.98	2.62	20.45	6.53	291,716	279,033	30,078
5/9/2013	16:00	23.45	26.07	2.62	19.76	6.31	280,819	268,609	29,064
5/10/2013	0:00	22.62	25.24	2.62	19.13	6.11	270,879	259,102	28,138
5/10/2013	8:00	21.86	24.48	2.62	18.56	5.92	261,778	250,396	27,291
5/10/2013	16:00	21.15	23.77	2.62	18.02	5.75	253,276	242,264	26,499
5/11/2013	0:00	20.5	23.12	2.62	17.53	5.59	245,492	234,818	25,775
5/11/2013	8:00	19.9	22.51	2.61	17.06	5.45	238,307	227,945	25,095
5/11/2013	16:00	19.33	21.95	2.62	16.64	5.31	231,481	221,416	24,470
5/12/2013	0:00	18.81	21.43	2.62	16.25	5.18	225,254	215,460	23,891
5/13/2013	0:00	17.44	20.05	2.61	15.20	4.85	208,848	199,767	22,352
5/14/2013	0:00	16.3	18.91	2.61	14.34	4.57	195,196	186,709	21,081
5/15/2013	0:00	15.34	17.95	2.61	13.61	4.34	183,700	175,713	20,011
5/16/2013	0:00	14.52	17.13	2.61	12.99	4.14	173,880	166,320	19,097
5/17/2013	0:00	13.81	16.42	2.61	12.45	3.97	165,378	158,187	18,305
5/18/2013	0:00	13.19	15.8	2.61	11.98	3.82	157,953	151,085	17,614
5/19/2013	0:00	12.65	15.25	2.6	11.56	3.69	151,486	144,900	17,001
5/20/2013	0:00	12.16	14.76	2.6	11.19	3.57	145,619	139,287	16,455
5/21/2013	0:00	11.73	14.33	2.6	10.87	3.46	140,469	134,362	15,975
5/22/2013	0:00	11.34	13.94	2.6	10.57	3.37	135,799	129,895	15,541
5/23/2013	0:00	10.99	13.58	2.59	10.30	3.28	131,608	125,885	15,139
5/24/2013	0:00	10.67	13.26	2.59	10.05	3.21	127,775	122,220	14,783
5/25/2013	0:00	10.38	12.97	2.59	9.83	3.14	124,303	118,898	14,459
5/26/2013	0:00	10.11	12.7	2.59	9.63	3.07	121,069	115,805	14,158
5/27/2013	0:00	9.87	12.45	2.58	9.44	3.01	118,195	113,056	13,880
5/28/2013	0:00	9.64	12.22	2.58	9.27	2.95	115,441	110,422	13,623
5/29/2013	0:00	9.43	12.01	2.58	9.11	2.90	112,926	108,016	13,389
5/30/2013	0:00	9.24	11.81	2.57	8.96	2.85	110,651	105,840	13,166
5/31/2013	0:00	9.06	11.63	2.57	8.82	2.81	108,495	103,778	12,965
6/1/2013	0:00	8.88	11.46	2.58	8.69	2.77	106,340	101,716	12,776
6/3/2013	0:00	8.57	11.14	2.57	8.45	2.69	102,628	98,165	12,419
6/5/2013	0:00	8.29	10.85	2.56	8.23	2.62	99,274	94,958	12,096
6/7/2013	0:00	8.04	10.6	2.56	8.04	2.56	96,281	92,095	11,817
6/9/2013	0:00	7.8	10.36	2.56	7.86	2.50	93,407	89,345	11,550

Date	Time	Cycle 32 Discharge Assemblies Only	Total Spent Fuel Pool Heat Load (MBTU/hr)	Non-Cycle 32 Heat Load (MBTU/hr)	South Pool Heat Load (MBTU/hr)	North Pool Heat Load (MBTU/hr)	Maximum Single Assembly Heat (BTU/hr)	Max of the 13 Bounding Arrangements (BTU/hr, see Fig. 3.10)	Average Assembly Heat (BTU/hr)
		Ref. 2.17	Ref. 2.17	Ref. 2.17	Using Ratios developed on Att 12, Pg. 1	Using Ratios developed on Att 12, Pg. 1	= 1.449 * Cycle 32 Total / 121 per Ref. 2.17	= 1.386 * Cycle 32 Total / 121 per Ref. 2.20	= Total Pool Heat / 897 per Att 12, Pg. 1
6/11/2013	0:00	7.59	10.14	2.55	7.69	2.45	90,892	86,940	11,304
6/13/2013	0:00	7.38	9.93	2.55	7.53	2.40	88,377	84,535	11,070
6/15/2013	0:00	7.19	9.74	2.55	7.39	2.35	86,102	82,358	10,858
6/17/2013	0:00	7.01	9.55	2.54	7.24	2.31	83,946	80,296	10,647
6/19/2013	0:00	6.84	9.38	2.54	7.11	2.27	81,910	78,349	10,457
6/21/2013	0:00	6.68	9.21	2.53	6.99	2.22	79,994	76,516	10,268
6/25/2013	0:00	6.38	8.9	2.52	6.75	2.15	76,402	73,080	9,922
6/29/2013	0:00	6.11	8.63	2.52	6.55	2.08	73,169	69,987	9,621
7/3/2013	0:00	5.86	8.37	2.51	6.35	2.02	70,175	67,124	9,331
7/7/2013	0:00	5.64	8.14	2.5	6.17	1.97	67,540	64,604	9,075
7/11/2013	0:00	5.43	7.93	2.5	6.02	1.91	65,025	62,198	8,841
7/15/2013	0:00	5.24	7.73	2.49	5.86	1.87	62,750	60,022	8,618
7/19/2013	0:00	5.07	7.55	2.48	5.73	1.82	60,714	58,075	8,417
7/23/2013	0:00	4.91	7.38	2.47	5.60	1.78	58,798	56,242	8,227
7/27/2013	0:00	4.76	7.22	2.46	5.48	1.74	57,002	54,524	8,049
8/6/2013	0:00	4.42	6.86	2.44	5.20	1.66	52,930	50,629	7,648
8/16/2013	0:00	4.13	6.56	2.43	4.98	1.58	49,458	47,307	7,313
8/26/2013	0:00	3.88	6.29	2.41	4.77	1.52	46,464	44,444	7,012
9/5/2013	0:00	3.66	6.05	2.39	4.59	1.46	43,829	41,924	6,745
9/15/2013	0:00	3.46	5.83	2.37	4.42	1.41	41,434	39,633	6,499
9/25/2013	0:00	3.27	5.64	2.37	4.28	1.36	39,159	37,456	6,288
10/5/2013	0:00	3.11	5.46	2.35	4.14	1.32	37,243	35,624	6,087
10/15/2013	0:00	2.96	5.29	2.33	4.01	1.28	35,447	33,905	5,897
10/25/2013	0:00	2.82	5.14	2.32	3.90	1.24	33,770	32,302	5,730
11/4/2013	0:00	2.69	4.99	2.3	3.79	1.20	32,213	30,813	5,563
11/24/2013	0:00	2.46	4.74	2.28	3.60	1.14	29,459	28,178	5,284
12/14/2013	0:00	2.27	4.52	2.25	3.43	1.09	27,184	26,002	5,039
1/3/2014	0:00	2.1	4.32	2.22	3.28	1.04	25,148	24,055	4,816
1/23/2014	0:00	1.96	4.15	2.19	3.15	1.00	23,471	22,451	4,627
2/12/2014	0:00	1.84	4.01	2.17	3.04	0.97	22,034	21,076	4,470
3/4/2014	0:00	1.73	3.87	2.14	2.94	0.93	20,717	19,816	4,314
3/24/2014	0:00	1.63	3.75	2.12	2.85	0.90	19,520	18,671	4,181
4/13/2014	0:00	1.54	3.65	2.11	2.77	0.88	18,442	17,640	4,069
5/3/2014	0:00	1.47	3.55	2.08	2.70	0.85	17,604	16,838	3,958
5/23/2014	0:00	1.4	3.46	2.06	2.63	0.83	16,765	16,036	3,857
6/12/2014	0:00	1.33	3.38	2.05	2.57	0.81	15,927	15,235	3,768
7/2/2014	0:00	1.28	3.3	2.02	2.51	0.79	15,328	14,662	3,679
7/22/2014	0:00	1.22	3.23	2.01	2.45	0.78	14,610	13,975	3,601
8/11/2014	0:00	1.17	3.17	2	2.41	0.76	14,011	13,402	3,534
8/31/2014	0:00	1.13	3.1	1.97	2.35	0.75	13,532	12,944	3,456

Date	Time	Cycle 32 Discharge Assemblies Only	Total Spent Fuel Pool Heat Load (MBTU/hr)	Non-Cycle 32 Heat Load (MBTU/hr)	South Pool Heat Load (MBTU/hr)	North Pool Heat Load (MBTU/hr)	Maximum Single Assembly Heat (BTU/hr)	Max of the 13 Bounding Arrangements (BTU/hr, see Fig. 3.10)	Average Assembly Heat (BTU/hr)
		Ref. 2.17	Ref. 2.17	Ref. 2.17	Using Ratios developed on Att 12, Pg. 1	Using Ratios developed on Att 12, Pg. 1	= 1.449 * Cycle 32 Total / 121 per Ref. 2.17	= 1.386 * Cycle 32 Total / 121 per Ref. 2.20	= Total Pool Heat / 897 per Att 12, Pg. 1
9/20/2014	0:00	1.08	3.04	1.96	2.31	0.73	12,933	12,371	3,389
10/10/2014	0:00	1.04	2.99	1.95	2.27	0.72	12,454	11,913	3,333
10/30/2014	0:00	1	2.93	1.93	2.23	0.70	11,975	11,455	3,266
11/19/2014	0:00	0.97	2.88	1.91	2.19	0.69	11,616	11,111	3,211
12/9/2014	0:00	0.93	2.83	1.9	2.15	0.68	11,137	10,653	3,155
12/29/2014	0:00	0.9	2.79	1.89	2.12	0.67	10,778	10,309	3,110
1/18/2015	0:00	0.87	2.74	1.87	2.08	0.66	10,418	9,965	3,055
2/7/2015	0:00	0.84	2.7	1.86	2.05	0.65	10,059	9,622	3,010
2/27/2015	0:00	0.81	2.66	1.85	2.02	0.64	9,700	9,278	2,965
3/19/2015	0:00	0.79	2.63	1.84	2.00	0.63	9,460	9,049	2,932
4/8/2015	0:00	0.76	2.59	1.83	1.97	0.62	9,101	8,705	2,887
4/28/2015	0:00	0.74	2.56	1.82	1.94	0.62	8,862	8,476	2,854
5/18/2015	0:00	0.72	2.52	1.8	1.91	0.61	8,622	8,247	2,809
6/7/2015	0:00	0.7	2.49	1.79	1.89	0.60	8,383	8,018	2,776
6/27/2015	0:00	0.68	2.46	1.78	1.87	0.59	8,143	7,789	2,742
7/17/2015	0:00	0.66	2.43	1.77	1.85	0.58	7,904	7,560	2,709
8/6/2015	0:00	0.64	2.4	1.76	1.82	0.58	7,664	7,331	2,676
8/26/2015	0:00	0.62	2.38	1.76	1.81	0.57	7,425	7,102	2,653
9/15/2015	0:00	0.6	2.35	1.75	1.79	0.56	7,185	6,873	2,620
10/5/2015	0:00	0.59	2.33	1.74	1.77	0.56	7,065	6,758	2,598
10/25/2015	0:00	0.57	2.3	1.73	1.75	0.55	6,826	6,529	2,564
11/14/2015	0:00	0.56	2.28	1.72	1.73	0.55	6,706	6,415	2,542
12/4/2015	0:00	0.54	2.26	1.72	1.72	0.54	6,467	6,185	2,520
12/24/2015	0:00	0.53	2.23	1.7	1.69	0.54	6,347	6,071	2,486
1/13/2016	0:00	0.52	2.21	1.69	1.68	0.53	6,227	5,956	2,464
2/2/2016	0:00	0.5	2.19	1.69	1.66	0.53	5,988	5,727	2,441
2/22/2016	0:00	0.49	2.17	1.68	1.65	0.52	5,868	5,613	2,419
3/13/2016	0:00	0.48	2.15	1.67	1.63	0.52	5,748	5,498	2,397
4/2/2016	0:00	0.47	2.14	1.67	1.63	0.51	5,628	5,384	2,386
4/22/2016	0:00	0.46	2.12	1.66	1.61	0.51	5,509	5,269	2,363

	A	B	C	D	E	F	G	H
1	Attachment 12, Sheet 1: Spent Fuel Pool Heat Loads: Load Locations							
2								
3	The pool m							
4	Rack #	Length (Numbers)	Width (Letters)	Empty Cells	Total Assemblies	Cycle 32 Assemblies	Other Assemblies	Edge Cells
5	1	9	10	4	=B5*C5-D5	10	=E5-F5	18
6	2	9	10	3	=B6*C6-D6	16	=E6-F6	9
7	3	9	10	0	=B7*C7-D7	14	=E7-F7	18
8	4	9	10	6	=B8*C8-D8	16	=E8-F8	9
9	5	9	10	1	=B9*C9-D9	13	=E9-F9	9
10	6	9	10	1	=B10*C10-D10	8	=E10-F10	18
11	7	9	10	22	=B11*C11-D11	10	=E11-F11	9
12	8	9	10	3	=B12*C12-D12	5	=E12-F12	18
13	9	9	10	51	=B13*C13-D13	13	=E13-F13	27
14	10	9	10	2	=B14*C14-D14	4	=E14-F14	26
15	11	9	10	0	=B15*C15-D15	12	=E15-F15	18
16			Sum	=SUM(D5:D15)				
17								
18				South Pool	=SUM(E5:E12)	=SUM(F5:F12)	=SUM(G5:G12)	
19				North Pool	=SUM(E13:E15)	=SUM(F13:F15)	=SUM(G13:G15)	
20				Total	=SUM(E5:E15)	=SUM(F5:F15)	=SUM(G5:G15)	
21				% in South	=E18/E20	=F18/F20	=G18/G20	
22				% in North	=E19/E20	=F19/F20	=G19/G20	
23								
24				oad for Others on 10/30/14	='Att12S2 Eqn'!E84	MBTU/hr	Att 12, Sh. 2	
25				ther Assembly on 10/30/14	=E24/G20*10^6	BTU/hr		
26				dge Cells in the South Pool	=SUM(H5:H12)	Assemblies		
27				Assemblies in South Pool	=E26*E25	BTU/hr		
28				per Assembly on 10/30/14	='Att12S2 Eqn'!D84/E20*10^6	BTU/hr	Att 12, Sh. 2	
29								
30				ad for Others on 5/18/2015	='Att12S2 Eqn'!E94	MBTU/hr	Att 12, Sh. 2	
31				ner Assembly on 5/18/2015	=E30/G20*10^6	BTU/hr		
32				dge Cells in the South Pool	=SUM(H5:H12)	Assemblies		
33				Assemblies in South Pool	=E32*E31	BTU/hr		
34				per Assembly on 5/18/2015	='Att12S2 Eqn'!D94/E20*10^6	BTU/hr	Att 12, Sh. 2	

	A	B	C	D	E	F	G	H	I	J
1	Attachment 12, Sheet 2: Spent Fuel Pool Heat Loads: Loads as a Function of Time									
2										
3	Date	Time	Heat Load from Cycle 32 Discharge Assemblies Only (MBTU/hr)	Total Spent Fuel Pool Heat Load (MBTU/hr)	Non-Cycle 32 Heat Load (MBTU/hr)	South Pool Heat Load (MBTU/hr)	North Pool Heat Load (MBTU/hr)	Maximum Single Assembly Heat (BTU/hr)	Max of the 13 Bounding Arrangements (see Fig. 3.10)	Average Assembly Heat (BTU/hr)
4			Ref. 2.17	Ref. 2.17	Ref. 2.17	Using Ratios developed on Att 12, Pg. 1	Using Ratios developed on Att 12, Pg. 1	= 1.449 * Cycle 32 Total / 121 per Ref. 2.17	= 1.386 * Cycle 32 Total / 121 per Ref. 2.20	= Total Pool Heat / 897 per Att 12, Pg. 1
5	41402	0	32.25	34.88	=D5-C5	='Att12S1 Eqn'!$F$21*E5+C5"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E5+C5"Att12S1 Eqn'!$G$22	=C5/121*1.449*10^6	=C5/121*1.386*10^6	=D5/'Att12S1 Eqn'!E$20*10^6
6	41402	0.333333	28.23	30.85	=D6-C6	='Att12S1 Eqn'!$F$21*E6+C6"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E6+C6"Att12S1 Eqn'!$G$22	=C6/121*1.449*10^6	=C6/121*1.386*10^6	=D6/'Att12S1 Eqn'!E$20*10^6
7	41402	0.666666	26.62	29.24	=D7-C7	='Att12S1 Eqn'!$F$21*E7+C7"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E7+C7"Att12S1 Eqn'!$G$22	=C7/121*1.449*10^6	=C7/121*1.386*10^6	=D7/'Att12S1 Eqn'!E$20*10^6
8	41403	0	25.39	28.01	=D8-C8	='Att12S1 Eqn'!$F$21*E8+C8"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E8+C8"Att12S1 Eqn'!$G$22	=C8/121*1.449*10^6	=C8/121*1.386*10^6	=D8/'Att12S1 Eqn'!E$20*10^6
9	41403	0.333333	24.36	26.98	=D9-C9	='Att12S1 Eqn'!$F$21*E9+C9"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E9+C9"Att12S1 Eqn'!$G$22	=C9/121*1.449*10^6	=C9/121*1.386*10^6	=D9/'Att12S1 Eqn'!E$20*10^6
10	41403	0.666666	23.45	26.07	=D10-C10	='Att12S1 Eqn'!$F$21*E10+C10"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E10+C10"Att12S1 Eqn'!$G$22	=C10/121*1.449*10^6	=C10/121*1.386*10^6	=D10/'Att12S1 Eqn'!E$20*10^6
11	41404	0	22.62	25.24	=D11-C11	='Att12S1 Eqn'!$F$21*E11+C11"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E11+C11"Att12S1 Eqn'!$G$22	=C11/121*1.449*10^6	=C11/121*1.386*10^6	=D11/'Att12S1 Eqn'!E$20*10^6
12	41404	0.333333	21.86	24.48	=D12-C12	='Att12S1 Eqn'!$F$21*E12+C12"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E12+C12"Att12S1 Eqn'!$G$22	=C12/121*1.449*10^6	=C12/121*1.386*10^6	=D12/'Att12S1 Eqn'!E$20*10^6
13	41404	0.666666	21.15	23.77	=D13-C13	='Att12S1 Eqn'!$F$21*E13+C13"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E13+C13"Att12S1 Eqn'!$G$22	=C13/121*1.449*10^6	=C13/121*1.386*10^6	=D13/'Att12S1 Eqn'!E$20*10^6
14	41405	0	20.5	23.12	=D14-C14	='Att12S1 Eqn'!$F$21*E14+C14"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E14+C14"Att12S1 Eqn'!$G$22	=C14/121*1.449*10^6	=C14/121*1.386*10^6	=D14/'Att12S1 Eqn'!E$20*10^6
15	41405	0.333333	19.9	22.51	=D15-C15	='Att12S1 Eqn'!$F$21*E15+C15"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E15+C15"Att12S1 Eqn'!$G$22	=C15/121*1.449*10^6	=C15/121*1.386*10^6	=D15/'Att12S1 Eqn'!E$20*10^6
16	41405	0.666666	19.33	21.95	=D16-C16	='Att12S1 Eqn'!$F$21*E16+C16"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E16+C16"Att12S1 Eqn'!$G$22	=C16/121*1.449*10^6	=C16/121*1.386*10^6	=D16/'Att12S1 Eqn'!E$20*10^6
17	41406	0	18.81	21.43	=D17-C17	='Att12S1 Eqn'!$F$21*E17+C17"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E17+C17"Att12S1 Eqn'!$G$22	=C17/121*1.449*10^6	=C17/121*1.386*10^6	=D17/'Att12S1 Eqn'!E$20*10^6
18	41407	0	17.44	20.05	=D18-C18	='Att12S1 Eqn'!$F$21*E18+C18"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E18+C18"Att12S1 Eqn'!$G$22	=C18/121*1.449*10^6	=C18/121*1.386*10^6	=D18/'Att12S1 Eqn'!E$20*10^6
19	41408	0	16.3	18.91	=D19-C19	='Att12S1 Eqn'!$F$21*E19+C19"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E19+C19"Att12S1 Eqn'!$G$22	=C19/121*1.449*10^6	=C19/121*1.386*10^6	=D19/'Att12S1 Eqn'!E$20*10^6
20	41409	0	15.34	17.95	=D20-C20	='Att12S1 Eqn'!$F$21*E20+C20"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E20+C20"Att12S1 Eqn'!$G$22	=C20/121*1.449*10^6	=C20/121*1.386*10^6	=D20/'Att12S1 Eqn'!E$20*10^6
21	41410	0	14.52	17.13	=D21-C21	='Att12S1 Eqn'!$F$21*E21+C21"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E21+C21"Att12S1 Eqn'!$G$22	=C21/121*1.449*10^6	=C21/121*1.386*10^6	=D21/'Att12S1 Eqn'!E$20*10^6
22	41411	0	13.81	16.42	=D22-C22	='Att12S1 Eqn'!$F$21*E22+C22"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E22+C22"Att12S1 Eqn'!$G$22	=C22/121*1.449*10^6	=C22/121*1.386*10^6	=D22/'Att12S1 Eqn'!E$20*10^6
23	41412	0	13.19	15.8	=D23-C23	='Att12S1 Eqn'!$F$21*E23+C23"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E23+C23"Att12S1 Eqn'!$G$22	=C23/121*1.449*10^6	=C23/121*1.386*10^6	=D23/'Att12S1 Eqn'!E$20*10^6
24	41413	0	12.65	15.25	=D24-C24	='Att12S1 Eqn'!$F$21*E24+C24"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E24+C24"Att12S1 Eqn'!$G$22	=C24/121*1.449*10^6	=C24/121*1.386*10^6	=D24/'Att12S1 Eqn'!E$20*10^6
25	41414	0	12.16	14.76	=D25-C25	='Att12S1 Eqn'!$F$21*E25+C25"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E25+C25"Att12S1 Eqn'!$G$22	=C25/121*1.449*10^6	=C25/121*1.386*10^6	=D25/'Att12S1 Eqn'!E$20*10^6
26	41415	0	11.73	14.33	=D26-C26	='Att12S1 Eqn'!$F$21*E26+C26"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E26+C26"Att12S1 Eqn'!$G$22	=C26/121*1.449*10^6	=C26/121*1.386*10^6	=D26/'Att12S1 Eqn'!E$20*10^6
27	41416	0	11.34	13.94	=D27-C27	='Att12S1 Eqn'!$F$21*E27+C27"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E27+C27"Att12S1 Eqn'!$G$22	=C27/121*1.449*10^6	=C27/121*1.386*10^6	=D27/'Att12S1 Eqn'!E$20*10^6
28	41417	0	10.99	13.58	=D28-C28	='Att12S1 Eqn'!$F$21*E28+C28"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E28+C28"Att12S1 Eqn'!$G$22	=C28/121*1.449*10^6	=C28/121*1.386*10^6	=D28/'Att12S1 Eqn'!E$20*10^6
29	41418	0	10.67	13.26	=D29-C29	='Att12S1 Eqn'!$F$21*E29+C29"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E29+C29"Att12S1 Eqn'!$G$22	=C29/121*1.449*10^6	=C29/121*1.386*10^6	=D29/'Att12S1 Eqn'!E$20*10^6
30	41419	0	10.38	12.97	=D30-C30	='Att12S1 Eqn'!$F$21*E30+C30"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E30+C30"Att12S1 Eqn'!$G$22	=C30/121*1.449*10^6	=C30/121*1.386*10^6	=D30/'Att12S1 Eqn'!E$20*10^6
31	41420	0	10.11	12.7	=D31-C31	='Att12S1 Eqn'!$F$21*E31+C31"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E31+C31"Att12S1 Eqn'!$G$22	=C31/121*1.449*10^6	=C31/121*1.386*10^6	=D31/'Att12S1 Eqn'!E$20*10^6
32	41421	0	9.87	12.45	=D32-C32	='Att12S1 Eqn'!$F$21*E32+C32"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E32+C32"Att12S1 Eqn'!$G$22	=C32/121*1.449*10^6	=C32/121*1.386*10^6	=D32/'Att12S1 Eqn'!E$20*10^6
33	41422	0	9.64	12.22	=D33-C33	='Att12S1 Eqn'!$F$21*E33+C33"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E33+C33"Att12S1 Eqn'!$G$22	=C33/121*1.449*10^6	=C33/121*1.386*10^6	=D33/'Att12S1 Eqn'!E$20*10^6
34	41423	0	9.43	12.01	=D34-C34	='Att12S1 Eqn'!$F$21*E34+C34"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E34+C34"Att12S1 Eqn'!$G$22	=C34/121*1.449*10^6	=C34/121*1.386*10^6	=D34/'Att12S1 Eqn'!E$20*10^6
35	41424	0	9.24	11.81	=D35-C35	='Att12S1 Eqn'!$F$21*E35+C35"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E35+C35"Att12S1 Eqn'!$G$22	=C35/121*1.449*10^6	=C35/121*1.386*10^6	=D35/'Att12S1 Eqn'!E$20*10^6
36	41425	0	9.06	11.63	=D36-C36	='Att12S1 Eqn'!$F$21*E36+C36"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E36+C36"Att12S1 Eqn'!$G$22	=C36/121*1.449*10^6	=C36/121*1.386*10^6	=D36/'Att12S1 Eqn'!E$20*10^6
37	41426	0	8.88	11.46	=D37-C37	='Att12S1 Eqn'!$F$21*E37+C37"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E37+C37"Att12S1 Eqn'!$G$22	=C37/121*1.449*10^6	=C37/121*1.386*10^6	=D37/'Att12S1 Eqn'!E$20*10^6
38	41428	0	8.57	11.14	=D38-C38	='Att12S1 Eqn'!$F$21*E38+C38"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E38+C38"Att12S1 Eqn'!$G$22	=C38/121*1.449*10^6	=C38/121*1.386*10^6	=D38/'Att12S1 Eqn'!E$20*10^6
39	41430	0	8.29	10.85	=D39-C39	='Att12S1 Eqn'!$F$21*E39+C39"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E39+C39"Att12S1 Eqn'!$G$22	=C39/121*1.449*10^6	=C39/121*1.386*10^6	=D39/'Att12S1 Eqn'!E$20*10^6
40	41432	0	8.04	10.6	=D40-C40	='Att12S1 Eqn'!$F$21*E40+C40"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E40+C40"Att12S1 Eqn'!$G$22	=C40/121*1.449*10^6	=C40/121*1.386*10^6	=D40/'Att12S1 Eqn'!E$20*10^6
41	41434	0	7.8	10.36	=D41-C41	='Att12S1 Eqn'!$F$21*E41+C41"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E41+C41"Att12S1 Eqn'!$G$22	=C41/121*1.449*10^6	=C41/121*1.386*10^6	=D41/'Att12S1 Eqn'!E$20*10^6
42	41436	0	7.59	10.14	=D42-C42	='Att12S1 Eqn'!$F$21*E42+C42"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E42+C42"Att12S1 Eqn'!$G$22	=C42/121*1.449*10^6	=C42/121*1.386*10^6	=D42/'Att12S1 Eqn'!E$20*10^6
43	41438	0	7.38	9.93	=D43-C43	='Att12S1 Eqn'!$F$21*E43+C43"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E43+C43"Att12S1 Eqn'!$G$22	=C43/121*1.449*10^6	=C43/121*1.386*10^6	=D43/'Att12S1 Eqn'!E$20*10^6
44	41440	0	7.19	9.74	=D44-C44	='Att12S1 Eqn'!$F$21*E44+C44"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E44+C44"Att12S1 Eqn'!$G$22	=C44/121*1.449*10^6	=C44/121*1.386*10^6	=D44/'Att12S1 Eqn'!E$20*10^6
45	41442	0	7.01	9.55	=D45-C45	='Att12S1 Eqn'!$F$21*E45+C45"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E45+C45"Att12S1 Eqn'!$G$22	=C45/121*1.449*10^6	=C45/121*1.386*10^6	=D45/'Att12S1 Eqn'!E$20*10^6
46	41444	0	6.84	9.38	=D46-C46	='Att12S1 Eqn'!$F$21*E46+C46"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E46+C46"Att12S1 Eqn'!$G$22	=C46/121*1.449*10^6	=C46/121*1.386*10^6	=D46/'Att12S1 Eqn'!E$20*10^6
47	41446	0	6.68	9.21	=D47-C47	='Att12S1 Eqn'!$F$21*E47+C47"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E47+C47"Att12S1 Eqn'!$G$22	=C47/121*1.449*10^6	=C47/121*1.386*10^6	=D47/'Att12S1 Eqn'!E$20*10^6
48	41450	0	6.38	8.9	=D48-C48	='Att12S1 Eqn'!$F$21*E48+C48"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E48+C48"Att12S1 Eqn'!$G$22	=C48/121*1.449*10^6	=C48/121*1.386*10^6	=D48/'Att12S1 Eqn'!E$20*10^6
49	41454	0	6.11	8.63	=D49-C49	='Att12S1 Eqn'!$F$21*E49+C49"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E49+C49"Att12S1 Eqn'!$G$22	=C49/121*1.449*10^6	=C49/121*1.386*10^6	=D49/'Att12S1 Eqn'!E$20*10^6
50	41458	0	5.86	8.37	=D50-C50	='Att12S1 Eqn'!$F$21*E50+C50"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E50+C50"Att12S1 Eqn'!$G$22	=C50/121*1.449*10^6	=C50/121*1.386*10^6	=D50/'Att12S1 Eqn'!E$20*10^6
51	41462	0	5.64	8.14	=D51-C51	='Att12S1 Eqn'!$F$21*E51+C51"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E51+C51"Att12S1 Eqn'!$G$22	=C51/121*1.449*10^6	=C51/121*1.386*10^6	=D51/'Att12S1 Eqn'!E$20*10^6
52	41466	0	5.43	7.93	=D52-C52	='Att12S1 Eqn'!$F$21*E52+C52"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E52+C52"Att12S1 Eqn'!$G$22	=C52/121*1.449*10^6	=C52/121*1.386*10^6	=D52/'Att12S1 Eqn'!E$20*10^6
53	41470	0	5.24	7.73	=D53-C53	='Att12S1 Eqn'!$F$21*E53+C53"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E53+C53"Att12S1 Eqn'!$G$22	=C53/121*1.449*10^6	=C53/121*1.386*10^6	=D53/'Att12S1 Eqn'!E$20*10^6
54	41474	0	5.07	7.55	=D54-C54	='Att12S1 Eqn'!$F$21*E54+C54"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E54+C54"Att12S1 Eqn'!$G$22	=C54/121*1.449*10^6	=C54/121*1.386*10^6	=D54/'Att12S1 Eqn'!E$20*10^6
55	41478	0	4.91	7.38	=D55-C55	='Att12S1 Eqn'!$F$21*E55+C55"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E55+C55"Att12S1 Eqn'!$G$22	=C55/121*1.449*10^6	=C55/121*1.386*10^6	=D55/'Att12S1 Eqn'!E$20*10^6
56	41482	0	4.76	7.22	=D56-C56	='Att12S1 Eqn'!$F$21*E56+C56"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E56+C56"Att12S1 Eqn'!$G$22	=C56/121*1.449*10^6	=C56/121*1.386*10^6	=D56/'Att12S1 Eqn'!E$20*10^6
57	41492	0	4.42	6.86	=D57-C57	='Att12S1 Eqn'!$F$21*E57+C57"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E57+C57"Att12S1 Eqn'!$G$22	=C57/121*1.449*10^6	=C57/121*1.386*10^6	=D57/'Att12S1 Eqn'!E$20*10^6
58	41502	0	4.13	6.56	=D58-C58	='Att12S1 Eqn'!$F$21*E58+C58"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E58+C58"Att12S1 Eqn'!$G$22	=C58/121*1.449*10^6	=C58/121*1.386*10^6	=D58/'Att12S1 Eqn'!E$20*10^6
59	41512	0	3.88	6.29	=D59-C59	='Att12S1 Eqn'!$F$21*E59+C59"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E59+C59"Att12S1 Eqn'!$G$22	=C59/121*1.449*10^6	=C59/121*1.386*10^6	=D59/'Att12S1 Eqn'!E$20*10^6
60	41522	0	3.66	6.05	=D60-C60	='Att12S1 Eqn'!$F$21*E60+C60"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E60+C60"Att12S1 Eqn'!$G$22	=C60/121*1.449*10^6	=C60/121*1.386*10^6	=D60/'Att12S1 Eqn'!E$20*10^6
61	41532	0	3.46	5.83	=D61-C61	='Att12S1 Eqn'!$F$21*E61+C61"Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E61+C61"Att12S1 Eqn'!$G$22	=C61/121*1.449*10^6	=C61/121*1.386*10^6	=D61/'Att12S1 Eqn'!E$20*10^6

	A	B	C	D	E	F	G	H	I	J
62	41542	0	3.27	5.64	=D62-C62	='Att12S1 Eqn'!$F$21*E62+C62*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E62+C62*'Att12S1 Eqn'!$G$22	=C62/121*1.449*10^6	=C62/121*1.386*10^6	=D62/'Att12S1 Eqn'!E$20*10^6
63	41552	0	3.11	5.46	=D63-C63	='Att12S1 Eqn'!$F$21*E63+C63*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E63+C63*'Att12S1 Eqn'!$G$22	=C63/121*1.449*10^6	=C63/121*1.386*10^6	=D63/'Att12S1 Eqn'!E$20*10^6
64	41562	0	2.96	5.29	=D64-C64	='Att12S1 Eqn'!$F$21*E64+C64*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E64+C64*'Att12S1 Eqn'!$G$22	=C64/121*1.449*10^6	=C64/121*1.386*10^6	=D64/'Att12S1 Eqn'!E$20*10^6
65	41572	0	2.82	5.14	=D65-C65	='Att12S1 Eqn'!$F$21*E65+C65*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E65+C65*'Att12S1 Eqn'!$G$22	=C65/121*1.449*10^6	=C65/121*1.386*10^6	=D65/'Att12S1 Eqn'!E$20*10^6
66	41582	0	2.69	4.99	=D66-C66	='Att12S1 Eqn'!$F$21*E66+C66*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E66+C66*'Att12S1 Eqn'!$G$22	=C66/121*1.449*10^6	=C66/121*1.386*10^6	=D66/'Att12S1 Eqn'!E$20*10^6
67	41602	0	2.46	4.74	=D67-C67	='Att12S1 Eqn'!$F$21*E67+C67*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E67+C67*'Att12S1 Eqn'!$G$22	=C67/121*1.449*10^6	=C67/121*1.386*10^6	=D67/'Att12S1 Eqn'!E$20*10^6
68	41622	0	2.27	4.52	=D68-C68	='Att12S1 Eqn'!$F$21*E68+C68*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E68+C68*'Att12S1 Eqn'!$G$22	=C68/121*1.449*10^6	=C68/121*1.386*10^6	=D68/'Att12S1 Eqn'!E$20*10^6
69	41642	0	2.1	4.32	=D69-C69	='Att12S1 Eqn'!$F$21*E69+C69*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E69+C69*'Att12S1 Eqn'!$G$22	=C69/121*1.449*10^6	=C69/121*1.386*10^6	=D69/'Att12S1 Eqn'!E$20*10^6
70	41662	0	1.96	4.15	=D70-C70	='Att12S1 Eqn'!$F$21*E70+C70*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E70+C70*'Att12S1 Eqn'!$G$22	=C70/121*1.449*10^6	=C70/121*1.386*10^6	=D70/'Att12S1 Eqn'!E$20*10^6
71	41682	0	1.84	4.01	=D71-C71	='Att12S1 Eqn'!$F$21*E71+C71*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E71+C71*'Att12S1 Eqn'!$G$22	=C71/121*1.449*10^6	=C71/121*1.386*10^6	=D71/'Att12S1 Eqn'!E$20*10^6
72	41702	0	1.73	3.87	=D72-C72	='Att12S1 Eqn'!$F$21*E72+C72*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E72+C72*'Att12S1 Eqn'!$G$22	=C72/121*1.449*10^6	=C72/121*1.386*10^6	=D72/'Att12S1 Eqn'!E$20*10^6
73	41722	0	1.63	3.75	=D73-C73	='Att12S1 Eqn'!$F$21*E73+C73*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E73+C73*'Att12S1 Eqn'!$G$22	=C73/121*1.449*10^6	=C73/121*1.386*10^6	=D73/'Att12S1 Eqn'!E$20*10^6
74	41742	0	1.54	3.65	=D74-C74	='Att12S1 Eqn'!$F$21*E74+C74*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E74+C74*'Att12S1 Eqn'!$G$22	=C74/121*1.449*10^6	=C74/121*1.386*10^6	=D74/'Att12S1 Eqn'!E$20*10^6
75	41762	0	1.47	3.55	=D75-C75	='Att12S1 Eqn'!$F$21*E75+C75*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E75+C75*'Att12S1 Eqn'!$G$22	=C75/121*1.449*10^6	=C75/121*1.386*10^6	=D75/'Att12S1 Eqn'!E$20*10^6
76	41782	0	1.4	3.46	=D76-C76	='Att12S1 Eqn'!$F$21*E76+C76*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E76+C76*'Att12S1 Eqn'!$G$22	=C76/121*1.449*10^6	=C76/121*1.386*10^6	=D76/'Att12S1 Eqn'!E$20*10^6
77	41802	0	1.33	3.38	=D77-C77	='Att12S1 Eqn'!$F$21*E77+C77*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E77+C77*'Att12S1 Eqn'!$G$22	=C77/121*1.449*10^6	=C77/121*1.386*10^6	=D77/'Att12S1 Eqn'!E$20*10^6
78	41822	0	1.28	3.3	=D78-C78	='Att12S1 Eqn'!$F$21*E78+C78*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E78+C78*'Att12S1 Eqn'!$G$22	=C78/121*1.449*10^6	=C78/121*1.386*10^6	=D78/'Att12S1 Eqn'!E$20*10^6
79	41842	0	1.22	3.23	=D79-C79	='Att12S1 Eqn'!$F$21*E79+C79*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E79+C79*'Att12S1 Eqn'!$G$22	=C79/121*1.449*10^6	=C79/121*1.386*10^6	=D79/'Att12S1 Eqn'!E$20*10^6
80	41862	0	1.17	3.17	=D80-C80	='Att12S1 Eqn'!$F$21*E80+C80*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E80+C80*'Att12S1 Eqn'!$G$22	=C80/121*1.449*10^6	=C80/121*1.386*10^6	=D80/'Att12S1 Eqn'!E$20*10^6
81	41882	0	1.13	3.1	=D81-C81	='Att12S1 Eqn'!$F$21*E81+C81*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E81+C81*'Att12S1 Eqn'!$G$22	=C81/121*1.449*10^6	=C81/121*1.386*10^6	=D81/'Att12S1 Eqn'!E$20*10^6
82	41902	0	1.08	3.04	=D82-C82	='Att12S1 Eqn'!$F$21*E82+C82*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E82+C82*'Att12S1 Eqn'!$G$22	=C82/121*1.449*10^6	=C82/121*1.386*10^6	=D82/'Att12S1 Eqn'!E$20*10^6
83	41922	0	1.04	2.99	=D83-C83	='Att12S1 Eqn'!$F$21*E83+C83*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E83+C83*'Att12S1 Eqn'!$G$22	=C83/121*1.449*10^6	=C83/121*1.386*10^6	=D83/'Att12S1 Eqn'!E$20*10^6
84	41942	0	1	2.93	=D84-C84	='Att12S1 Eqn'!$F$21*E84+C84*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E84+C84*'Att12S1 Eqn'!$G$22	=C84/121*1.449*10^6	=C84/121*1.386*10^6	=D84/'Att12S1 Eqn'!E$20*10^6
85	41962	0	0.97	2.88	=D85-C85	='Att12S1 Eqn'!$F$21*E85+C85*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E85+C85*'Att12S1 Eqn'!$G$22	=C85/121*1.449*10^6	=C85/121*1.386*10^6	=D85/'Att12S1 Eqn'!E$20*10^6
86	41982	0	0.93	2.83	=D86-C86	='Att12S1 Eqn'!$F$21*E86+C86*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E86+C86*'Att12S1 Eqn'!$G$22	=C86/121*1.449*10^6	=C86/121*1.386*10^6	=D86/'Att12S1 Eqn'!E$20*10^6
87	42002	0	0.9	2.79	=D87-C87	='Att12S1 Eqn'!$F$21*E87+C87*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E87+C87*'Att12S1 Eqn'!$G$22	=C87/121*1.449*10^6	=C87/121*1.386*10^6	=D87/'Att12S1 Eqn'!E$20*10^6
88	42022	0	0.87	2.74	=D88-C88	='Att12S1 Eqn'!$F$21*E88+C88*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E88+C88*'Att12S1 Eqn'!$G$22	=C88/121*1.449*10^6	=C88/121*1.386*10^6	=D88/'Att12S1 Eqn'!E$20*10^6
89	42042	0	0.84	2.7	=D89-C89	='Att12S1 Eqn'!$F$21*E89+C89*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E89+C89*'Att12S1 Eqn'!$G$22	=C89/121*1.449*10^6	=C89/121*1.386*10^6	=D89/'Att12S1 Eqn'!E$20*10^6
90	42062	0	0.81	2.66	=D90-C90	='Att12S1 Eqn'!$F$21*E90+C90*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E90+C90*'Att12S1 Eqn'!$G$22	=C90/121*1.449*10^6	=C90/121*1.386*10^6	=D90/'Att12S1 Eqn'!E$20*10^6
91	42082	0	0.79	2.63	=D91-C91	='Att12S1 Eqn'!$F$21*E91+C91*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E91+C91*'Att12S1 Eqn'!$G$22	=C91/121*1.449*10^6	=C91/121*1.386*10^6	=D91/'Att12S1 Eqn'!E$20*10^6
92	42102	0	0.76	2.59	=D92-C92	='Att12S1 Eqn'!$F$21*E92+C92*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E92+C92*'Att12S1 Eqn'!$G$22	=C92/121*1.449*10^6	=C92/121*1.386*10^6	=D92/'Att12S1 Eqn'!E$20*10^6
93	42122	0	0.74	2.56	=D93-C93	='Att12S1 Eqn'!$F$21*E93+C93*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E93+C93*'Att12S1 Eqn'!$G$22	=C93/121*1.449*10^6	=C93/121*1.386*10^6	=D93/'Att12S1 Eqn'!E$20*10^6
94	42142	0	0.72	2.52	=D94-C94	='Att12S1 Eqn'!$F$21*E94+C94*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E94+C94*'Att12S1 Eqn'!$G$22	=C94/121*1.449*10^6	=C94/121*1.386*10^6	=D94/'Att12S1 Eqn'!E$20*10^6
95	42162	0	0.7	2.49	=D95-C95	='Att12S1 Eqn'!$F$21*E95+C95*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E95+C95*'Att12S1 Eqn'!$G$22	=C95/121*1.449*10^6	=C95/121*1.386*10^6	=D95/'Att12S1 Eqn'!E$20*10^6
96	42182	0	0.68	2.46	=D96-C96	='Att12S1 Eqn'!$F$21*E96+C96*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E96+C96*'Att12S1 Eqn'!$G$22	=C96/121*1.449*10^6	=C96/121*1.386*10^6	=D96/'Att12S1 Eqn'!E$20*10^6
97	42202	0	0.66	2.43	=D97-C97	='Att12S1 Eqn'!$F$21*E97+C97*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E97+C97*'Att12S1 Eqn'!$G$22	=C97/121*1.449*10^6	=C97/121*1.386*10^6	=D97/'Att12S1 Eqn'!E$20*10^6
98	42222	0	0.64	2.4	=D98-C98	='Att12S1 Eqn'!$F$21*E98+C98*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E98+C98*'Att12S1 Eqn'!$G$22	=C98/121*1.449*10^6	=C98/121*1.386*10^6	=D98/'Att12S1 Eqn'!E$20*10^6
99	42242	0	0.62	2.38	=D99-C99	='Att12S1 Eqn'!$F$21*E99+C99*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E99+C99*'Att12S1 Eqn'!$G$22	=C99/121*1.449*10^6	=C99/121*1.386*10^6	=D99/'Att12S1 Eqn'!E$20*10^6
100	42262	0	0.6	2.35	=D100-C100	='Att12S1 Eqn'!$F$21*E100+C100*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E100+C100*'Att12S1 Eqn'!$G$22	=C100/121*1.449*10^6	=C100/121*1.386*10^6	=D100/'Att12S1 Eqn'!E$20*10^6
101	42282	0	0.59	2.33	=D101-C101	='Att12S1 Eqn'!$F$21*E101+C101*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E101+C101*'Att12S1 Eqn'!$G$22	=C101/121*1.449*10^6	=C101/121*1.386*10^6	=D101/'Att12S1 Eqn'!E$20*10^6
102	42302	0	0.57	2.3	=D102-C102	='Att12S1 Eqn'!$F$21*E102+C102*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E102+C102*'Att12S1 Eqn'!$G$22	=C102/121*1.449*10^6	=C102/121*1.386*10^6	=D102/'Att12S1 Eqn'!E$20*10^6
103	42322	0	0.56	2.28	=D103-C103	='Att12S1 Eqn'!$F$21*E103+C103*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E103+C103*'Att12S1 Eqn'!$G$22	=C103/121*1.449*10^6	=C103/121*1.386*10^6	=D103/'Att12S1 Eqn'!E$20*10^6
104	42342	0	0.54	2.26	=D104-C104	='Att12S1 Eqn'!$F$21*E104+C104*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E104+C104*'Att12S1 Eqn'!$G$22	=C104/121*1.449*10^6	=C104/121*1.386*10^6	=D104/'Att12S1 Eqn'!E$20*10^6
105	42362	0	0.53	2.23	=D105-C105	='Att12S1 Eqn'!$F$21*E105+C105*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E105+C105*'Att12S1 Eqn'!$G$22	=C105/121*1.449*10^6	=C105/121*1.386*10^6	=D105/'Att12S1 Eqn'!E$20*10^6
106	42382	0	0.52	2.21	=D106-C106	='Att12S1 Eqn'!$F$21*E106+C106*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E106+C106*'Att12S1 Eqn'!$G$22	=C106/121*1.449*10^6	=C106/121*1.386*10^6	=D106/'Att12S1 Eqn'!E$20*10^6
107	42402	0	0.5	2.19	=D107-C107	='Att12S1 Eqn'!$F$21*E107+C107*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E107+C107*'Att12S1 Eqn'!$G$22	=C107/121*1.449*10^6	=C107/121*1.386*10^6	=D107/'Att12S1 Eqn'!E$20*10^6
108	42422	0	0.49	2.17	=D108-C108	='Att12S1 Eqn'!$F$21*E108+C108*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E108+C108*'Att12S1 Eqn'!$G$22	=C108/121*1.449*10^6	=C108/121*1.386*10^6	=D108/'Att12S1 Eqn'!E$20*10^6
109	42442	0	0.48	2.15	=D109-C109	='Att12S1 Eqn'!$F$21*E109+C109*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E109+C109*'Att12S1 Eqn'!$G$22	=C109/121*1.449*10^6	=C109/121*1.386*10^6	=D109/'Att12S1 Eqn'!E$20*10^6
110	42462	0	0.47	2.14	=D110-C110	='Att12S1 Eqn'!$F$21*E110+C110*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E110+C110*'Att12S1 Eqn'!$G$22	=C110/121*1.449*10^6	=C110/121*1.386*10^6	=D110/'Att12S1 Eqn'!E$20*10^6
111	42482	0	0.46	2.12	=D111-C111	='Att12S1 Eqn'!$F$21*E111+C111*'Att12S1 Eqn'!$G$21	='Att12S1 Eqn'!$F$22*E111+C111*'Att12S1 Eqn'!$G$22	=C111/121*1.449*10^6	=C111/121*1.386*10^6	=D111/'Att12S1 Eqn'!E$20*10^6

GOTHIC Output for October 2014 Case

TITLE= "D:\0p4738\Kewaunee\temp_oct.txt || GOTHIC 8.0(QA) Oct/28/2013 13:13:21"
VARIABLES= "Time (sec)" "cv4C" "cv5C" "cv9C" "NT1n"

Time (s)	$T_{max,North}$ (°F)	$T_{max,South}$ (°F)	$T_{max,bld\ exh}$ (°F)	$T_{max,SFP\ exh}$ (°F)
0.0000000	0.0000000	0.0000000	0.0000000	79.99963
5000.085	161.9651	169.5667	155.5400	145.3012
10000.28	161.8836	169.5003	154.4129	145.1407
15000.34	161.4547	169.1657	153.3211	144.6472
20000.40	161.1306	168.9018	152.6170	144.3011
25000.65	161.5214	169.2050	152.7591	144.7412
30000.85	163.8631	171.2770	154.7947	147.4704
35000.86	166.9025	174.0273	158.2899	150.7886
40000.96	169.5487	176.4019	161.3155	153.6483
45001.04	171.2217	177.9371	163.2162	155.4483
50001.13	172.1412	178.7882	164.1319	156.3592
55001.36	172.0052	178.6365	163.7275	156.0244
60001.48	170.7249	177.4542	161.9713	154.4450
65001.65	169.4300	176.3798	160.7109	153.0186
70001.82	167.8306	175.0328	158.7498	151.2677
75002.03	166.5050	173.8872	157.3046	149.8162
80002.10	165.2618	172.8046	156.0280	148.4559
85002.37	164.2301	171.8264	154.9037	147.2497
90002.61	163.2174	170.9467	153.8891	146.1426
95002.63	162.4046	170.2490	153.0915	145.2931
100002.8	161.7605	169.6811	152.4545	144.6126
105002.9	161.2510	169.2238	151.9357	144.0715
110002.9	161.3715	169.2854	151.9863	144.2317
115003.0	163.2055	170.7545	153.7660	146.2360
120003.2	166.2427	173.5433	157.2943	149.7063
125003.3	168.9996	175.9967	160.4739	152.7407
130003.5	170.9584	177.7633	162.7292	154.8991
135003.7	172.0759	178.8110	163.9337	156.0696
140003.9	172.2180	178.9330	163.8922	156.0802
145003.9	171.1076	177.8995	162.3365	154.6696
150004.0	169.7874	176.7713	160.7382	153.1824
155004.2	168.2368	175.4639	159.0464	151.4775
160004.4	166.7856	174.2112	157.4796	149.9066
165004.6	165.5000	173.0970	156.1721	148.5164
170004.8	164.4168	172.0693	154.9999	147.2499
175004.9	163.3643	171.1340	153.9626	146.1178
180005.0	162.4607	170.3719	153.0931	145.1848
185005.2	161.7768	169.7695	152.4168	144.4673
190005.3	161.2246	169.2729	151.8643	143.8907
195005.5	161.0660	169.1098	151.6597	143.7549

GOTHIC Output for October 2014 Case (cont'd)

Time (s)	$T_{max,North}$ (°F)	$T_{max,South}$ (°F)	$T_{max,bld\ exh}$ (°F)	$T_{max,SFP\ exh}$ (°F)
200005.6	162.2593	170.0041	152.7254	145.0793
205005.8	165.2415	172.6725	156.0846	148.5063
210005.9	168.1813	175.2773	159.4800	151.7595
215006.1	170.4027	177.2601	162.0450	154.2162
220006.4	171.7371	178.5114	163.5471	155.6876
225006.5	172.1623	178.9108	163.8930	156.0452
230006.7	171.3691	178.1690	162.7160	154.9669
235006.9	170.0172	176.9703	160.9812	153.3822
240007.0	168.5823	175.7842	159.4134	151.8146
245007.2	166.9976	174.4392	157.7005	150.0961
250007.4	165.6786	173.2998	156.3455	148.6737
255007.7	164.4652	172.2310	155.1406	147.3660
260007.7	163.4649	171.2482	154.0646	146.1901
265008.0	162.4954	170.3991	153.1309	145.1804
270008.1	161.7584	169.7562	152.4203	144.4216
275008.2	161.1557	169.2202	151.8307	143.8058
280008.4	160.8370	168.9197	151.4812	143.5009
285008.5	161.4112	169.3339	151.9539	144.1537
290008.5	164.1330	171.6782	154.8905	147.3078
295008.6	167.2117	174.3937	158.4131	150.7371
300008.8	169.7091	176.6065	161.3057	153.5245
305009.0	171.1984	177.9967	163.0185	155.1898
310009.0	171.9508	178.6996	163.7667	155.9374
315009.2	171.5217	178.2997	163.0540	155.2825
320009.4	170.1766	177.0856	161.2588	153.6495
325009.6	168.8535	176.0071	159.7695	152.1732
330009.8	167.1866	174.5925	157.9635	150.3573
335009.9	165.8196	173.4087	156.5479	148.8835
340009.9	164.5576	172.2994	155.2989	147.5273
345010.1	163.4290	171.2975	154.2067	146.3286
350010.2	162.4734	170.3684	153.2081	145.2338
355010.3	161.7345	169.6782	152.4473	144.4294
360010.5	161.0980	169.1080	151.8251	143.7748
365010.5	160.6400	168.6868	151.3502	143.3179
370010.7	160.9152	168.8727	151.5458	143.6679
375010.8	163.0054	170.6806	153.7578	146.1551
380010.9	166.1574	173.4155	157.3091	149.6913
385011.1	168.8429	175.7896	160.4127	152.6889
390011.2	170.5972	177.4127	162.4680	154.6649
395011.4	171.5652	178.3186	163.4981	155.6774
400011.6	171.5488	178.2897	163.2656	155.5004
405011.8	170.2949	177.1384	161.5605	153.9301
410011.8	169.0052	176.0647	160.0267	152.4640

GOTHIC Output for October 2014 Case (cont'd)

Time (s)	$T_{max,North}$ (°F)	$T_{max,South}$ (°F)	$T_{max,bld\ exh}$ (°F)	$T_{max,SFP\ exh}$ (°F)
415012.0	167.3670	174.7049	158.2692	150.6638
420012.2	165.9531	173.4778	156.7756	149.1325
425012.3	164.6561	172.3366	155.4915	147.7327
430012.4	163.4923	171.3029	154.3595	146.4933
435012.7	162.4337	170.3502	153.3403	145.3672
440012.7	161.5919	169.5808	152.5089	144.4787
445012.8	160.9321	168.9832	151.8531	143.7917
450012.9	160.4618	168.4874	151.3132	143.2377
455012.9	160.4387	168.4447	151.2335	143.2880
460013.2	161.9082	169.6946	152.7051	145.0628
465013.3	165.0584	172.3877	156.1786	148.6188
470013.5	167.8777	174.8906	159.4577	151.7739
475013.7	169.9181	176.7549	161.8433	154.0782
480013.8	171.1074	177.8642	163.1920	155.3710
485014.0	171.3443	178.0913	163.3146	155.5049
490014.0	170.4197	177.1995	161.9089	154.2528
495014.1	169.1106	176.0650	160.2770	152.7205
500014.1	167.6053	174.8336	158.6562	151.0627
505014.1	166.0824	173.5284	157.0229	149.4055
510014.2	164.7741	172.3811	155.7103	147.9814
515014.4	163.5645	171.3055	154.5309	146.6837
520014.6	162.4785	170.3298	153.4825	145.5262
525014.7	161.5680	169.4942	152.5855	144.5594
530014.9	160.8702	168.8543	151.8946	143.8275
535015.1	160.3060	168.3354	151.3284	143.2448
540015.3	160.0751	168.1033	151.0558	143.0397
545015.4	160.9271	168.7897	151.8150	144.0781
550015.6	163.9023	171.3047	155.0070	147.4718
555015.7	166.8913	173.9683	158.4742	150.8387
560015.8	169.1863	176.0420	161.1747	153.4298
565016.0	170.5413	177.3397	162.7798	154.9489
570016.3	171.1183	177.8830	163.3180	155.4767
575016.4	170.5069	177.2760	162.3213	154.5819
580016.4	169.2299	176.0825	160.5582	153.0068
585016.6	167.8662	174.9652	159.0542	151.4837
590016.8	166.2427	173.5886	157.3027	149.7115
595017.1	164.9010	172.4273	155.9336	148.2536
600017.3	163.6598	171.3275	154.7196	146.9055
605017.4	162.5449	170.3286	153.6453	145.7097
610017.5	161.5670	169.4338	152.6837	144.6646
615017.5	160.8384	168.7525	151.9600	143.8960
620017.5	160.2345	168.2003	151.3587	143.2686
625017.6	159.8647	167.8485	150.9546	142.9079

GOTHIC Output for October 2014 Case (cont'd)

Time (s)	$T_{max,North}$ (°F)	$T_{max,South}$ (°F)	$T_{max,bld\ exh}$ (°F)	$T_{max,SFP\ exh}$ (°F)
630017.8	160.2629	168.1499	151.2882	143.4194
635017.8	162.7769	170.2750	153.8781	146.3393
640017.9	165.8595	172.9996	157.4249	149.8348
645018.2	168.4131	175.2913	160.4379	152.7230
650018.3	169.9561	176.7813	162.2999	154.4712
655018.3	170.8028	177.5771	163.1670	155.3291
660018.4	170.5905	177.3496	162.6809	154.8954
665018.5	169.3183	176.1671	160.8881	153.2863
670018.8	168.0937	175.0695	159.4003	151.8703
675018.8	166.4287	173.6783	157.6098	150.0394
680018.8	165.0518	172.4885	156.1762	148.5403
685019.1	163.7721	171.3681	154.9221	147.1520
690019.3	162.6375	170.3551	153.8219	145.9270
695019.3	161.6087	169.4183	152.8240	144.8140
700019.4	160.8280	168.6901	152.0427	143.9854
705019.7	160.2132	168.1025	151.4135	143.3242
710019.8	159.7333	167.6455	150.9063	142.8185
715020.0	159.8562	167.7377	150.9770	143.0644
720020.3	161.7047	169.2960	152.8180	145.2509
725020.5	164.8330	172.0302	156.3627	148.8164
730020.5	167.5155	174.4415	159.5431	151.8600
735020.6	169.3616	176.2106	161.7796	153.9678
740020.6	170.4358	177.2196	162.9422	155.0913
745020.9	170.5617	177.3016	162.8515	155.0566
750020.9	169.4615	176.2811	161.2613	153.6110
755021.1	168.2113	175.1559	159.6895	152.1399
760021.3	166.6614	173.8124	157.9816	150.4108
765021.5	165.2223	172.5738	156.4428	148.8392
770021.8	163.9281	171.4430	155.1562	147.4284
775021.8	162.7488	170.4014	154.0106	146.1585
780021.9	161.6991	169.4518	152.9910	145.0226
785022.2	160.8509	168.6582	152.1423	144.1021
790022.4	160.2110	168.0355	151.4794	143.4012
795022.6	159.6937	167.5358	150.9362	142.8425
800022.7	159.5197	167.3931	150.7500	142.7713
805022.9	160.7306	168.4008	151.8715	144.2421
810023.0	163.7787	171.0344	155.2488	147.7471
815023.3	166.6242	173.5987	158.6295	150.9790
820023.4	168.7217	175.5936	161.1785	153.3826
825023.4	170.0526	176.8319	162.6493	154.8081
830023.6	170.4566	177.1867	162.9309	155.1062
835023.6	169.6578	176.4291	161.6962	153.9896
840023.9	168.3698	175.2743	160.0065	152.4378

GOTHIC Output for October 2014 Case (cont'd)

Time (s)	$T_{max,North}$ (°F)	$T_{max,South}$ (°F)	$T_{max,bld\ exh}$ (°F)	$T_{max,SFP\ exh}$ (°F)
845024.1	166.9661	174.0398	158.4323	150.8586
850024.2	165.4191	172.6863	156.7391	149.1587
855024.4	164.1093	171.5469	155.4060	147.7260
860024.6	162.8942	170.4767	154.2202	146.4090
864000.0	162.0247	169.6998	153.3794	145.4715

GOTHIC Output for May 2015 Case

TITLE= "D:\0p4738\Kewaunee\temp_may.txt || GOTHIC 8.0(QA) Oct/28/2013 14:30:33"
VARIABLES= "Time (sec)" "cv4C" "cv5C" "cv9C" "NT1n"

Time (s)	$T_{max,North}$ (°F)	$T_{max,South}$ (°F)	$T_{max,bld\ exh}$ (°F)	$T_{max,SFP\ exh}$ (°F)
0.0000000	0.0000000	0.0000000	0.0000000	79.99963
5000.010	171.6005	182.6411	162.3168	152.4715
10000.21	171.4421	182.4447	160.4893	152.1517
15000.38	170.8244	181.8020	159.6137	151.3307
20000.54	170.7576	181.7678	159.4093	151.2915
25000.61	171.9352	183.0731	160.5553	152.8715
30000.63	174.6863	185.8045	163.4910	156.1581
35000.73	177.8763	188.9327	167.0300	159.8419
40000.84	180.4323	191.6047	170.0703	162.9553
45000.99	181.9684	193.4017	172.0717	165.0292
50001.08	182.9695	194.4927	173.2202	166.2477
55001.18	180.3239	194.6547	173.1948	166.2613
60001.29	179.1473	193.4635	171.6263	164.7282
65001.34	177.2282	191.4925	169.2234	162.3070
70001.48	174.7722	188.6665	166.1234	158.9593
75001.56	173.1168	186.7789	164.1197	156.7377
80001.76	171.7962	185.2637	162.5476	154.9751
85001.88	170.7057	183.9963	161.2086	153.5017
90001.91	169.6789	182.8211	159.9638	152.1431
95001.95	168.9117	181.9513	159.0284	151.1600
100002.1	168.2310	181.1913	158.2202	150.3047
105002.1	167.8915	180.8530	157.8210	149.9572
110002.2	168.6008	181.8607	158.7712	151.2094
115002.4	170.3983	184.2835	161.5258	154.0738
120002.4	173.5456	187.4762	165.2695	157.8865
125002.5	176.2770	190.3490	168.4647	161.2873
130002.6	178.1704	192.4902	170.8101	163.7684
135002.8	179.2318	193.8262	172.2344	165.3039
140002.9	179.5043	194.1969	172.5708	165.6775
145002.9	178.7622	193.3377	171.4208	164.5865
150003.1	177.1340	191.5636	169.1700	162.4139
155003.2	174.8590	188.8391	166.1899	159.1616
160003.4	172.8927	186.6904	163.8670	156.6501
165003.4	171.5356	185.1204	162.2766	154.8480
170003.5	170.3849	183.7974	160.9141	153.3384
175003.6	169.3564	182.5990	159.6607	151.9590
180003.7	168.5357	181.6564	158.6626	150.8948
185003.9	167.8450	180.8829	157.8498	150.0305
190003.9	167.3677	180.3771	157.2880	149.4872
195003.9	167.7252	180.9516	157.7744	150.2292

GOTHIC Output for May 2015 Case (cont'd)

Time (s)	$T_{max,North}$ (°F)	$T_{max,South}$ (°F)	$T_{max,bld\ exh}$ (°F)	$T_{max,SFP\ exh}$ (°F)
200004.1	169.0798	182.9684	160.0109	152.6127
205004.3	172.1234	186.1759	163.8037	156.3687
210004.6	175.1136	189.2064	167.2227	160.0060
215004.6	177.1601	191.5760	169.8250	162.7880
220004.6	178.4220	193.1308	171.5279	164.6085
225004.7	179.0394	193.7772	172.2087	165.3432
230004.8	178.6071	193.2592	171.4645	164.6502
235004.9	177.2705	191.7481	169.4738	162.7689
240005.0	175.1728	189.2940	166.7251	159.8499
245005.1	172.9414	186.8023	163.9788	156.8981
250005.1	171.3868	185.1311	162.2722	154.9886
255005.2	170.1588	183.7382	160.8604	153.4013
260005.4	169.0645	182.4955	159.5896	151.9897
265005.6	168.1672	181.4663	158.5056	150.8259
270005.8	167.4717	180.6772	157.6808	149.9452
275006.0	166.8811	180.0270	156.9792	149.2349
280006.1	166.9582	180.2568	157.1089	149.5702
285006.2	167.9089	181.8179	158.8208	151.3943
290006.3	170.7296	184.8720	162.3756	154.9712
295006.3	173.9701	188.0449	166.0326	158.7604
300006.5	176.2011	190.6406	168.9152	161.8731
305006.6	177.6397	192.3339	170.7925	163.9032
310006.7	178.7325	193.2894	171.8604	165.0542
315006.8	178.6560	193.0909	171.5002	164.7889
320007.0	177.4064	191.8019	169.8211	163.1141
325007.2	175.3538	189.7263	167.2852	160.5648
330007.4	173.1527	187.0033	164.2531	157.3062
335007.5	171.3769	185.1991	162.3618	155.2251
340007.5	169.9138	183.7223	160.8937	153.5444
345007.5	168.7749	182.4654	159.6199	152.1198
350007.6	167.7584	181.3295	158.4474	150.8384
355007.6	167.0397	180.5162	157.5908	149.9353
360007.7	166.3850	179.7852	156.8275	149.1243
365007.8	166.1921	179.6564	156.6013	149.0395
370007.9	166.9635	180.9168	157.8858	150.5366
375008.1	169.4019	183.6025	161.0296	153.6411
380008.2	172.7261	186.8419	164.7688	157.5249
385008.3	175.2309	189.6364	167.9410	160.8637
390008.5	177.0206	191.5237	170.0819	163.2091
395008.7	178.2907	192.7468	171.4219	164.6050
400008.8	178.5908	192.9488	171.5491	164.8188
405008.9	177.6271	191.8209	170.0953	163.4961
410009.0	175.7649	189.9053	167.7040	161.1954

GOTHIC Output for May 2015 Case (cont'd)

Time (s)	$T_{max,North}$ (°F)	$T_{max,South}$ (°F)	$T_{max,bld\ exh}$ (°F)	$T_{max,SFP\ exh}$ (°F)
415009.2	173.3082	187.2686	164.6596	157.8224
420009.3	171.4902	185.3071	162.5330	155.5207
425009.4	169.9360	183.7563	160.9962	153.7576
430009.5	168.6575	182.4678	159.6945	152.2946
435009.6	167.4580	181.2801	158.4818	150.9515
440009.8	166.6326	180.3843	157.5448	149.9594
445010.0	165.9514	179.6292	156.7560	149.1229
450010.2	165.5533	179.2215	156.2922	148.7020
455010.3	166.0792	180.0895	157.0735	149.7661
460010.3	168.1286	182.3958	159.7304	152.4078
465010.3	171.4476	185.6386	163.4874	156.2902
470010.5	174.3293	188.5934	166.9371	159.7848
475010.7	176.2769	190.7343	169.3531	162.4408
480010.7	177.7826	192.2201	170.9809	164.1229
485010.8	178.3526	192.7111	171.4513	164.6593
490010.9	177.7452	191.9382	170.3918	163.7770
495011.0	176.1025	190.1547	168.1408	161.7565
500011.2	173.7196	187.6152	165.3117	158.5871
505011.3	171.5966	185.4533	162.7691	155.8754
510011.5	170.0084	183.8558	161.1411	154.0405
515011.6	168.6336	182.4941	159.7989	152.4947
520011.8	167.4107	181.2732	158.5603	151.1064
525011.9	166.4497	180.2927	157.5385	150.0105
530012.1	165.6922	179.5108	156.7278	149.1497
535012.2	165.1515	178.9469	156.1060	148.5469
540012.3	165.4404	179.3916	156.4351	149.1316
545012.4	166.9709	181.2536	158.5168	151.2457
550012.6	170.1263	184.4066	162.1654	154.9973
555012.8	173.3040	187.5371	165.8483	158.7050
560012.9	175.4782	189.9286	168.5878	161.6322
565013.1	177.1719	191.6035	170.4278	163.5410
570013.3	178.0808	192.4204	171.2605	164.4815
575013.5	177.7980	191.9926	170.6104	163.9734
580013.6	176.4173	190.4625	168.6604	162.2350
585013.8	174.1279	188.0391	165.8815	159.4809
590013.9	171.7079	185.6762	163.1108	156.3259
595014.0	170.0919	183.9834	161.3228	154.3470
600014.1	168.6855	182.5523	159.9290	152.7191
605014.2	167.4926	181.3036	158.6824	151.2952
610014.3	166.4630	180.2317	157.5677	150.0854
615014.3	165.7014	179.4374	156.7394	149.2087
620014.4	165.0193	178.7413	156.0020	148.4492
625014.6	165.0391	178.8349	155.9805	148.6295

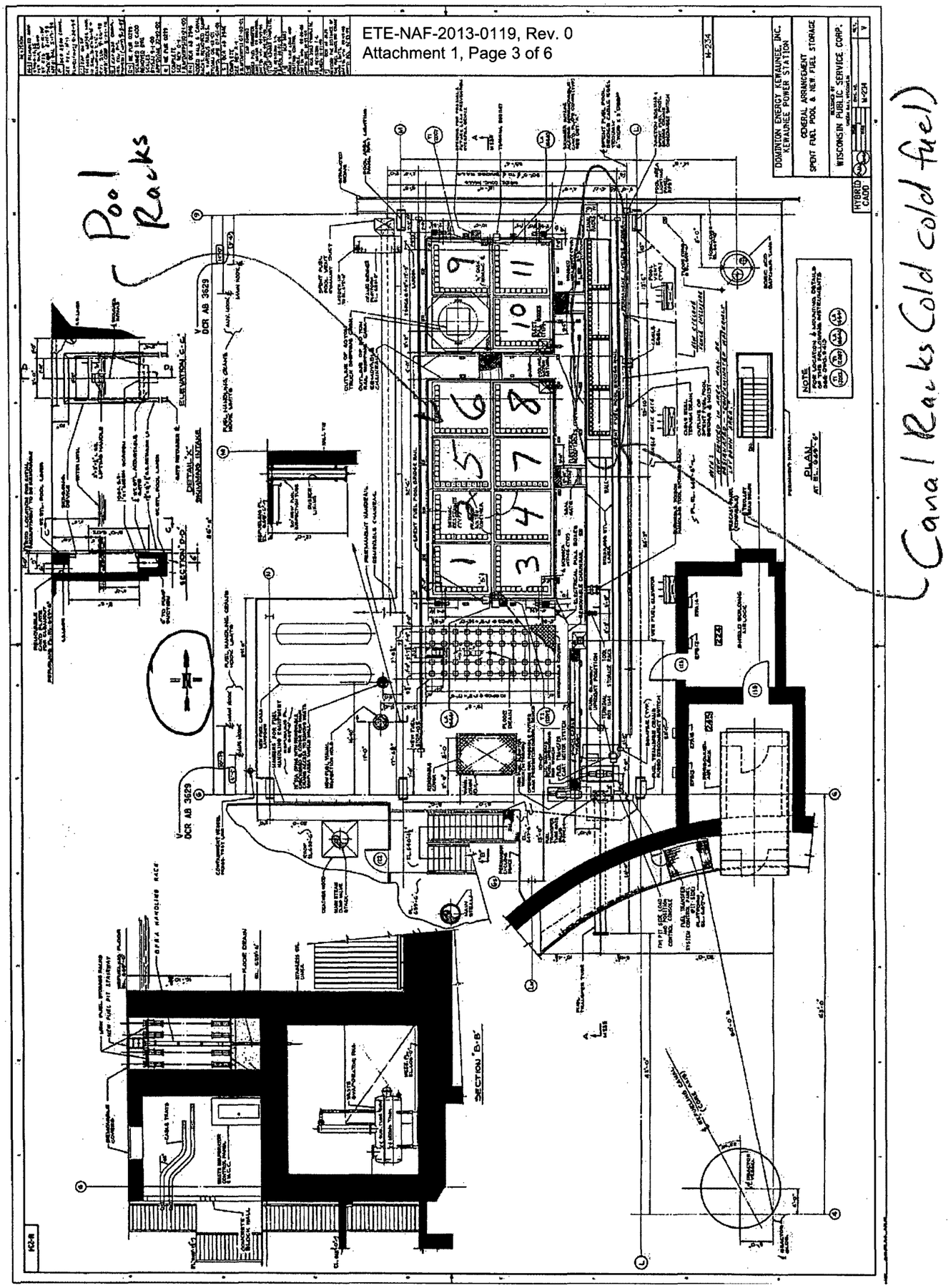
GOTHIC Output for May 2015 Case (cont'd)

Time (s)	$T_{max,North}$ (°F)	$T_{max,South}$ (°F)	$T_{max,bld\ exh}$ (°F)	$T_{max,SFP\ exh}$ (°F)
630014.7	166.1935	180.2952	157.5460	150.3072
635014.8	168.8535	183.1855	160.8781	153.7206
640014.9	172.1823	186.4230	164.6388	157.5499
645014.9	174.7426	189.0994	167.8010	160.7786
650015.0	176.5244	190.9339	169.7874	162.9131
655015.2	177.6854	192.0508	170.9954	164.1569
660015.2	177.8048	192.0262	170.8418	164.1120
665015.4	176.6688	190.7008	169.0756	162.6463
670015.4	174.6890	188.5792	166.5232	160.2511
675015.5	171.9683	185.8611	163.5869	156.8536
680015.7	170.2211	184.1482	161.5582	154.6951
685015.8	168.8339	182.6524	160.0732	152.9766
690015.9	167.6401	181.3847	158.8427	151.5310
695016.0	166.5225	180.2256	157.6556	150.2166
700016.3	165.7164	179.3926	156.7806	149.2860
705016.4	165.0077	178.6534	156.0052	148.4744
710016.4	164.7068	178.3849	155.6534	148.2283
715016.6	165.6238	179.5223	156.7642	149.5742
720016.6	167.8361	182.0222	159.6541	152.4995
725016.8	171.0446	185.3186	163.4511	156.3842
730016.8	173.8794	188.1480	166.8512	159.7874
735016.9	175.8782	190.2685	169.1722	162.2470
740017.1	177.2325	191.6102	170.6390	163.7517
745017.1	177.6617	191.9411	170.9086	164.0970
750017.2	176.9064	190.9465	169.5187	163.0099
755017.3	175.1402	189.0264	167.1074	160.8765
760017.4	172.3801	186.1719	164.1183	157.5530
765017.6	170.4600	184.3494	161.8439	155.0813
770017.8	169.0267	182.8146	160.2572	153.2998
775017.9	167.8137	181.4927	158.9980	151.7929
780017.9	166.6681	180.2926	157.7830	150.4310
785018.1	165.7627	179.3717	156.8215	149.3964
790018.3	165.0340	178.6134	156.0367	148.5502
795018.4	164.5722	178.1433	155.5109	148.0558
800018.6	165.1297	178.8190	156.0657	148.9113
805018.9	166.9088	180.9378	158.4802	151.3471
810019.0	169.8857	184.2024	162.2232	155.1828
815019.3	172.9249	187.1826	165.8245	158.7937
820019.4	175.2299	189.5518	168.4882	161.5101
825019.4	176.7860	191.1395	170.2286	163.3095
830019.6	177.4513	191.7638	170.8583	163.9826
835019.8	177.0500	191.1342	169.9077	163.2876
840020.0	175.5012	189.4326	167.6879	161.4399

GOTHIC Output for May 2015 Case (cont'd)

Time (s)	$T_{max,North}$ (°F)	$T_{max,South}$ (°F)	$T_{max,bld\ exh}$ (°F)	$T_{max,SFP\ exh}$ (°F)
845020.1	173.0867	186.8433	164.8296	158.4707
850020.1	170.6582	184.4326	162.1498	155.5238
855020.2	169.2479	183.0120	160.5062	153.6517
860020.3	167.9843	181.6353	159.1544	152.0712
864000.0	167.0691	180.6340	158.1742	150.9412

Spent Fuel Pool Map



Spent Fuel Pool Map

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Revised for Current (planning simulation) Spent Fuel Pool Cycle 32 2013 SFP Post-Core Offload

RACK 1 RACK 2 RACK 5 (partial)

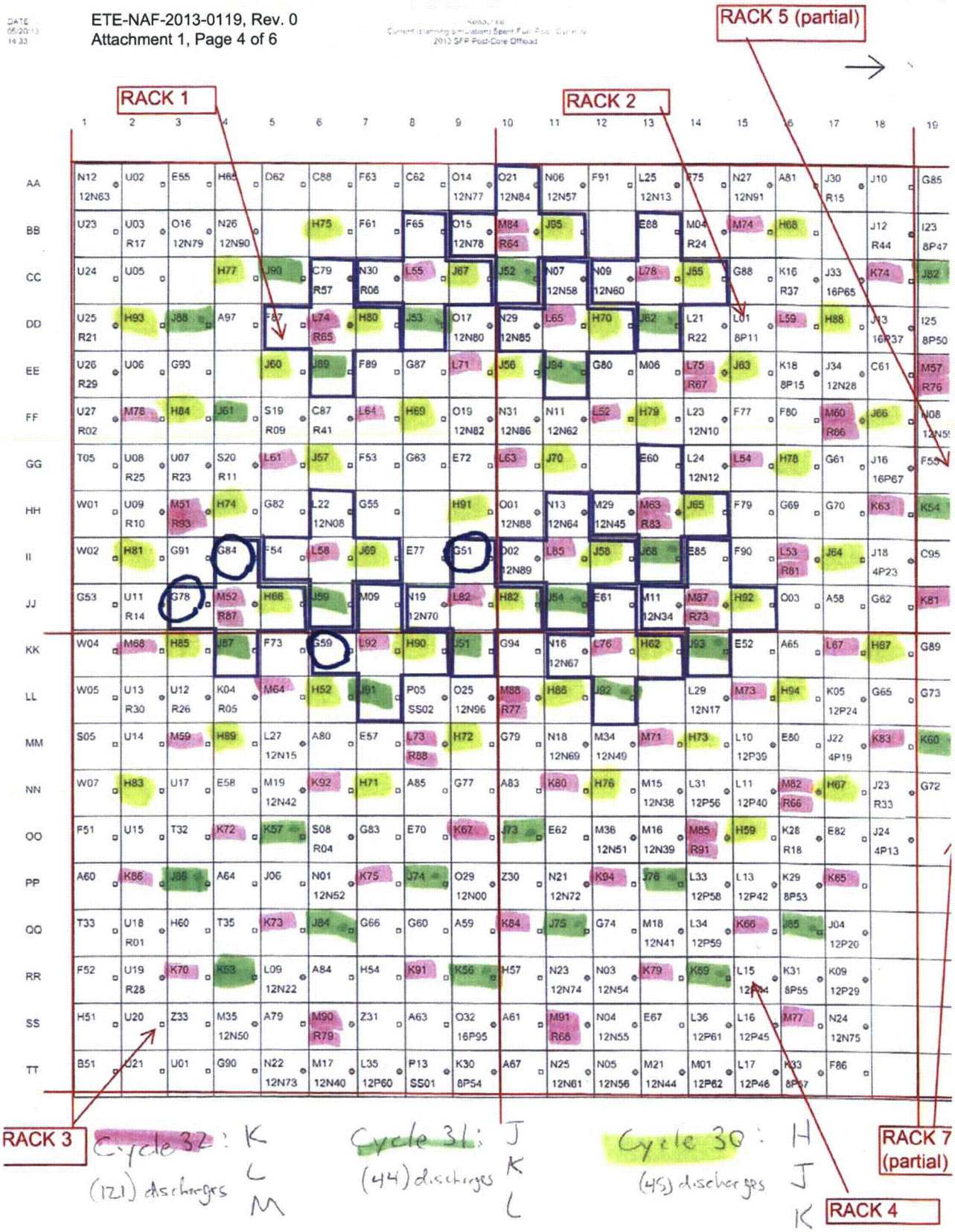
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
AA	N12 12N63	U02	E55	H65	D62	C88	F63	C62	O14 12N77	O21 12N84	N06 12N57	F91	L25 12N13	F75	N27 12N91	A81	J30 R15	J10	G85
BB	U23	U03 R17	O16 12N79	N26 12N90		H75	F61	F65	O15 12N78	M84 R64	J95		E88	M04 R24	M74	H68		J12 R44	I23 8P47
CC	U24	U05		H77	J90	C79 R57	N30 R06	L55	J67	J52	N07 12N58	N09 12N60	L78	J55	G88	K16 R37	J33 16P65	K74	J82
DD	U25 R21	H93	J88	A97	F87	L74 R65	H80	J53	O17 12N80	N29 12N85	L65	H70	J62	L21 R22	L01 8P11	L59	H88	J13 16P37	I25 8P50
EE	U26 R29	U06	G93		J60	J89	F89	G87	L71	J56	J94	G80	M06	L75 R67	J63	K18 8P15	J34 12N28	C61	M57 R76
FF	U27 R02	M78	H84	J61	S19 R09	C87 R41	L64	H69	O19 12N82	N31 12N86	N11 12N62	L52	H79	L23 12N10	F77	F80	M60 R86	J66	N08 12N5[illegible]
GG	T05	U08 R25	U07 R23	S20 R11	L61	J57	F53	G63	E72	L63	J70		E60	L24 12N12	L54	H78	G61	J16 16P67	F55
HH	W01	U09 R10	M51 R93	H74	G82	L22 12N08	G55		H91	O01 12N88	N13 12N64	M29 12N45	M63 R83	J65	F79	G69	G70	K63	K54
II	W02	H81	G91	G84	F54	L58	J69	E77	G51	O02 12N89	L85	J58	J68	E85	F90	L53 R81	J64	J18 4P23	C95
JJ	G53	U11 R14	G78	M52 R87	H66	J59	M09	N19 12N70	L82	H82	J54	E61	M11 12N34	M87 R73	H92	Q03	A58	G62	K81
KK	W04	M68	H85	J87	F73	G59	L92	H90	J51	G94	N16 12N67	L76	H62	J93	E52	A65	L67	H87	G89
LL	W05	U13 R30	U12 R26	K04 R05	M64	H52	J91	P05 SS02	O25 12N96	M88 R77	H86	J92		L29 12N17	M73	H94	K05 12P24	G65	G73
MM	S05	U14	M59	H89	L27 12N15	A80	E57	L73 R88	H72	G79	N18 12N69	M34 12N49	M71	H73	L10 12P39	E80	J22 4P19	K83	K60
NN	W07	H83	U17	E58	M19 12N42	K92	H71	A85	G77	A83	K80	H76	M15 12N38	L31 12P56	L11 12P40	M82 R66	H67	J23 R33	G72
OO	F51	U15	T32	K72	K57	S08 R04	G83	E70	K67	J73	E62	M36 12N51	M16 12N39	M85 R91	H59	K28 R18	E82	J24 4P13	
PP	A60	K86	J86	A64	J06	N01 12N52	K75	J74	O29 12N00	Z30	N21 12N72	K94	J76	L33 12P58	L13 12P42	K29 8P53	K65		
QQ	T33	U18 R01	H60	T35	K73	J84	G66	G60	A59	K84	J75	G74	M18 12N41	L34 12P59	K66	J85	J04 12P20		
RR	F52	U19 R28	K70	K53	L09 12N22	A84	H54	K91	K56	H57	N23 12N74	N03 12N54	K79	K69	L15 12P44	K31 8P55	K09 12P29		
SS	H51	U20	Z33	M35 12N50	A79	M90 R79	Z31	A63	O32 16P95	A61	M91 R68	N04 12N55	E67	L36 12P61	L16 12P45	M77	N24 12N75		
TT	B51	U21	U01	G90	N22 12N73	M17 12N40	L35 12P60	P13 SS01	K30 8P54	A67	N25 12N61	N05 12N56	M21 12N44	M01 12P62	L17 12P46	K33 8P57	F86		

RACK 3 RACK 4 RACK 7 (partial)

Cycle 32: K L M
(121) discharges

Cycle 31: J K L
(44) discharges

Cycle 30: H J K
(45) discharges



Spent Fuel Pool Map

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Kewaunee
Current (planning simulation) Spent Fuel Pool Cycle 32
2013 SFP Post-Core Offload

N

	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
AA	M10 12N33	C80	N15 12N66	L28 12N16	F70	F18 16P92	E38 12P54	E18 16P17	D38 4P17	G54	C40 12P12	C20 12P18	G81	B20 12B35A	A41 12P52	U22 R12	C65
BB	M93 R72	D51	U28	D60	F39 16P86	F19 12N31	E39 12P53	E19 16P23	D39 4P25	D20 16P51	D01 4P27	C21 12P50	C01 16P09	B21 16P19	M30 12N46	E59	D76 RS01
CC	C69 R50	E81	E71	L81	F40 8P06	Z28	E40 16P06	E20 4P14	D40 12P38	D21 12P11	F83	C22 12P05	C02 16P47	B22 16P03	B02 16P32	A23 8P36	D59
DD	H64	K71	J83	F62	F71	G52	F01 16P90	E21 16P01	H63	Z14	D02 12P51	L94	C03 16P27	B23 16P35	G71	D75	D58
EE	I06 8P46	C75 R38	C84 R39	D55 R62	K68	J72	U04 R20	L07 12N19		D23 4P21	D03 4P31W	O36 R53	D82	6B4C 1981-1	M80 R78	C56	N28 12N92
FF		C85 R63	K88	J80	E76	L20 12N06	F03 4P22	E23 12N20	E03 16P56	D24 8P39	D04 12P34	D64	L91	J32 16P38	D84	I24 8P48	C78
GG	K82	J81	E69	H55	G56	M66 R71	F04 16P85	E24 4P28	E04 8P21	D25 4P04	L51	E83	G92	M26	E51	D74	D67
HH	C77	H58	D68 R52	K89	J71	C66	F05 16P88	E25 16P58	E05 16P02	G02 R54	D77	C93	D57	L80	C51	RACK PD12*	D63
II	F58	K78	K55	E79	C72 R46	E65	L89	E26 16P26	E06 8P17	E66	N32 12N87	M70	E84	D88	D52 R31	E78	C96
JJ	K58	C86	C92	H53	K77	K51	C52 R59	E27 12N26	E07 16P77	L69	D79 R58	A66	D65	D83	L84	C91	C94
KK	C81	F57	K87	K61	F60	N17 12N68	P02 R40	E28 12N09	E08 16P61	E86 R34	F67	N14 12N65	M56	F68	L26 12N14	K02 R49	F66
LL	K93	K52	C89 R55	G29 R08	C76	K64	J79	E29 16P41	E09 16P66	O24 12N95	L68	D86	D81	D72	M32 R27	D73	C53
MM	I14 R56	7B4C 1981-2	E64	K69	K62	L30 12P55	L08 R16	E30 16P43	E10 16P13	D87		E74		L62	E56	C58	D78
NN	G75	K90	J77	DC-1	L32 12P57	O06 PD18	K85	E31 16P63	E11 8P27		D71 R42	C33 16P42	D80	D89	D85	D70	D54
OO		D61 R45	D66 R60	E75	K76	J78	E68	E32 16P28	E12 16P24	D32 4P08	D13 4P07	C64 R36	E54	E90	L86	E63	U16 R03
PP				S28 PD80	D56 R48	P08 R51	N20 12N71	M54	E87	D33 12P35	D14 16P20	H61	L57	C74	O30 16P93	N02 12N53	C68
QQ				C90 R35	C60	L70	L14 12P43	C59 PD49	D90 R61	Z10	D15 12P33	C54	W12 R43	D69	T16	A37 16P81	N10 12N76
RR				L60	H56	Z29	Z26	Z25	E15 16P79	D35 8P34	D16 16P31	C37 12P14	C17 16P54	B37 16P08	B17 8P26	A38 16P80	C70 PD19
SS				M20 12N43	D53 PD11	F36	F16	E36 8P16	E16 16P83	D36	D17 16P78	C38 16P12	C18 16P44	B38 12P15	B18 12P32	A39 16P84	K32 8P56
TT				E53	F84	M12 12N35	F17 4P11	E37 8P18	E17 PD51	D37 12P02	D18 PD26	C39 4P26	F56	B39 16P34	B19 PD83	A40 PD74	L12 12P41

Spent Fuel Pool Map

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Keweaunee
Current (planning simulation) Spent Fuel Pool - Cycle 32
2013 SFP Post-Core Offload

N

	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
AA																		X04
BB											F64	J21 12N30	M69	Z35	X13	G24 8P37	I18	Z16
CC											L87					L88	G31 PD04	Z15
DD														L83			X05	X02
EE												L90		1B4C 1988-1			M94 R89	X33
FF										L56		2B4C 1988-2			L66			X34
GG													L95					X35
HH											L77					L79		X36
II														M65 R82				X17
JJ											F78	G67	G57	G68	F72	F76	M79 R75	X14
KK	J01 PD61	F88	F59	G58	F81	J03 12P19	J14 16P70	B75	X21	L93	J19 8P30	X07	Z34	J20 16P29	M53 R90	F93	J36 16P39	W23
LL	A98	F69	M58	C67		B94	B85	B76	B66	B56	A88	A69	L72 R84	O18 12N81	G64	O20 12N83	O22 12N93	W24
MM	C71	C73 R47	X03	A62	Z07	X24	B86	IPLATE1 16P25	B67	B57	IMB7	A70	Z36	O26 12N97	O27 12N98	M89 R92	F92	X12
NN	X25	G86	Z11	F85	O28 12N99	X26	B87	B78	M55	B58	A90	O31 16P94	A51	M72	SAMPLE COUPON	G11 PD70	F74	W26
OO	C57	E73	Z32	Z08	X09	X27	X23	B79	G19 PD06	IPLATE3 12P04	A91	M81 R69	X06	3B4C 1979-3	G23 PD64	F82	M92 R80	W27
PP	G27 PD09	A68	G76	B77	A89	X28	B89	B80	B70	B60	A92	A72	A53	Z20	M62	M14 12N37	M24	W28
QQ	K26 R19	F94	M61	M33 12N48	B88	X29	B90	B81	X22	B61	A93	X08	M86 R85	Z21	E89	I29 8P12	J08	W29
RR	B59	A52	I13	B71	I12	X30	B91 R07	B82	B73	5B4C 1979-2	M75	A94	A54	4B4C 1979-1	I20 8P14	M67	I17 8P51	W30
SS	A74	K07 12P26	C55	Z01	I28	Z06	B92	B72	M83 R70	B68	X10	A55	A56	M76	X01	I15 16P71	W21	X20
TT	B83	A95	Z23		C63	DFA RS05	B93	B84	B74	B64	A96	A77	A57	J17 8P13	I27	X19	X18	X16

ATTACHMENT 15

EVALUATION OF THE HEAT TRANSFER ACROSS ASSEMBLIES

Preparer	Reviewer
Daniele Ludovisi	Matthew M. Ross
Daniele Ludovisi · November 8th, 2013	Matthew M. Ross 11/8/13
signature, date	signature, date

1. Purpose and Scope

The purpose of this attachment is to evaluate the heat transfer from one assembly to another. The results of the COBRA run are elaborated and simple heat balances are performed on different sections of the assemblies to estimate the net heat loss from the high to the low heat generation rate assembly.

2. Introduction

Section 3.2 in the main body of the calculation describes the COBRA model used for the calculation of the cladding maximum surface temperature. Attachment 9 documents the COBRA outputs and echo of the inputs. The results of the COBRA run are elaborated in this attachment to evaluate the heat transfer from one assembly to another. Heat transfer through thermal convection, conduction and radiation modes are considered and heat balance is performed on the various sections of the assemblies. Finally, a global heat balance is performed to the find the net heat gain/loss for each assembly.

3. Methodology

The COBRA model (Section 3.2 in the main body of the calculation) considers three assemblies in line with the high heat generation rate assembly in the middle. The assemblies are subdivided into 24 vertical sections consisting of slabs and channels. Figure 1 shows a horizontal cross section of the three assembly system. Due to symmetry, only the heat balance on half edge between Assembly 1 and 2 (Slabs 1, 21 and 23) is considered in this attachment (blue area in Figure 1).

Figure 2 shows the heat transfer resistances (heat transfer modes) evaluated in this attachment for the heat balance of the slabs. The heat generated within each rod is dissipated on its surface by convection to the air in the channel and radiation to the other rods and assembly outer walls. Since the rod and air temperatures within each assembly are fairly uniform, only the rods and channels closest to the edge of the assemblies are considered in the calculations.

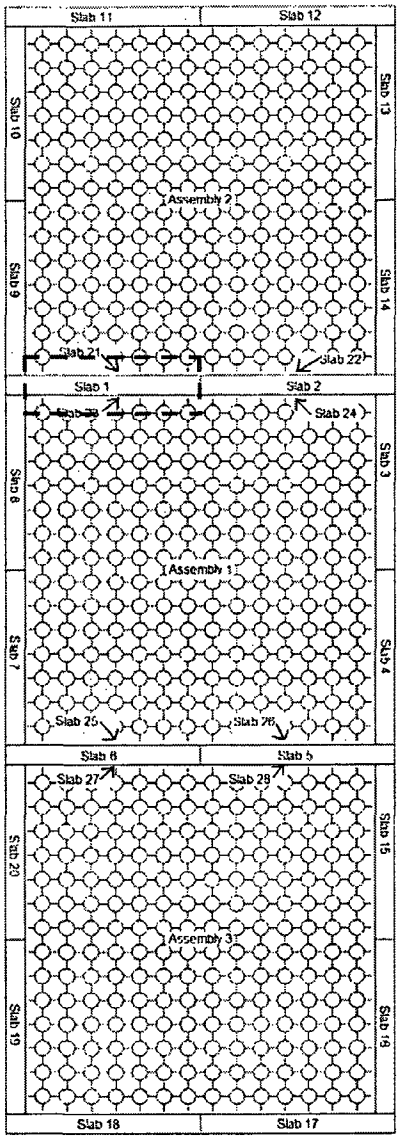

Figure 1. Horizontal cross section of the three assembly system.

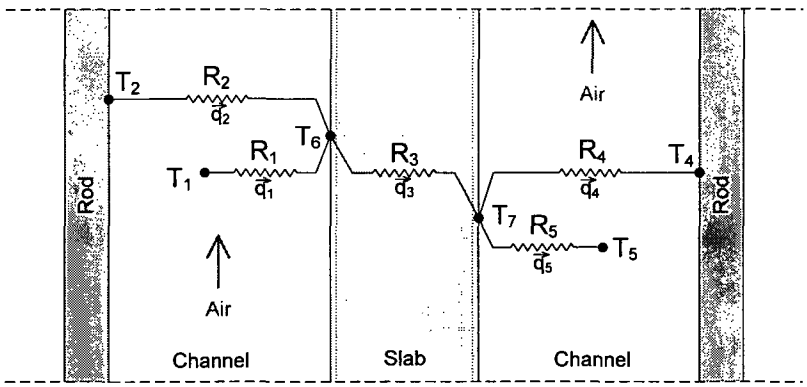

Figure 2. Heat transfer mechanisms between two assemblies.

The following symbols are used in Figure 2:

R_1: Convection heat transfer resistance between the air in the channel (Assembly 1) and the portion of the slab connected to it;

R_2: Radiation heat transfer resistance between the rod (Assembly 1) and the portion of the slab adjacent;

R_3: Conduction heat transfer resistance between through the slab;

R_4: Radiation heat transfer resistance between the rod (Assembly 2) and the portion of the slab adjacent;

R_5: Convection heat transfer resistance between the air in the channel (Assembly 2) and the portion of the slab connected to it;

T_i: Air or surface temperature of the rods or slab;

q_i: Heat transfer associated to resistance R_i.

The quantities above are defined as follows [Ref. A15-1]:

$$q_1 = \frac{T_1 - T_6}{R_1} \tag{1}$$

$$q_2 = \frac{T_2 - T_6}{R_2} \tag{2}$$

$$q_3 = \frac{T_6 - T_7}{R_3} \tag{3}$$

$$q_4 = \frac{T_7 - T_4}{R_4} \tag{4}$$

$$q_5 = \frac{T_7 - T_5}{R_5} \tag{5}$$

where:

$$R_1 = \frac{1}{h_{convection}\ Area}$$

$$R_2 = \frac{1}{h_{radiation.A1}\ Area}$$

$$R_3 = \frac{slab\_thickness}{k_{slab}\ Area}$$

$$R_4 = \frac{1}{h_{radiation.A2}\ Area}$$

$$R_5 = \frac{1}{h_{convection}\ Area}$$

$$h_{radiation.A1} = \frac{\sigma\left(T_2^2 + T_6^2\right)\left(T_2 + T_6\right)}{\left(\frac{1-\varepsilon_{rod}}{\varepsilon_{rod}}\right)\frac{Area_{slab}}{Area_{rod}} + \frac{1}{F_{rod.slab}} + \frac{1-\varepsilon_{slab}}{\varepsilon_{slab}}}$$

$$h_{radiation.A2} = \frac{\sigma\left(T_4^2 + T_7^2\right)\left(T_4 + T_7\right)}{\left(\frac{1-\varepsilon_{rod}}{\varepsilon_{rod}}\right)\frac{Area_{slab}}{Area_{rod}} + \frac{1}{F_{rod.slab}} + \frac{1-\varepsilon_{slab}}{\varepsilon_{slab}}}$$

with σ is the Stefan-Boltzmann constant [$0.1714 \cdot 10^{-8}$ BTU/(hr-ft^2-R^4)], ε is the surface emission coefficient, $F_{rod.slab}$ is the view factor between the rod and the slab, and $h_{convection}$ is the convection heat transfer coefficient. As a simplification to the calculations, the areas of the slab section ("$Area_{slab}$") and the rod section ("$Area_{rod}$") involved in the radiation heat transfer processes are considered to be equal and both equal to the convection and conduction heat transfer areas (indicated as "Area" in the equations above).

The slab thermal conductivity, emission coefficients and convection heat transfer coefficient are specified equal to the values used in the COBRA analysis, i.e.:

$$k_{slab} = 0.0231 \text{ BTU/(hr-ft-°F)}$$

$$\text{slab\_thickness} = 0.906 \text{ inches}$$

$$\varepsilon_{slab} = 0.2$$

$$\varepsilon_{rod} = 0.8$$

$$h_{convection} = \frac{k_{air}}{D_{hydro.channel}} \max(0.33\, Re^{06}\, Pr^{0.3}, 0.83\, Re^{0.33}\, Pr^{0.33})$$

where [A15-1]:

Re = Reynolds number = air_velocity x $D_{hydro.channel}$ / v_{air};

$D_{hydro.channel}$ = hydraulic diameter of the channel (from COBRA output);

air_velocity = velocity of the air in the channel (from COBRA output).

The air Prandtl number (Pr), thermal conductivity (k_{air}) and kinematic viscosity (ν_{air}) are interpolated from the air properties provided in the COBRA input file as follows:

$$k_{air} = -5.18\cdot10^{-13}\,T_{air}^3 - 5.299\cdot10^{-10}\,T_{air}^2 + 1.975\cdot10^{-5}\,T_{air} + 1.339\cdot10^{-2}$$

$$\nu_{air} = -6.18595\cdot10^{-14}\,T_{air}^3 + 3.961513\cdot10^{-10}\,T_{air}^2 + 4.529778\cdot10^{-7}\,T_{air} + 1.335015\cdot10^{-4}$$

$$Pr_{air} = -1.77748\cdot10^{-10}\,T_{air}^3 + 5.2645\cdot10^{-7}\,T_{air}^2 - 4.22077\cdot10^{-4}\,T_{air} + 7.87466\cdot10^{-1}$$

with k_{air} in BTU/(hr-ft-°F), ν_{air} in ft^2/s, Pr_{air} dimensionless and T_{air} is degree Fahrenheit.

The air specific heat is also used in the computations documented in this attachment. Similarly to the air properties above, the specified heat is also interpolated from the air properties provided in the COBRA input file:

$$c_{p\cdot air} = 1.24847958\cdot10^{-17}\,T_{air}^5 - 4.2051314\cdot10^{-14}\,T_{air}^4 + 3.85066422\cdot10^{-11}\,T_{air}^3 + 5.36256073\cdot10^{-9}\,T_{air}^2 + 8.70396044\cdot10^{-6}\,T_{air} + 2.38996296\cdot10^{-1}$$

with $c_{p.air}$ in BTU/(lb-°F) and T_{air} is degree Fahrenheit.

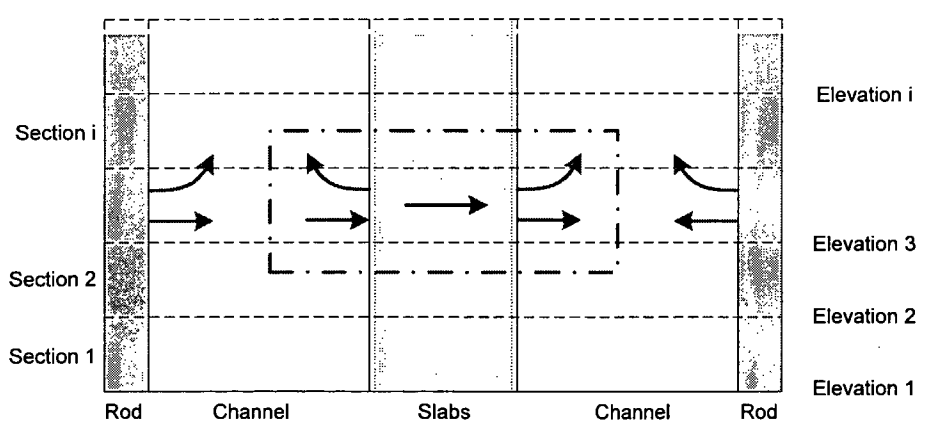

Figure 3. Slab heat balance.

For each vertical section of the assemblies (see Figure 3), the thermal circuit shown in Figure 2 is solved by using Equations 1 to 5 and specifying that $q_3 = q_1 + q_2 = q_4 + q_5$. The closed form solution for the total heat transfer through the slab section is the derived to be the following:

$$q_{Total.section.i} = q_3 = \frac{\left(\frac{T_1}{R_1}+\frac{T_2}{R_2}\right)\left(\frac{1}{R_4}+\frac{1}{R_5}\right)-\left(\frac{T_4}{R_4}+\frac{T_5}{R_5}\right)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)}{R_3\left(\frac{1}{R_1}+\frac{1}{R_2}\right)\left(\frac{1}{R_4}+\frac{1}{R_5}\right)+\left(\frac{1}{R_4}+\frac{1}{R_5}\right)+\left(\frac{1}{R_1}+\frac{1}{R_2}\right)}$$

The above equation is applied every assembly section in the vertical direction (see Figure 3) and the heat transfer in each section is added to find the total heat transfer from the high to the low heat generation rate assembly.

$$q_{Total.Slab} = \sum_{i=1}^{24} q_{Total.section.i}$$

The energy gained by the air flow in each assembly is also computed by considering the heat gain in each vertical section (see Figure 4). Due to significant change in air temperature in the vertical direction, evaluating the air properties are in each section ensure that the overall heat balance is accurate.

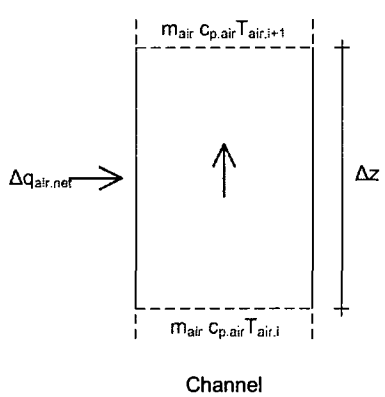

Figure 4. Air heat balance.

Therefore, the energy gained by the air flow in each assembly is computed as follows:

$$q_{Total.Air} = \sum_{i=1}^{24} \Delta q_{net,i} = \sum_{i=1}^{24} m_{air} \times \left[c_{p.air} \left(\frac{T_{air,i} + T_{air,i+1}}{2} \right) \times \left(T_{air,i+1} - T_{air,i} \right) \right]$$

For each assembly, the total heat transfer through the slabs is added/subtracted to the total heat gained by the air:

$$q_{Total.Assembly} = q_{Total.Air} \pm q_{Total.Slabs}$$

The computed value is compared to the total heat generation rate specified in COBRA for that assembly to ensure that the two values are in reasonable agreement based on the simplifications to the calculations described in this attachment. In particular, due to the compact geometry of the assembly, the radiation heat transfer between the rods and the slab is considered to occur only horizontally (this also matches the COBRA methodology [Ref. A15-2]). The view factor between the rods and the slab is also considered to be one and the rod/slab area ratio is considered to be 1 for simplification. Furthermore, due to the low thermal conductivity of the slabs, heat transfer between the slabs is not considered. This greatly simplifies the calculation without significant loss in accuracy.

4. Documentation of Computer Codes

Microsoft Office Professional 2003 SP-2 including Excel, S&L Program No. 03.2.286-1.0, 02/02/2004. The validation of Excel is implicit in the detailed review of all spreadsheets used in this attachment. All computer runs were performed using S&L PC. No. ZL8439 under the Microsoft Windows XP Professional Version 2002 Service Pack 3 operating system.

5. Calculation

All the calculations are performed in Microsoft Excel. Table 1 shows the output data from COBRA used in this attachment. The heat balance is performed on Slab 1 only due to the symmetry of the system. Consequently, the results of Channels 1 to 8 and Rod 1 to 8 in Assembly 1, and Channels 211 to 218 and Rods 183 to 190 in Assembly 2 are used for the calculations. Slab 21 and 23 have zero thickness, thus there is no thermal resistance associated to them but they are used to document the surface temperatures of Slab 1. Table 2 computed the average of various variables in each vertical section of the system, while are used in other tables. Table 3 computes the thermal resistances and heat flow in vertical portion of the assembly as described above in Section 3. Table 4 uses the results from Table 3 to calculate the total heat transfer through the assembly walls and also computes the air overall heat gain in each assembly. Finally, Table 5 summarizes the results obtained in the previous table and compares the total heat generation in each assembly with the total heat gained by the air and heat transfer through the walls. The slab surface temperatures computed in Table 3 are also compared to those obtained from COBRA. Since the computation of the heat transfer coefficient associated to the radiation thermal resistance requires the knowledge of the slab surface temperatures which are unknown, the computations performed in Table 3 are done iteratively until convergence is reached. Table 6 is used to speed-up the numerical iterations by allowing the use of the results from the previous iterations for the next iteration through a simple "copy/paste" process.

Tables 1eq to 6eq show the equations used to generate Tables 1 to 6.

Table 1

Heat generation	Assembly 1	Assembly 2	Assembly 3
Heat generation per unit volume [MBTU/(hr-ft3)]	0.00549	0.001103	0.001103
Number of heated rods [-]	179	179	179
Rod diameter [in]	0.422	0.422	0.422
Rod length [ft]	12	12	12

Average values	Assembly 1				Assembly 2				Assembly 3			
	Temperature [°F]	Flow [lb/s]	Velocity [ft/s]	Area [in^2]	Temperature [°F]	Flow [lb/s]	Velocity [ft/s]	Area [in^2]	Temperature [°F]	Flow [lb/s]	Velocity [ft/s]	Area [in^2]
Elevation 1	200.0000	0.0144855	0.8384427	41.464930	200.0000	0.0110061	0.6370498	41.464930	200.0000	0.0110061	0.6370498	41.464930
Elevation 2	238.5873	0.0144855	0.8881182	41.464930	210.7345	0.0110061	0.6475667	41.464930	210.7348	0.0110061	0.647567	41.464930
Elevation 3	276.2126	0.0144855	0.9364678	41.464930	221.2669	0.0110061	0.6578818	41.464930	221.2677	0.0110061	0.6578826	41.464930
Elevation 4	313.2503	0.0144855	0.9836002	41.464930	231.9092	0.0110061	0.6683038	41.464930	231.9108	0.0110061	0.6683055	41.464930
Elevation 5	349.6782	0.0144855	1.0295654	41.464930	242.7208	0.0110061	0.6788911	41.464930	242.7236	0.0110061	0.678894	41.464930
Elevation 6	385.8009	0.0144855	1.0750734	41.464930	253.7167	0.0110061	0.6896573	41.464930	253.7211	0.0110061	0.6896619	41.464930
Elevation 7	421.4445	0.0144855	1.1202787	41.464930	264.9019	0.0110061	0.700606	41.464930	264.9082	0.0110061	0.7006127	41.464930
Elevation 8	456.6797	0.0144855	1.1651722	41.464930	276.2780	0.0110061	0.7117375	41.464930	276.2866	0.0110061	0.7117467	41.464930
Elevation 9	491.6180	0.0144855	1.2096517	41.464930	287.8450	0.0110061	0.723044	41.464930	287.8562	0.0110061	0.7230561	41.464930
Elevation 10	525.9470	0.0144855	1.253548	41.464930	299.6029	0.0110061	0.7344289	41.464930	299.6169	0.0110061	0.7344447	41.464930
Elevation 11	559.8961	0.0144855	1.2969502	41.464930	311.4088	0.0110061	0.7458268	41.464930	311.4254	0.0110061	0.7458447	41.464930
Elevation 12	593.5618	0.0144855	1.3398427	41.464930	323.3981	0.0110061	0.7573048	41.464930	323.4177	0.0110061	0.7573254	41.464930
Elevation 13	626.6304	0.0144855	1.3819332	41.464930	335.5729	0.0110061	0.7689349	41.464930	335.5955	0.0110061	0.7689586	41.464930
Elevation 14	659.3582	0.0144855	1.4234197	41.464930	347.9296	0.0110061	0.7807356	41.464930	347.9552	0.0110061	0.7807625	41.464930
Elevation 15	691.8180	0.0144855	1.4644936	41.464930	360.4658	0.0110061	0.7927056	41.464930	360.4944	0.0110061	0.7927356	41.464930
Elevation 16	723.7350	0.0144855	1.5050175	41.464930	373.1790	0.0110061	0.8048448	41.464930	373.2106	0.0110061	0.8048778	41.464930
Elevation 17	755.3068	0.0144855	1.5450986	41.464930	386.0666	0.0110061	0.8171526	41.464930	386.1010	0.0110061	0.8171886	41.464930
Elevation 18	786.6256	0.0144855	1.5848217	41.464930	399.1262	0.0110061	0.8296289	41.464930	399.1635	0.0110061	0.8296677	41.464930
Elevation 19	817.4923	0.0144855	1.6239506	41.464930	412.2548	0.0110061	0.8422733	41.464930	412.2943	0.0110061	0.8423148	41.464930
Elevation 20	847.9689	0.0144855	1.6625898	41.464930	425.5406	0.0110061	0.8550833	41.464930	425.5825	0.0110061	0.8551273	41.464930
Elevation 21	878.2069	0.0144855	1.7008951	41.464930	438.9892	0.0110061	0.8680585	41.464930	439.0334	0.0110061	0.8681049	41.464930
Elevation 22	908.0808	0.0144855	1.7387834	41.464930	452.5932	0.0110061	0.8811847	41.464930	452.6397	0.0110061	0.8812335	41.464930
Elevation 23	937.3883	0.0144855	1.7762183	41.464930	466.3315	0.0110061	0.894436	41.464930	466.3801	0.0110061	0.8944869	41.464930
Elevation 24	966.3839	0.0144855	1.8132214	41.464930	480.1136	0.0110061	0.9077219	41.464930	480.1643	0.0110061	0.9077748	41.464930
Elevation 25	994.4826	0.0144855	1.848952	41.464930	493.4934	0.0110061	0.9206025	41.464930	493.5460	0.0110061	0.9206574	41.464930

Air temperature [°F]	Assembly 1								Assembly 2							
	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8	Channel 211	Channel 212	Channel 213	Channel 214	Channel 215	Channel 216	Channel 217	Channel 218
Elevation 1	200.0000	200.0000	200.0000	200.0000	200.0000	200.0000	200.0000	200.0000	200.0000	200.0000	200.0000	200.0000	200.0000	200.0000	200.0000	200.0000
Elevation 2	224.0727	226.5344	227.3562	227.6585	227.8011	227.8811	227.9208	227.9285	208.7106	209.5448	209.7710	209.8513	209.8884	209.9094	209.9203	209.9226
Elevation 3	251.1969	255.4941	257.1668	257.9101	258.3087	258.5392	258.6593	258.6892	218.2133	219.9899	220.4951	220.7047	220.8127	220.8744	220.9071	220.9156
Elevation 4	281.5688	286.4244	288.6624	289.7999	290.4706	290.8783	291.0983	291.1555	229.0464	231.5882	232.3360	232.6762	232.8646	232.9761	233.0364	233.0526
Elevation 5	313.9695	318.6261	321.1373	322.5538	323.4542	324.0277	324.3454	324.4287	240.9425	244.1728	245.1215	245.5771	245.8420	246.0038	246.0928	246.1165
Elevation 6	347.6691	351.8218	354.4229	356.0141	357.0869	357.7963	358.1976	358.3019	253.6389	257.5428	258.6622	259.2156	259.5475	259.7550	259.8705	259.9007
Elevation 7	382.2721	385.7766	388.3255	389.9863	391.1581	391.9564	392.4152	392.5322	266.9482	271.5302	272.8008	273.4364	273.8246	274.0713	274.2095	274.2450
Elevation 8	417.2691	420.0862	422.4977	424.1500	425.3582	426.2007	426.6907	426.8124	280.7355	286.0003	287.4089	288.1140	288.5486	288.8274	288.9844	289.0237
Elevation 9	452.4629	454.6319	456.8778	458.4789	459.6823	460.5360	461.0367	461.1570	294.8964	300.8374	302.3668	303.1277	303.5977	303.9006	304.0714	304.1132
Elevation 10	487.6811	489.2453	491.3010	492.8128	493.9736	494.8082	495.3006	495.4143	309.2740	315.8480	317.4942	318.3053	318.8051	319.1277	319.3097	319.3532
Elevation 11	522.5975	523.6115	525.4706	526.8737	527.9696	528.7654	529.2367	529.3409	323.8492	331.0773	332.8347	333.6910	334.2163	334.5550	334.7458	334.7905
Elevation 12	557.3025	557.8369	559.5205	560.8191	561.8468	562.5987	563.0448	563.1386	338.6183	346.4731	348.3346	349.2313	349.7781	350.1298	350.3275	350.3731
Elevation 13	591.7312	591.8399	593.3502	594.5373	595.4872	596.1863	596.6013	596.6840	353.5407	361.9906	363.9481	364.8805	365.4454	365.8075	366.0106	366.0568
Elevation 14	625.6397	625.3698	626.7186	627.7969	628.6679	629.3118	629.6942	629.7663	368.5814	377.5903	379.6352	380.5991	381.1790	381.5493	381.7565	381.8032
Elevation 15	659.2259	658.6254	659.8385	660.8237	661.6259	662.2209	662.5741	662.6369	383.7141	393.2442	395.3681	396.3592	396.9516	397.3285	397.5387	397.5859
Elevation 16	692.4333	691.5476	692.6347	693.5309	694.2658	694.8126	695.1369	695.1914	398.9007	408.8847	411.0710	412.0818	412.6821	413.0625	413.2740	413.3214
Elevation 17	725.0926	723.9633	724.9359	725.7501	726.4225	726.9240	727.2211	727.2685	414.0773	424.5049	426.7543	427.7850	428.3935	428.7778	428.9910	429.0389
Elevation 18	757.4252	756.0808	756.9581	757.7042	758.3245	758.7882	759.0627	759.1042	429.2910	440.1206	442.4244	443.4719	444.0868	444.4739	444.6882	444.7365
Elevation 19	789.3934	787.8667	788.6546	789.3357	789.9056	790.3325	790.5850	790.6213	444.5217	455.7169	458.0679	459.1295	459.7496	460.1387	460.3538	460.4025
Elevation 20	820.8374	819.1590	819.8665	820.4883	821.0121	821.4054	821.6378	821.6698	459.7609	471.2845	473.6758	474.7486	475.3726	475.7630	475.9785	476.0276
Elevation 21	851.9364	850.1164	850.7571	851.3304	851.8167	852.1825	852.3986	852.4272	475.0039	486.8191	489.2436	490.3250	490.9516	491.3427	491.5582	491.6077
Elevation 22	882.6969	880.7603	881.3382	881.8647	882.3141	882.6527	882.8526	882.8781	490.2288	502.2878	504.7288	505.8113	506.4362	506.8255	507.0398	507.0895
Elevation 23	912.8916	910.8677	911.3885	911.8721	912.2877	912.6015	912.7867	912.8096	505.3560	517.6033	520.0690	521.1576	521.7840	522.1735	522.3876	522.4377
Elevation 24	942.5015	940.4132	940.8943	941.3481	941.7400	942.0363	942.2110	942.2323	520.2169	532.7172	535.2087	536.3047	536.9339	537.3244	537.5390	537.5896
Elevation 25	970.7032	968.9340	969.4539	969.9225	970.3197	970.6168	970.7914	970.8144	534.0250	547.0561	549.6317	550.7658	551.4166	551.8196	552.0407	552.0938

Table 1

Air velocity [ft/s]	Assembly 1								Assembly 2							
	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8	Channel 211	Channel 212	Channel 213	Channel 214	Channel 215	Channel 216	Channel 217	Channel 218
Elevation 1	0.8384427	0.8384427	0.8384427	0.8384427	0.8384427	0.8384427	0.8384427	0.8384427	0.6370498	0.6370498	0.6370498	0.6370498	0.6370498	0.6370498	0.6370498	0.6370498
Elevation 2	0.8694925	0.8726677	0.8737276	0.8741175	0.8743014	0.8744047	0.8744559	0.8744658	0.6455863	0.6464038	0.6466255	0.6467042	0.6467406	0.6467612	0.6467718	0.6467741
Elevation 3	0.9044782	0.9100208	0.9121784	0.9131372	0.9136513	0.9139485	0.9141035	0.9141420	0.6548991	0.6566402	0.6571353	0.6573407	0.6574466	0.6575070	0.6575391	0.6575475
Elevation 4	0.9436529	0.9499159	0.9528025	0.9542696	0.9551347	0.9556607	0.9559443	0.9560182	0.6655157	0.6680068	0.6687396	0.6690730	0.6692576	0.6693669	0.6694261	0.6694419
Elevation 5	0.9850510	0.9909259	0.9940943	0.9958814	0.9970174	0.9977410	0.9981418	0.9982469	0.6771742	0.6803399	0.6812696	0.6817162	0.6819757	0.6821343	0.6822215	0.6822447
Elevation 6	1.0275685	1.0328077	1.0360895	1.0380971	1.0394505	1.0403456	1.0408519	1.0409834	0.6896169	0.6934427	0.6945397	0.6950821	0.6954073	0.6956108	0.6957239	0.6957536
Elevation 7	1.0712258	1.0756473	1.0788632	1.0809586	1.0824369	1.0834441	1.0840230	1.0841706	0.7026601	0.7071506	0.7083959	0.7090188	0.7093992	0.7096409	0.7097764	0.7098112
Elevation 8	1.1155974	1.1191870	1.1222599	1.1243653	1.1259049	1.1269784	1.1276028	1.1277579	0.7161720	0.7213316	0.7227120	0.7234031	0.7238290	0.7241022	0.7242561	0.7242946
Elevation 9	1.1604427	1.1632065	1.1660684	1.1681086	1.1696420	1.1707298	1.1713678	1.1715211	0.7300499	0.7358542	0.7373204	0.7380497	0.7385003	0.7387907	0.7389545	0.7389945
Elevation 10	1.2053192	1.2073124	1.2099318	1.2118582	1.2133373	1.2144008	1.2150282	1.2151731	0.7439417	0.7502437	0.7518217	0.7525992	0.7530784	0.7533876	0.7535621	0.7536037
Elevation 11	1.2498679	1.2511626	1.2535362	1.2553276	1.2567267	1.2577428	1.2583445	1.2584776	0.7579137	0.7648427	0.7665273	0.7673482	0.7678517	0.7681764	0.7683593	0.7684022
Elevation 12	1.2941776	1.2948599	1.2970096	1.2986675	1.2999797	1.3009397	1.3015091	1.3016289	0.7720716	0.7796013	0.7813857	0.7822453	0.7827695	0.7831066	0.7832962	0.7833399
Elevation 13	1.3381347	1.3382735	1.3402018	1.3417174	1.3429302	1.3438227	1.3443526	1.3444582	0.7863764	0.7944766	0.7963530	0.7972469	0.7977884	0.7981355	0.7983302	0.7983745
Elevation 14	1.3811437	1.3808021	1.3825093	1.3838741	1.3849765	1.3857915	1.3862754	1.3863667	0.8007946	0.8094307	0.8113909	0.8123149	0.8128708	0.8132258	0.8134244	0.8134692
Elevation 15	1.4236535	1.4228933	1.4244287	1.4256757	1.4266910	1.4274442	1.4278911	1.4279707	0.8153010	0.8244367	0.8264727	0.8274228	0.8279907	0.8283519	0.8285534	0.8285987
Elevation 16	1.4656837	1.4645626	1.4659385	1.4670728	1.4680030	1.4686951	1.4691055	1.4691745	0.8298591	0.8395148	0.8416314	0.8426101	0.8431913	0.8435595	0.8437644	0.8438103
Elevation 17	1.5070832	1.5056510	1.5068845	1.5079170	1.5087697	1.5094057	1.5097826	1.5098426	0.8445421	0.8546377	0.8568155	0.8578135	0.8584026	0.8587746	0.8589811	0.8590274
Elevation 18	1.5480875	1.5463826	1.5474951	1.5484413	1.5492280	1.5498161	1.5501642	1.5502169	0.8592715	0.8697564	0.8719868	0.8730010	0.8735964	0.8739711	0.8741786	0.8742253
Elevation 19	1.5886297	1.5866936	1.5876927	1.5885564	1.5892792	1.5898207	1.5901409	1.5901869	0.8740174	0.8848562	0.8871324	0.8881602	0.8887606	0.8891373	0.8893455	0.8893927
Elevation 20	1.6284651	1.6263399	1.6272357	1.6280231	1.6286864	1.6291843	1.6294786	1.6295191	0.8887715	0.8999283	0.9022435	0.9032821	0.9038862	0.9042643	0.9044729	0.9045204
Elevation 21	1.6678424	1.6655379	1.6663491	1.6670751	1.6676908	1.6681540	1.6684276	1.6684638	0.9035293	0.9149684	0.9173158	0.9183628	0.9189694	0.9193480	0.9195567	0.9196046
Elevation 22	1.7067911	1.7043389	1.7050706	1.7057373	1.7063063	1.7067351	1.7069882	1.7070204	0.9182695	0.9299491	0.9323171	0.9333671	0.9339734	0.9343510	0.9345589	0.9346071
Elevation 23	1.7451465	1.7425645	1.7432289	1.7438459	1.7443761	1.7447765	1.7450127	1.7450420	0.9329255	0.9448063	0.9471983	0.9482543	0.9488620	0.9492398	0.9494476	0.9494961
Elevation 24	1.7829213	1.7802572	1.7808709	1.7814498	1.7819498	1.7823278	1.7825507	1.7825778	0.9473418	0.9594680	0.9618850	0.9629482	0.9635586	0.9639375	0.9641456	0.9641947
Elevation 25	1.8188996	1.8166426	1.8173058	1.8179036	1.8184103	1.8187894	1.8190121	1.8190414	0.9607367	0.9733779	0.9758765	0.9769766	0.9776080	0.9779989	0.9782134	0.9782649

Slab temperature [°F]	Slabs 23	Slab 1	Slab 21
Section 1	231.8212	229.5280	215.1134
Section 2	259.8799	245.3897	226.9620
Section 3	290.5471	266.4127	240.7539
Section 4	322.5199	289.4494	255.6110
Section 5	355.4186	313.5123	271.1590
Section 6	388.9469	338.1917	287.1876
Section 7	422.7877	363.2338	303.5482
Section 8	456.8608	388.4955	320.1252
Section 9	490.9573	413.8204	336.7589
Section 10	524.8699	439.1161	353.4591
Section 11	558.6989	464.3675	370.1962
Section 12	592.3063	489.5072	386.9279
Section 13	625.5520	514.4735	403.6180
Section 14	658.5842	539.2795	420.2530
Section 15	691.2752	563.8701	436.7764
Section 16	723.5443	588.2188	453.1848
Section 17	755.5604	612.3678	469.4976
Section 18	787.2269	636.2914	485.7074
Section 19	818.4645	659.9631	501.8081
Section 20	849.4152	683.4015	517.8038
Section 21	880.0157	706.5214	533.6556
Section 22	910.0729	729.0514	549.2814
Section 23	939.5636	750.1753	564.4970
Section 24	967.6608	766.6734	578.3877

Table 1

Rod temperature [°F]	Assembly 1								Assembly 2							
	Rod 1	Rod 2	Rod 3	Rod 4	Rod 5	Rod 6	Rod 7	Rod 8	Rod 183	Rod 184	Rod 185	Rod 186	Rod 187	Rod 188	Rod 189	Rod 190
Section 1	250.7	253.0	254.1	254.6	254.8	255.0	255.1	255.0	214.7	215.3	215.6	215.7	215.8	215.9	215.9	215.9
Section 2	281.6	285.5	287.6	288.7	289.4	289.8	289.9	289.9	224.7	226.0	226.6	226.9	227.1	227.2	227.2	227.2
Section 3	314.0	318.4	321.2	322.8	323.9	324.5	324.8	324.8	235.6	237.3	238.2	238.7	239.0	239.1	239.2	239.2
Section 4	347.3	351.8	354.9	356.9	358.3	359.1	359.5	359.5	247.4	249.4	250.5	251.1	251.5	251.7	251.8	251.8
Section 5	381.4	385.7	388.9	391.2	392.7	393.8	394.2	394.2	259.7	262.1	263.3	264.1	264.5	264.8	265.0	265.0
Section 6	416.0	420.0	423.2	425.5	427.2	428.3	428.8	428.7	272.7	275.3	276.7	277.5	278.1	278.4	278.6	278.6
Section 7	450.8	454.4	457.4	459.8	461.5	462.6	463.2	463.1	286.1	289.0	290.5	291.4	292.0	292.4	292.5	292.5
Section 8	485.6	488.9	491.7	494.0	495.7	496.8	497.4	497.3	299.8	303.0	304.6	305.6	306.2	306.6	306.8	306.8
Section 9	520.3	523.2	525.8	528.0	529.6	530.7	531.2	531.2	313.8	317.2	318.9	319.9	320.6	321.0	321.2	321.2
Section 10	554.7	557.2	559.7	561.6	563.2	564.2	564.7	564.7	328.0	331.6	333.4	334.4	335.2	335.6	335.8	335.8
Section 11	588.8	591.0	593.3	595.1	596.6	597.5	598.0	597.9	342.4	346.2	348.0	349.2	349.9	350.4	350.6	350.6
Section 12	622.6	624.5	626.5	628.2	629.5	630.5	630.9	630.8	357.0	360.9	362.9	364.0	364.8	365.3	365.5	365.5
Section 13	655.9	657.5	659.4	661.0	662.2	663.0	663.4	663.4	371.7	375.8	377.8	379.0	379.8	380.3	380.5	380.5
Section 14	688.9	690.3	692.0	693.4	694.6	695.4	695.7	695.7	386.5	390.7	392.8	394.0	394.8	395.3	395.5	395.5
Section 15	721.4	722.7	724.2	725.5	726.5	727.3	727.6	727.5	401.4	405.7	407.9	409.1	409.9	410.4	410.6	410.6
Section 16	753.4	754.5	755.9	757.1	758.1	758.8	759.1	759.0	416.3	420.8	422.9	424.2	425.0	425.5	425.7	425.7
Section 17	785.2	786.1	787.4	788.5	789.4	790.0	790.3	790.3	431.2	435.8	438.0	439.3	440.1	440.6	440.8	440.8
Section 18	816.5	817.3	818.5	819.5	820.3	820.9	821.1	821.1	446.2	450.9	453.1	454.4	455.2	455.7	455.9	455.9
Section 19	847.4	848.1	849.1	850.1	850.8	851.4	851.6	851.6	461.2	465.9	468.2	469.5	470.3	470.8	471.0	471.0
Section 20	877.9	878.5	879.5	880.4	881.1	881.6	881.8	881.8	476.2	481.0	483.3	484.6	485.4	485.9	486.1	486.1
Section 21	908.1	908.6	909.5	910.3	911.0	911.5	911.7	911.6	491.2	496.0	498.3	499.6	500.4	501.0	501.2	501.2
Section 22	937.7	938.2	939.0	939.8	940.4	940.8	941.0	941.0	506.2	511.0	513.3	514.6	515.4	515.9	516.2	516.2
Section 23	966.9	967.3	968.1	968.8	969.4	969.8	970.0	969.9	520.9	525.8	528.1	529.4	530.2	530.7	531.0	531.0
Section 24	994.6	995.1	996.0	996.8	997.4	997.8	998.0	998.0	534.7	539.8	542.2	543.6	544.4	545.0	545.2	545.2

Table 2

Average values	Assembly 1				Assembly 2				Assembly 3			
	Temperature [°F]	Flow [lb/s]	Velocity [ft/s]	Area [in^2]	Temperature [°F]	Flow [lb/s]	Velocity [ft/s]	Area [in^2]	Temperature [°F]	Flow [lb/s]	Velocity [ft/s]	Area [in^2]
Section 1	219.294	0.014	0.863	41.465	205.367	0.011	0.642	41.465	205.367	0.011	0.642	41.465
Section 2	257.400	0.014	0.912	41.465	216.001	0.011	0.653	41.465	216.001	0.011	0.653	41.465
Section 3	294.731	0.014	0.960	41.465	226.588	0.011	0.663	41.465	226.589	0.011	0.663	41.465
Section 4	331.464	0.014	1.007	41.465	237.315	0.011	0.674	41.465	237.317	0.011	0.674	41.465
Section 5	367.740	0.014	1.052	41.465	248.219	0.011	0.684	41.465	248.222	0.011	0.684	41.465
Section 6	403.623	0.014	1.098	41.465	259.309	0.011	0.695	41.465	259.315	0.011	0.695	41.465
Section 7	439.062	0.014	1.143	41.465	270.590	0.011	0.706	41.465	270.597	0.011	0.706	41.465
Section 8	474.149	0.014	1.187	41.465	282.062	0.011	0.717	41.465	282.071	0.011	0.717	41.465
Section 9	508.783	0.014	1.232	41.465	293.724	0.011	0.729	41.465	293.737	0.011	0.729	41.465
Section 10	542.922	0.014	1.275	41.465	305.506	0.011	0.740	41.465	305.521	0.011	0.740	41.465
Section 11	576.729	0.014	1.318	41.465	317.403	0.011	0.752	41.465	317.422	0.011	0.752	41.465
Section 12	610.096	0.014	1.361	41.465	329.486	0.011	0.763	41.465	329.507	0.011	0.763	41.465
Section 13	642.994	0.014	1.403	41.465	341.751	0.011	0.775	41.465	341.775	0.011	0.775	41.465
Section 14	675.588	0.014	1.444	41.465	354.198	0.011	0.787	41.465	354.225	0.011	0.787	41.465
Section 15	707.777	0.014	1.485	41.465	366.822	0.011	0.799	41.465	366.853	0.011	0.799	41.465
Section 16	739.521	0.014	1.525	41.465	379.623	0.011	0.811	41.465	379.656	0.011	0.811	41.465
Section 17	770.966	0.014	1.565	41.465	392.596	0.011	0.823	41.465	392.632	0.011	0.823	41.465
Section 18	802.059	0.014	1.604	41.465	405.691	0.011	0.836	41.465	405.729	0.011	0.836	41.465
Section 19	832.731	0.014	1.643	41.465	418.898	0.011	0.849	41.465	418.938	0.011	0.849	41.465
Section 20	863.088	0.014	1.682	41.465	432.265	0.011	0.862	41.465	432.308	0.011	0.862	41.465
Section 21	893.144	0.014	1.720	41.465	445.791	0.011	0.875	41.465	445.837	0.011	0.875	41.465
Section 22	922.735	0.014	1.758	41.465	459.462	0.011	0.888	41.465	459.510	0.011	0.888	41.465
Section 23	951.886	0.014	1.795	41.465	473.223	0.011	0.901	41.465	473.272	0.011	0.901	41.465
Section 24	980.433	0.014	1.831	41.465	486.804	0.011	0.914	41.465	486.855	0.011	0.914	41.465

Air temperature [°F]	Assembly 1								Assembly 2							
	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8	Channel 211	Channel 212	Channel 213	Channel 214	Channel 215	Channel 216	Channel 217	Channel 218
Section 1	212.0	213.3	213.7	213.8	213.9	213.9	214.0	214.0	204.4	204.8	204.9	204.9	204.9	205.0	205.0	205.0
Section 2	237.6	241.0	242.3	242.8	243.1	243.2	243.3	243.3	213.5	214.8	215.1	215.3	215.4	215.4	215.4	215.4
Section 3	266.4	271.0	272.9	273.9	274.4	274.7	274.9	274.9	223.6	225.8	226.4	226.7	226.8	226.9	227.0	227.0
Section 4	297.8	302.5	304.9	306.2	307.0	307.5	307.7	307.8	235.0	237.9	238.7	239.1	239.4	239.5	239.6	239.6
Section 5	330.8	335.2	337.8	339.3	340.3	340.9	341.3	341.4	247.3	250.9	251.9	252.4	252.7	252.9	253.0	253.0
Section 6	365.0	368.8	371.4	373.0	374.1	374.9	375.3	375.4	260.3	264.5	265.7	266.3	266.7	266.9	267.0	267.1
Section 7	399.8	402.9	405.4	407.1	408.3	409.1	409.6	409.7	273.8	278.8	280.1	280.8	281.2	281.4	281.6	281.6
Section 8	434.9	437.4	439.7	441.3	442.5	443.4	443.9	444.0	287.8	293.4	294.9	295.6	296.1	296.4	296.5	296.6
Section 9	470.1	471.9	474.1	475.6	476.8	477.7	478.2	478.3	302.1	308.3	309.9	310.7	311.2	311.5	311.7	311.7
Section 10	505.1	506.4	508.4	509.8	511.0	511.8	512.3	512.4	316.6	323.5	325.2	326.0	326.5	326.8	327.0	327.1
Section 11	540.0	540.7	542.5	543.8	544.9	545.7	546.1	546.2	331.2	338.8	340.6	341.5	342.0	342.3	342.5	342.6
Section 12	574.5	574.8	576.4	577.7	578.7	579.4	579.8	579.9	346.1	354.2	356.1	357.1	357.6	358.0	358.2	358.2
Section 13	608.7	608.6	610.0	611.2	612.1	612.7	613.1	613.2	361.1	369.8	371.8	372.7	373.3	373.7	373.9	373.9
Section 14	642.4	642.0	643.3	644.3	645.1	645.8	646.1	646.2	376.1	385.4	387.5	388.5	389.1	389.4	389.6	389.7
Section 15	675.8	675.1	676.2	677.2	677.9	678.5	678.9	678.9	391.3	401.1	403.2	404.2	404.8	405.2	405.4	405.5
Section 16	708.8	707.8	708.8	709.6	710.3	710.9	711.2	711.2	406.5	416.7	418.9	419.9	420.5	420.9	421.1	421.2
Section 17	741.3	740.0	740.9	741.7	742.4	742.9	743.1	743.2	421.7	432.3	434.6	435.6	436.2	436.6	436.8	436.9
Section 18	773.4	772.0	772.8	773.5	774.1	774.6	774.8	774.9	436.9	447.9	450.2	451.3	451.9	452.3	452.5	452.6
Section 19	805.1	803.5	804.3	804.9	805.5	805.9	806.1	806.1	452.1	463.5	465.9	466.9	467.6	468.0	468.2	468.2
Section 20	836.4	834.6	835.3	835.9	836.4	836.8	837.0	837.0	467.4	479.1	481.5	482.5	483.2	483.6	483.8	483.8
Section 21	867.3	865.4	866.0	866.6	867.1	867.4	867.6	867.7	482.6	494.6	497.0	498.1	498.7	499.1	499.3	499.3
Section 22	897.8	895.8	896.4	896.9	897.3	897.6	897.8	897.8	497.8	509.9	512.4	513.5	514.1	514.5	514.7	514.8
Section 23	927.7	925.6	926.1	926.6	927.0	927.3	927.5	927.5	512.8	525.2	527.6	528.7	529.4	529.7	530.0	530.0
Section 24	956.6	954.7	955.2	955.6	956.0	956.3	956.5	956.5	527.1	539.9	542.4	543.5	544.2	544.6	544.8	544.8

Table 2

Air velocity [ft/s]	Assembly 1								Assembly 2							
	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8	Channel 211	Channel 212	Channel 213	Channel 214	Channel 215	Channel 216	Channel 217	Channel 218
Section 1	0.85	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
Section 2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Section 3	0.92	0.93	0.93	0.93	0.93	0.93	0.94	0.94	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66
Section 4	0.96	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.67	0.67	0.68	0.68	0.68	0.68	0.68	0.68
Section 5	1.01	1.01	1.02	1.02	1.02	1.02	1.02	1.02	0.68	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Section 6	1.05	1.05	1.06	1.06	1.06	1.06	1.06	1.06	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Section 7	1.09	1.10	1.10	1.10	1.10	1.11	1.11	1.11	0.71	0.71	0.72	0.72	0.72	0.72	0.72	0.72
Section 8	1.14	1.14	1.14	1.15	1.15	1.15	1.15	1.15	0.72	0.73	0.73	0.73	0.73	0.73	0.73	0.73
Section 9	1.18	1.19	1.19	1.19	1.19	1.19	1.19	1.19	0.74	0.74	0.74	0.75	0.75	0.75	0.75	0.75
Section 10	1.23	1.23	1.23	1.23	1.24	1.24	1.24	1.24	0.75	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Section 11	1.27	1.27	1.28	1.28	1.28	1.28	1.28	1.28	0.76	0.77	0.77	0.77	0.78	0.78	0.78	0.78
Section 12	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	0.78	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Section 13	1.36	1.36	1.36	1.36	1.36	1.36	1.37	1.37	0.79	0.80	0.80	0.80	0.81	0.81	0.81	0.81
Section 14	1.40	1.40	1.40	1.40	1.41	1.41	1.41	1.41	0.81	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Section 15	1.44	1.44	1.45	1.45	1.45	1.45	1.45	1.45	0.82	0.83	0.83	0.84	0.84	0.84	0.84	0.84
Section 16	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	0.84	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Section 17	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	0.85	0.86	0.86	0.87	0.87	0.87	0.87	0.87
Section 18	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	0.87	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Section 19	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	0.88	0.89	0.89	0.90	0.90	0.90	0.90	0.90
Section 20	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	0.90	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Section 21	1.69	1.68	1.69	1.69	1.69	1.69	1.69	1.69	0.91	0.92	0.92	0.93	0.93	0.93	0.93	0.93
Section 22	1.73	1.72	1.72	1.72	1.73	1.73	1.73	1.73	0.93	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Section 23	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	0.94	0.95	0.95	0.96	0.96	0.96	0.96	0.96
Section 24	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	0.95	0.97	0.97	0.97	0.97	0.97	0.97	0.97

Slab temperature [°F]	Slabs 23	Slab 1	Slab 21
Section 1	231.8	229.5	215.1
Section 2	259.9	245.4	227.0
Section 3	290.5	266.4	240.8
Section 4	322.5	289.4	255.6
Section 5	355.4	313.5	271.2
Section 6	388.9	338.2	287.2
Section 7	422.8	363.2	303.5
Section 8	456.9	388.5	320.1
Section 9	491.0	413.8	336.8
Section 10	524.9	439.1	353.5
Section 11	558.7	464.4	370.2
Section 12	592.3	489.5	386.9
Section 13	625.6	514.5	403.6
Section 14	658.6	539.3	420.3
Section 15	691.3	563.9	436.8
Section 16	723.5	588.2	453.2
Section 17	755.6	612.4	469.5
Section 18	787.2	636.3	485.7
Section 19	818.5	660.0	501.8
Section 20	849.4	683.4	517.8
Section 21	880.0	706.5	533.7
Section 22	910.1	729.1	549.3
Section 23	939.6	750.2	564.5
Section 24	967.7	766.7	578.4

Table 2

Rod temperature [°F]	Assembly 1								Assembly 2							
	Rod 1	Rod 2	Rod 3	Rod 4	Rod 5	Rod 6	Rod 7	Rod 8	Rod 183	Rod 184	Rod 185	Rod 186	Rod 187	Rod 188	Rod 189	Rod 190
Section 1	250.7	253.0	254.1	254.6	254.8	255.0	255.1	255.0	214.7	215.3	215.6	215.7	215.8	215.9	215.9	215.9
Section 2	281.6	285.5	287.6	288.7	289.4	289.8	289.9	289.9	224.7	226.0	226.6	226.9	227.1	227.2	227.2	227.2
Section 3	314.0	318.4	321.2	322.8	323.9	324.5	324.8	324.8	235.6	237.3	238.2	238.7	239.0	239.1	239.2	239.2
Section 4	347.3	351.8	354.9	356.9	358.3	359.1	359.5	359.5	247.4	249.4	250.5	251.1	251.5	251.7	251.8	251.8
Section 5	381.4	385.7	388.9	391.2	392.7	393.8	394.2	394.2	259.7	262.1	263.3	264.1	264.5	264.8	265.0	265.0
Section 6	416.0	420.0	423.2	425.5	427.2	428.3	428.8	428.7	272.7	275.3	276.7	277.5	278.1	278.4	278.6	278.6
Section 7	450.8	454.4	457.4	459.8	461.5	462.6	463.2	463.1	286.1	289.0	290.5	291.4	292.0	292.4	292.5	292.5
Section 8	485.6	488.9	491.7	494.0	495.7	496.8	497.4	497.3	299.8	303.0	304.6	305.6	306.2	306.6	306.8	306.8
Section 9	520.3	523.2	525.8	528.0	529.6	530.7	531.2	531.2	313.8	317.2	318.9	319.9	320.6	321.0	321.2	321.2
Section 10	554.7	557.2	559.7	561.6	563.2	564.2	564.7	564.7	328.0	331.6	333.4	334.4	335.2	335.6	335.8	335.8
Section 11	588.8	591.0	593.3	595.1	596.6	597.5	598.0	597.9	342.4	346.2	348.0	349.2	349.9	350.4	350.6	350.6
Section 12	622.6	624.5	626.5	628.2	629.5	630.5	630.9	630.8	357.0	360.9	362.9	364.0	364.8	365.3	365.5	365.5
Section 13	655.9	657.5	659.4	661.0	662.2	663.0	663.4	663.4	371.7	375.8	377.8	379.0	379.8	380.3	380.5	380.5
Section 14	688.9	690.3	692.0	693.4	694.6	695.4	695.7	695.7	386.5	390.7	392.8	394.0	394.8	395.3	395.5	395.5
Section 15	721.4	722.7	724.2	725.5	726.5	727.3	727.6	727.5	401.4	405.7	407.9	409.1	409.9	410.4	410.6	410.6
Section 16	753.4	754.5	755.9	757.1	758.1	758.8	759.1	759.0	416.3	420.8	422.9	424.2	425.0	425.5	425.7	425.7
Section 17	785.2	786.1	787.4	788.5	789.4	790.0	790.3	790.3	431.2	435.8	438.0	439.3	440.1	440.6	440.8	440.8
Section 18	816.5	817.3	818.5	819.5	820.3	820.9	821.1	821.1	446.2	450.9	453.1	454.4	455.2	455.7	455.9	455.9
Section 19	847.4	848.1	849.1	850.1	850.8	851.4	851.6	851.6	461.2	465.9	468.2	469.5	470.3	470.8	471.0	471.0
Section 20	877.9	878.5	879.5	880.4	881.1	881.6	881.8	881.8	476.2	481.0	483.3	484.6	485.4	485.9	486.1	486.1
Section 21	908.1	908.6	909.5	910.3	911.0	911.5	911.7	911.6	491.2	496.0	498.3	499.6	500.4	501.0	501.2	501.2
Section 22	937.7	938.2	939.0	939.8	940.4	940.8	941.0	941.0	506.2	511.0	513.3	514.6	515.4	515.9	516.2	516.2
Section 23	966.9	967.3	968.1	968.8	969.4	969.8	970.0	969.9	520.9	525.8	528.1	529.4	530.2	530.7	531.0	531.0
Section 24	994.6	995.1	996.0	996.8	997.4	997.8	998.0	998.0	534.7	539.8	542.2	543.6	544.4	545.0	545.2	545.2

Table 3

Slab to rod area ratio (rad.)	1

Section 1

		Assembly 1								Assembly 2							
		Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8	Channel 211	Channel 212	Channel 213	Channel 214	Channel 215	Channel 216	Channel 217	Channel 218
T1/T4	Air temperature [°F]	212.0	213.3	213.7	213.8	213.9	213.9	214.0	214.0	204.4	204.8	204.9	204.9	204.9	205.0	205.0	205.0
	Air velocity [ft/s]	0.85	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
T2/T5	Rod temperature [°F]	250.7	253	254.1	254.6	254.8	255	255.1	255	214.7	215.3	215.6	215.7	215.8	215.9	215.9	215.9
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	217.4	218.8	219.3	219.5	219.6	219.7	219.7	219.7	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	207.6	208.2	208.4	208.4	208.5	208.5	208.5	208.5
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft^2]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0175	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174
	Kynematic visc. air [ft^2/s]	0.000247	0.000248	0.000248	0.000248	0.000248	0.000248	0.000248	0.000248	0.000242	0.000242	0.000242	0.000242	0.000242	0.000242	0.000242	0.000242
	Prandt numb. [-]	0.719945	0.719671	0.719580	0.719547	0.719531	0.719522	0.719518	0.719517	0.721681	0.721585	0.721559	0.721550	0.721546	0.721543	0.721542	0.721542
	Reynolds numb. [-]	207.43	215.60	215.51	215.48	215.46	215.45	215.45	215.45	158.79	165.17	165.15	165.15	165.14	165.14	165.14	165.14
	Stefan-Boltzmann c. [BTU/(hr-ft^2-R^4)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft^2-°F)]	2.150	2.117	2.117	2.117	2.117	2.117	2.117	2.117	1.817	1.789	1.789	1.789	1.789	1.789	1.789	1.789
	Radiation heat trsf [BTU/(ft^2-°F)]	4.4E-01	4.4E-01	4.4E-01	4.4E-01	4.4E-01	4.4E-01	4.4E-01	4.4E-01	3.9E-01	4.0E-01	4.0E-01	4.0E-01	4.0E-01	4.0E-01	4.0E-01	4.0E-01
R1	R_convection [(hr-°F)/BTU]	20.8	20.4	20.4	20.4	20.4	20.4	20.4	40.8	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	102.6	98.2	97.8	97.7	97.6	97.5	97.5	195.1	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	24.6	24.1	24.1	24.1	24.1	24.1	24.1	48.3
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	113.6	109.2	109.1	109.0	109.0	109.0	109.0	218.0
	Slab average temp [°F]	212.48	213.50	213.85	213.99	214.05	214.10	214.12	214.12	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	217.4	218.8	219.3	219.5	219.6	219.7	219.7	219.7	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	207.6	208.2	208.4	208.4	208.5	208.5	208.5	208.5
	Heat transfer [BTU/hr]	0.06720	0.07553	0.07779	0.07874	0.07909	0.07934	0.07952	0.03971	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.2573
Q_rad. [BTU/hr]	0.3245
Total [BTU/hr]	0.0672
Q_cond. [BTU/hr]	0.0672
Q_conv. [BTU/hr]	0.1301
Q_rad. [BTU/hr]	-0.0629
Total [BTU/hr]	0.0672
Total heat transfer slab [BTU/hr]	0.5769

Section 2

		Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8	Channel 211	Channel 212	Channel 213	Channel 214	Channel 215	Channel 216	Channel 217	Channel 218
T1/T4	Air temperature [°F]	237.6	241.0	242.3	242.8	243.1	243.2	243.3	243.3	213.5	214.8	215.1	215.3	215.4	215.4	215.4	215.4
	Air velocity [ft/s]	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
T2/T5	Rod temperature [°F]	281.6	285.5	287.6	288.7	289.4	289.8	289.9	289.9	224.7	226	226.6	226.9	227.1	227.2	227.2	227.2
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	243.0	246.4	247.8	248.4	248.7	248.9	249.0	249.0	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	218.8	220.5	221.0	221.2	221.4	221.4	221.4	221.5
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft^2]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0180	0.0181	0.0181	0.0181	0.0182	0.0182	0.0182	0.0182	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176
	Kynematic visc. air [ft^2/s]	0.000263	0.000265	0.000266	0.000266	0.000266	0.000266	0.000266	0.000266	0.000248	0.000248	0.000249	0.000249	0.000249	0.000249	0.000249	0.000249
	Prandt numb. [-]	0.714509	0.713831	0.713583	0.713480	0.713426	0.713398	0.713380	0.713376	0.719628	0.719339	0.719259	0.719227	0.719211	0.719202	0.719197	0.719196
	Reynolds numb. [-]	202.40	209.94	209.70	209.59	209.54	209.51	209.49	209.49	157.39	163.57	163.51	163.49	163.48	163.47	163.47	163.47
	Stefan-Boltzmann c. [BTU/(hr-ft^2-R^4)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft^2-°F)]	2.173	2.142	2.143	2.144	2.144	2.144	2.144	2.144	1.824	1.796	1.797	1.797	1.797	1.797	1.797	1.797
	Radiation heat trsf [BTU/(ft^2-°F)]	4.9E-01	5.0E-01	5.0E-01	5.0E-01	5.1E-01	5.1E-01	5.1E-01	5.1E-01	4.1E-01	4.2E-01	4.2E-01	4.2E-01	4.2E-01	4.2E-01	4.2E-01	4.2E-01
R1	R_convection [(hr-°F)/BTU]	20.6	20.2	20.1	20.1	20.1	20.1	20.1	40.3	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	91.1	86.5	85.8	85.5	85.3	85.2	85.2	170.4	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	24.5	24.0	24.0	24.0	24.0	24.0	24.0	48.0
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	108.4	103.8	103.5	103.4	103.3	103.3	103.3	206.6
	Slab average temp [°F]	230.9075176	233.443079	234.388432	234.8097086	235.045102	235.1785585	235.2312745	235.2412642	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	243.0	246.4	247.8	248.4	248.7	248.9	249.0	249.0	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	218.8	220.5	221.0	221.2	221.4	221.4	221.4	221.5
	Heat transfer [BTU/hr]	0.16494	0.18393	0.18988	0.19259	0.19413	0.19503	0.19542	0.09774	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.2593
Q_rad. [BTU/hr]	0.4242
Total [BTU/hr]	0.1649
Q_cond. [BTU/hr]	0.1649
Q_conv. [BTU/hr]	0.2190
Q_rad. [BTU/hr]	-0.0541
Total [BTU/hr]	0.1649
Total heat transfer slab [BTU/hr]	1.4136

Section 3

		Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8	Channel 211	Channel 212	Channel 213	Channel 214	Channel 215	Channel 216	Channel 217	Channel 218
T1/T4	Air temperature [°F]	266.4	271.0	272.9	273.9	274.4	274.7	274.9	274.9	223.6	225.8	226.4	226.7	226.8	226.9	227.0	227.0
	Air velocity [ft/s]	0.92	0.93	0.93	0.93	0.93	0.93	0.94	0.94	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66
T2/T5	Rod temperature [°F]	314	318.4	321.2	322.8	323.9	324.5	324.8	324.8	235.8	237.3	238.2	238.7	239	239.1	239.2	239.2
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	271.5	276.1	278.1	279.2	279.8	280.2	280.4	280.4	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	231.4	233.8	234.7	235.1	235.3	235.4	235.5	235.5
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft^2]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0186	0.0187	0.0187	0.0187	0.0188	0.0188	0.0188	0.0188	0.0178	0.0178	0.0178	0.0178	0.0178	0.0178	0.0178	0.0178
	Kynematic visc. air [ft^2/s]	0.000281	0.000284	0.000285	0.000286	0.000286	0.000287	0.000287	0.000287	0.000254	0.000255	0.000256	0.000256	0.000256	0.000256	0.000256	0.000256
	Prandt numb. [-]	0.709029	0.708216	0.707873	0.707709	0.707617	0.707561	0.707532	0.707524	0.717417	0.716958	0.716826	0.716768	0.716737	0.716719	0.716709	0.716706
	Reynolds numb. [-]	197.04	204.18	203.82	203.64	203.54	203.48	203.45	203.44	155.85	161.84	161.75	161.70	161.68	161.67	161.66	161.66
	Stefan-Boltzmann c. [BTU/(hr-ft^2-R^4)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft^2-°F)]	2.199	2.169	2.171	2.171	2.172	2.172	2.172	2.172	1.832	1.805	1.805	1.805	1.806	1.806	1.806	1.806
	Radiation heat trsf [BTU/(ft^2-°F)]	5.6E-01	5.7E-01	5.7E-01	5.8E-01	5.8E-01	5.8E-01	5.8E-01	5.8E-01	4.3E-01	4.4E-01	4.4E-01	4.4E-01	4.4E-01	4.4E-01	4.4E-01	4.4E-01
R1	R_convection [(hr-°F)/BTU]	20.4	19.9	19.9	19.9	19.9	19.9	19.9	39.7	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	80.4	76.2	75.4	75.0	74.8	74.6	74.6	149.1	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	24.4	23.9	23.9	23.9	23.9	23.9	23.9	47.8
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	103.0	98.4	98.0	97.8	97.7	97.6	97.6	195.2
	Slab average temp [°F]	251.4453891	254.9321186	256.3944432	257.1243814	257.5605836	257.8059619	257.9391101	257.9617602	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	271.5	276.1	278.1	279.2	279.8	280.2	280.4	280.4	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	231.4	233.8	234.7	235.1	235.3	235.4	235.5	235.5
	Heat transfer [BTU/hr]	0.27462	0.29953	0.30823	0.31280	0.31567	0.31741	0.31826	0.15920	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.2533
Q_rad. [BTU/hr]	0.5280
Total [BTU/hr]	0.2746
Q_cond. [BTU/hr]	0.2746
Q_conv. [BTU/hr]	0.3159
Q_rad. [BTU/hr]	-0.0413
Total [BTU/hr]	0.2746
Total heat transfer slab [BTU/hr]	2.3057

Section 4

		Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8	Channel 211	Channel 212	Channel 213	Channel 214	Channel 215	Channel 216	Channel 217	Channel 218
T1/T4	Air temperature [°F]	297.8	302.5	304.9	306.2	307.0	307.5	307.7	307.8	235.0	237.9	238.7	239.1	239.4	239.5	239.6	239.6
	Air velocity [ft/s]	0.96	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.67	0.67	0.68	0.68	0.68	0.68	0.68	0.68
T2/T5	Rod temperature [°F]	347.3	351.8	354.9	356.9	358.3	359.1	359.5	359.5	247.4	249.4	250.5	251.1	251.5	251.7	251.8	251.8
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	302.6	307.3	309.8	311.2	312.1	312.7	313.0	313.0	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	245.1	248.2	249.3	249.8	250.1	250.3	250.4	250.5
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft^2]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0192	0.0193	0.0193	0.0194	0.0194	0.0194	0.0194	0.0194	0.0180	0.0181	0.0181	0.0181	0.0181	0.0181	0.0181	0.0181
	Kynematic visc. air [ft^2/s]	0.000302	0.000305	0.000307	0.000308	0.000308	0.000308	0.000309	0.000309	0.000261	0.000263	0.000263	0.000264	0.000264	0.000264	0.000264	0.000264
	Prandt numb. [-]	0.703770	0.703037	0.702677	0.702486	0.702368	0.702295	0.702255	0.702245	0.715045	0.714460	0.714289	0.714209	0.714163	0.714136	0.714121	0.714117
	Reynolds numb. [-]	191.49	198.41	197.98	197.75	197.62	197.53	197.48	197.47	154.17	159.99	159.86	159.80	159.77	159.75	159.73	159.73
	Stefan-Boltzmann c. [BTU/(hr-ft^2-R^4)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft^2-°F)]	2.228	2.197	2.199	2.200	2.200	2.201	2.201	2.201	1.841	1.814	1.815	1.815	1.815	1.815	1.815	1.815
	Radiation heat trsf [BTU/(ft^2-°F)]	6.3E-01	6.4E-01	6.5E-01	6.5E-01	6.6E-01	6.6E-01	6.6E-01	6.6E-01	4.6E-01	4.6E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01	4.7E-01
R1	R_convection [(hr-°F)/BTU]	20.1	19.7	19.6	19.6	19.6	19.6	19.6	39.2	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	70.9	67.2	66.5	66.0	65.8	65.6	65.5	131.0	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	24.3	23.8	23.8	23.8	23.8	23.8	23.8	47.6
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	97.5	93.0	92.5	92.3	92.2	92.1	92.0	184.1
	Slab average temp [°F]	273.8353552	277.7382095	279.5258513	280.5103678	281.1346585	281.508206	281.7069058	281.742715	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	302.6	307.3	309.8	311.2	312.1	312.7	313.0	313.0	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	245.1	248.2	249.3	249.8	250.1	250.3	250.4	250.5
	Heat transfer [BTU/hr]	0.39253	0.41915	0.42912	0.43522	0.43927	0.44178	0.44311	0.22167	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.2382
Q_rad. [BTU/hr]	0.6308
Total [BTU/hr]	0.3925
Q_cond. [BTU/hr]	0.3925
Q_conv. [BTU/hr]	0.4160
Q_rad. [BTU/hr]	-0.0235
Total [BTU/hr]	0.3925
Total heat transfer slab [BTU/hr]	3.2218

Section 5

		Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8	Channel 211	Channel 212	Channel 213	Channel 214	Channel 215	Channel 216	Channel 217	Channel 218
T1/T4	Air temperature [°F]	330.8	335.2	337.8	339.3	340.3	340.9	341.3	341.4	247.3	250.9	251.9	252.4	252.7	252.9	253.0	253.0
	Air velocity [ft/s]	1.01	1.01	1.02	1.02	1.02	1.02	1.02	1.02	0.68	0.69	0.69	0.69	0.69	0.69	0.69	0.69
T2/T5	Rod temperature [°F]	381.4	385.7	388.9	391.2	392.7	393.8	394.2	394.2	259.7	262.1	263.3	264.1	264.5	264.8	265	265
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	335.2	339.7	342.4	344.1	345.2	345.9	346.3	346.4	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	259.8	263.3	264.6	265.3	265.7	266.0	266.1	266.1
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft^2]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0198	0.0199	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0182	0.0183	0.0183	0.0183	0.0183	0.0183	0.0183	0.0183
	Kynematic visc. air [ft^2/s]	0.000324	0.000328	0.000329	0.000330	0.000331	0.000332	0.000332	0.000332	0.000269	0.000271	0.000272	0.000272	0.000272	0.000272	0.000272	0.000272
	Prandt numb. [-]	0.699015	0.698440	0.698112	0.697921	0.697797	0.697717	0.697672	0.697660	0.712596	0.711908	0.711710	0.711614	0.711558	0.711522	0.711503	0.711498
	Reynolds numb. [-]	185.90	192.70	192.26	192.01	191.84	191.73	191.67	191.66	152.39	158.05	157.90	157.82	157.78	157.76	157.73	157.73
	Stefan-Boltzmann c. [BTU/(hr-ft^2-R^4)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft^2-°F)]	2.258	2.224	2.227	2.228	2.229	2.229	2.229	2.230	1.850	1.824	1.825	1.825	1.825	1.826	1.826	1.826
	Radiation heat trsf [BTU/(ft^2-°F)]	7.2E-01	7.3E-01	7.3E-01	7.4E-01	7.4E-01	7.5E-01	7.5E-01	7.5E-01	4.9E-01	4.9E-01	4.9E-01	5.0E-01	5.0E-01	5.0E-01	5.0E-01	5.0E-01
R1	R_convection [(hr-°F)/BTU]	19.8	19.4	19.4	19.4	19.4	19.4	19.4	38.7	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	62.6	59.4	58.7	58.3	58.0	57.9	57.8	115.5	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	24.2	23.7	23.7	23.7	23.6	23.6	23.6	47.3
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	92.1	87.7	87.2	87.0	86.8	86.7	86.7	173.3
	Slab average temp [°F]	297.4893708	301.5373858	303.5069657	304.6955383	305.4492683	305.9579617	306.215198	306.2620881	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	335.2	339.7	342.4	344.1	345.2	345.9	346.3	346.4	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	259.8	263.3	264.6	265.3	265.7	266.0	266.1	266.1
	Heat transfer [BTU/hr]	0.51589	0.54151	0.55167	0.55867	0.56355	0.56693	0.56844	0.28436	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.2220
Q_rad. [BTU/hr]	0.7377
Total [BTU/hr]	0.5157
Q_cond. [BTU/hr]	0.5157
Q_conv. [BTU/hr]	0.5151
Q_rad. [BTU/hr]	0.0006
Total [BTU/hr]	0.5157
Total heat transfer slab [BTU/hr]	4.1508

Section 6

		Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Channel 7	Channel 8	Channel 211	Channel 212	Channel 213	Channel 214	Channel 215	Channel 216	Channel 217	Channel 218
T1/T4	Air temperature [°F]	365.0	368.8	371.4	373.0	374.1	374.9	375.3	375.4	260.3	264.5	265.7	266.3	266.7	266.9	267.0	267.1
	Air velocity [ft/s]	1.05	1.05	1.06	1.06	1.06	1.06	1.06	1.06	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
T2/T5	Rod temperature [°F]	418	420	423.2	425.5	427.2	428.3	428.8	428.7	272.7	275.3	276.7	277.5	278.1	278.4	278.6	278.6
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	369.0	373.1	375.8	377.6	378.9	379.8	380.2	380.2	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	275.1	279.1	280.5	281.3	281.8	282.1	282.3	282.3
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft^2]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0205	0.0206	0.0206	0.0207	0.0207	0.0207	0.0207	0.0207	0.0185	0.0186	0.0186	0.0186	0.0186	0.0186	0.0186	0.0186
	Kynematic visc. air [ft^2/s]	0.000349	0.000351	0.000353	0.000354	0.000355	0.000356	0.000356	0.000356	0.000277	0.000280	0.000281	0.000281	0.000281	0.000281	0.000282	0.000282
	Prandt numb. [-]	0.694904	0.694492	0.694221	0.694051	0.693936	0.693858	0.693814	0.693803	0.710136	0.709361	0.709146	0.709039	0.708974	0.708934	0.708911	0.708905
	Reynolds numb. [-]	180.45	187.16	186.75	186.50	186.32	186.20	186.13	186.11	150.56	156.05	155.88	155.80	155.75	155.71	155.70	155.69
	Stefan-Boltzmann c. [BTU/(hr-ft^2-R^4)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft^2-°F)]	2.286	2.253	2.255	2.256	2.257	2.258	2.258	2.258	1.861	1.834	1.835	1.836	1.836	1.836	1.836	1.836
	Radiation heat trsf [BTU/(ft^2-°F)]	8.1E-01	8.2E-01	8.3E-01	8.3E-01	8.4E-01	8.4E-01	8.4E-01	8.4E-01	5.2E-01	5.2E-01	5.3E-01	5.3E-01	5.3E-01	5.3E-01	5.3E-01	5.3E-01
R1	R_convection [(hr-°F)/BTU]	19.6	19.2	19.1	19.1	19.1	19.1	19.1	38.2	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	55.4	52.6	52.1	51.7	51.4	51.3	51.2	102.4	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	24.1	23.5	23.5	23.5	23.5	23.5	23.5	47.0
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	86.9	82.6	82.1	81.9	81.7	81.6	81.5	163.1
	Slab average temp [°F]	322.0508386	326.116655	328.1871823	329.4688789	330.3577624	330.9320679	331.2422184	331.2812027	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	369.0	373.1	375.8	377.6	378.9	379.8	380.2	380.2	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	275.1	279.1	280.5	281.3	281.8	282.1	282.3	282.3
	Heat transfer [BTU/hr]	0.64189	0.66616	0.67584	0.68293	0.68832	0.69207	0.69397	0.34706	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.2067
Q_rad. [BTU/hr]	0.8486
Total [BTU/hr]	0.6419
Q_cond. [BTU/hr]	0.6419
Q_conv. [BTU/hr]	0.6145
Q_rad. [BTU/hr]	0.0274
Total [BTU/hr]	0.6419
Total heat transfer slab [BTU/hr]	5.0881

Table 3

Section 7	T1/T4	Air temperature [°F]	399.8	402.9	405.4	407.1	408.3	409.1	409.6	409.7	273.8	278.8	280.1	280.8	281.2	281.4	281.6	281.6
		Air velocity [ft/s]	1.09	1.10	1.10	1.10	1.10	1.11	1.11	1.11	0.71	0.71	0.72	0.72	0.72	0.72	0.72	0.72
	T2/T5	Rod temperature [°F]	450.8	454.4	457.4	459.8	461.5	462.6	463.2	463.1	288.1	289	290.5	291.4	292	292.4	292.5	292.5
		Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		Slab high temp [°F]	403.5	407.1	409.7	411.6	412.9	413.8	414.3	414.4	-	-	-	-	-	-	-	-
		Slab low temp [°F]	-	-	-	-	-	-	-	-	290.9	295.4	296.9	297.7	298.3	298.6	298.8	298.8
		Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
		Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
		Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
		Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
		Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
		Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
		Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
		Thermal cond. air [BTU/(hr-ft-°F)]	0.0212	0.0212	0.0213	0.0213	0.0213	0.0213	0.0214	0.0214	0.0187	0.0188	0.0189	0.0189	0.0189	0.0189	0.0189	0.0189
		Kynematic visc. air [ft²/s]	0.000374	0.000376	0.000378	0.000379	0.000380	0.000381	0.000381	0.000381	0.000288	0.000289	0.000290	0.000291	0.000291	0.000291	0.000291	0.000291
		Prandt numb. [-]	0.691511	0.691241	0.691034	0.690897	0.690800	0.690734	0.690696	0.690686	0.707712	0.706866	0.706638	0.706525	0.706456	0.706412	0.706387	0.706381
		Reynolds numb. [-]	175.27	181.91	181.54	181.30	181.12	181.00	180.93	180.92	148.69	154.04	153.85	153.76	153.70	153.66	153.64	153.64
		Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
		Conv. heat trsf [BTU/(ft²-°F)]	2.315	2.281	2.284	2.285	2.286	2.287	2.287	2.287	1.871	1.845	1.846	1.847	1.847	1.847	1.847	1.847
		Radiation heat trsf [BTU/(ft²-°F)]	9.1E-01	9.2E-01	9.3E-01	9.4E-01	9.4E-01	9.5E-01	9.5E-01	9.5E-01	5.5E-01	5.6E-01	5.6E-01	5.6E-01	5.6E-01	5.6E-01	5.6E-01	5.6E-01
	R1	R_convection [(hr-°F)/BTU]	19.3	18.9	18.9	18.9	18.9	18.9	18.9	37.7	-	-	-	-	-	-	-	-
	R2	R_radiation [(hr-°F)/BTU]	49.1	46.8	46.3	46.0	45.8	45.6	45.5	91.1	-	-	-	-	-	-	-	-
	R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
	R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	23.9	23.4	23.4	23.4	23.4	23.4	23.4	46.7
	R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	81.9	77.8	77.3	77.0	76.9	76.7	76.7	153.4
		Slab average temp [°F]	347.1859897	351.2277833	353.3055067	354.6647484	355.6067924	356.2354041	356.5766751	356.6180588	-	-	-	-	-	-	-	-
	T6	Slab high temp [°F]	403.5	407.1	409.7	411.6	412.9	413.8	414.3	414.4	-	-	-	-	-	-	-	-
	T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	290.9	295.4	296.9	297.7	298.3	298.6	298.8	298.8
		Heat transfer [BTU/hr]	0.76966	0.79182	0.79992	0.80720	0.81276	0.81658	0.81891	0.40953	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.1931
Q_rad. [BTU/hr]	0.9627
Total [BTU/hr]	0.7697
Q_cond. [BTU/hr]	0.7697
Q_conv. [BTU/hr]	0.7114
Q_rad. [BTU/hr]	0.0582
Total [BTU/hr]	0.7697
Total heat transfer slab [BTU/hr]	6.0284

Section 8	T1/T4	Air temperature [°F]	434.9	437.4	439.7	441.3	442.5	443.4	443.9	444.0	287.8	293.4	294.9	295.6	296.1	296.4	296.5	296.6
		Air velocity [ft/s]	1.14	1.14	1.14	1.15	1.15	1.15	1.15	1.15	0.72	0.73	0.73	0.73	0.73	0.73	0.73	0.73
	T2/T5	Rod temperature [°F]	485.6	488.9	491.7	494	495.7	496.8	497.4	497.3	299.8	303	304.6	305.6	306.2	306.6	306.8	306.8
		Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		Slab high temp [°F]	438.3	441.4	444.0	445.8	447.2	448.1	448.6	448.7	-	-	-	-	-	-	-	-
		Slab low temp [°F]	-	-	-	-	-	-	-	-	307.0	311.9	313.5	314.4	315.0	315.4	315.6	315.6
		Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
		Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
		Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
		Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
		Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
		Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
		Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
		Thermal cond. air [BTU/(hr-ft-°F)]	0.0218	0.0219	0.0219	0.0220	0.0220	0.0220	0.0220	0.0220	0.0190	0.0191	0.0192	0.0192	0.0192	0.0192	0.0192	0.0192
		Kynematic visc. air [ft²/s]	0.000400	0.000402	0.000404	0.000405	0.000406	0.000407	0.000407	0.000407	0.000295	0.000299	0.000300	0.000300	0.000301	0.000301	0.000301	0.000301
		Prandt numb. [-]	0.688858	0.688697	0.688551	0.688451	0.688377	0.688328	0.688296	0.688289	0.705358	0.704455	0.704222	0.704107	0.704035	0.703990	0.703964	0.703958
		Reynolds numb. [-]	170.40	176.97	176.65	176.43	176.26	176.15	176.08	176.06	146.82	152.01	151.81	151.71	151.65	151.61	151.59	151.58
		Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
		Conv. heat trsf [BTU/(ft²-°F)]	2.346	2.311	2.313	2.314	2.315	2.316	2.316	2.316	1.882	1.856	1.857	1.858	1.858	1.858	1.858	1.859
		Radiation heat trsf [BTU/(ft²-°F)]	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00	5.8E-01	5.9E-01	5.9E-01	6.0E-01	6.0E-01	6.0E-01	6.0E-01	6.0E-01
	R1	R_convection [(hr-°F)/BTU]	19.1	18.7	18.7	18.7	18.6	18.6	18.6	37.3	-	-	-	-	-	-	-	-
	R2	R_radiation [(hr-°F)/BTU]	43.8	41.8	41.4	41.1	40.9	40.8	40.7	81.4	-	-	-	-	-	-	-	-
	R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
	R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	23.8	23.3	23.2	23.2	23.2	23.2	23.2	46.5
	R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	77.2	73.2	72.8	72.5	72.3	72.2	72.2	144.3
		Slab average temp [°F]	372.6540505	376.6856483	378.740306	380.1184498	381.0868462	381.7402225	382.1082922	382.1487937	-	-	-	-	-	-	-	-
	T6	Slab high temp [°F]	438.3	441.4	444.0	445.8	447.2	448.1	448.6	448.7	-	-	-	-	-	-	-	-
	T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	307.0	311.9	313.5	314.4	315.0	315.4	315.6	315.6
		Heat transfer [BTU/hr]	0.89769	0.91799	0.92451	0.93121	0.93677	0.94084	0.94289	0.47150	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.1820
Q_rad. [BTU/hr]	1.0797
Total [BTU/hr]	0.8977
Q_cond. [BTU/hr]	0.8977
Q_conv. [BTU/hr]	0.8048
Q_rad. [BTU/hr]	0.0929
Total [BTU/hr]	0.8977
Total heat transfer slab [BTU/hr]	6.9632

Section 9	T1/T4	Air temperature [°F]	470.1	471.9	474.1	475.6	476.8	477.7	478.2	478.3	302.1	308.3	309.9	310.7	311.2	311.5	311.7	311.7
		Air velocity [ft/s]	1.18	1.19	1.19	1.19	1.19	1.19	1.19	1.19	0.74	0.74	0.74	0.75	0.75	0.75	0.75	0.75
	T2/T5	Rod temperature [°F]	520.3	523.2	525.8	528	529.6	530.7	531.2	531.2	313.8	317.2	318.9	319.9	320.6	321	321.2	321.2
		Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		Slab high temp [°F]	473.3	476.0	478.3	480.1	481.4	482.4	482.9	482.9	-	-	-	-	-	-	-	-
		Slab low temp [°F]	-	-	-	-	-	-	-	-	323.3	328.6	330.3	331.2	331.9	332.3	332.5	332.5
		Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
		Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
		Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
		Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
		Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
		Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
		Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
		Thermal cond. air [BTU/(hr-ft-°F)]	0.0225	0.0225	0.0226	0.0226	0.0226	0.0226	0.0227	0.0227	0.0193	0.0194	0.0194	0.0195	0.0195	0.0195	0.0195	0.0195
		Kynematic visc. air [ft²/s]	0.000428	0.000429	0.000431	0.000432	0.000433	0.000434	0.000434	0.000434	0.000305	0.000309	0.000310	0.000311	0.000311	0.000311	0.000311	0.000311
		Prandt numb. [-]	0.686925	0.686842	0.686749	0.686683	0.686634	0.686599	0.686579	0.686574	0.703104	0.702163	0.701929	0.701814	0.701743	0.701697	0.701671	0.701665
		Reynolds numb. [-]	165.84	172.33	172.05	171.85	171.69	171.58	171.52	171.51	144.94	149.98	149.76	149.66	149.59	149.55	149.53	149.52
		Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
		Conv. heat trsf [BTU/(ft²-°F)]	2.376	2.340	2.342	2.344	2.345	2.345	2.346	2.346	1.892	1.867	1.868	1.869	1.869	1.869	1.870	1.870
		Radiation heat trsf [BTU/(ft²-°F)]	1.1E+00	1.2E+00	1.2E+00	1.2E+00	1.2E+00	1.2E+00	1.2E+00	1.2E+00	6.2E-01	6.3E-01	6.3E-01	6.3E-01	6.3E-01	6.3E-01	6.4E-01	6.4E-01
	R1	R_convection [(hr-°F)/BTU]	18.8	18.4	18.4	18.4	18.4	18.4	18.4	36.8	-	-	-	-	-	-	-	-
	R2	R_radiation [(hr-°F)/BTU]	39.2	37.4	37.1	36.9	36.7	36.6	36.6	73.1	-	-	-	-	-	-	-	-
	R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
	R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	23.7	23.1	23.1	23.1	23.1	23.1	23.1	46.2
	R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	72.8	69.0	68.5	68.3	68.1	68.0	67.9	135.9
		Slab average temp [°F]	398.3083928	402.3029303	404.3184198	405.679664	406.6534865	407.3171532	407.6727938	407.728976	-	-	-	-	-	-	-	-
	T6	Slab high temp [°F]	473.3	476.0	478.3	480.1	481.4	482.4	482.9	482.9	-	-	-	-	-	-	-	-
	T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	323.3	328.6	330.3	331.2	331.9	332.3	332.5	332.5
		Heat transfer [BTU/hr]	1.02548	1.04418	1.04904	1.05515	1.06022	1.06403	1.06604	0.53316	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.1736
Q_rad. [BTU/hr]	1.1991
Total [BTU/hr]	1.0255
Q_cond. [BTU/hr]	1.0255
Q_conv. [BTU/hr]	0.8953
Q_rad. [BTU/hr]	0.1302
Total [BTU/hr]	1.0255
Total heat transfer slab [BTU/hr]	7.8973

Section 10	T1/T4	Air temperature [°F]	505.1	506.4	508.4	509.8	511.0	511.8	512.3	512.4	316.8	323.5	325.2	326.0	326.5	326.8	327.0	327.1
		Air velocity [ft/s]	1.23	1.23	1.23	1.23	1.24	1.24	1.24	1.24	0.75	0.76	0.76	0.76	0.76	0.76	0.76	0.76
	T2/T5	Rod temperature [°F]	554.7	557.2	559.7	561.6	563.2	564.2	564.7	564.7	328	331.6	333.4	334.4	335.2	335.6	335.8	335.8
		Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		Slab high temp [°F]	508.3	510.4	512.6	514.3	515.6	516.5	517.0	517.0	-	-	-	-	-	-	-	-
		Slab low temp [°F]	-	-	-	-	-	-	-	-	339.7	345.4	347.2	348.1	348.8	349.2	349.4	349.4
		Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
		Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
		Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
		Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
		Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
		Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
		Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
		Thermal cond. air [BTU/(hr-ft-°F)]	0.0232	0.0232	0.0232	0.0233	0.0233	0.0233	0.0233	0.0233	0.0196	0.0197	0.0197	0.0198	0.0198	0.0198	0.0198	0.0198
		Kynematic visc. air [ft²/s]	0.000455	0.000456	0.000458	0.000459	0.000460	0.000461	0.000461	0.000461	0.000315	0.000319	0.000321	0.000321	0.000321	0.000322	0.000322	0.000322
		Prandt numb. [-]	0.685680	0.685646	0.685597	0.685562	0.685535	0.685516	0.685505	0.685503	0.700970	0.700008	0.699773	0.699660	0.699591	0.699546	0.699521	0.699515
		Reynolds numb. [-]	161.57	167.97	167.73	167.55	167.42	167.32	167.26	167.25	143.06	147.95	147.72	147.61	147.55	147.50	147.48	147.47
		Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
		Conv. heat trsf [BTU/(ft²-°F)]	2.407	2.370	2.372	2.373	2.374	2.375	2.375	2.375	1.903	1.878	1.879	1.880	1.880	1.880	1.881	1.881
		Radiation heat trsf [BTU/(ft²-°F)]	1.3E+00	1.3E+00	1.3E+00	1.3E+00	1.3E+00	1.3E+00	1.3E+00	1.3E+00	6.5E-01	6.6E-01	6.7E-01	6.7E-01	6.7E-01	6.7E-01	6.7E-01	6.7E-01
	R1	R_convection [(hr-°F)/BTU]	18.6	18.2	18.2	18.2	18.2	18.2	18.2	36.3	-	-	-	-	-	-	-	-
	R2	R_radiation [(hr-°F)/BTU]	35.2	33.7	33.5	33.3	33.1	33.0	33.0	66.0	-	-	-	-	-	-	-	-
	R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
	R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	23.5	23.0	23.0	23.0	23.0	23.0	23.0	45.9
	R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	68.6	65.0	64.6	64.3	64.2	64.1	64.0	128.0
		Slab average temp [°F]	423.9616301	427.9322691	429.919326	431.2121427	432.1956834	432.8392232	433.1936771	433.2461818	-	-	-	-	-	-	-	-
	T6	Slab high temp [°F]	508.3	510.4	512.6	514.3	515.6	516.5	517.0	517.0	-	-	-	-	-	-	-	-
	T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	339.7	345.4	347.2	348.1	348.8	349.2	349.4	349.4
		Heat transfer [BTU/hr]	1.15200	1.16936	1.17272	1.17766	1.18235	1.18580	1.18773	0.59398	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.1676
Q_rad. [BTU/hr]	1.3196
Total [BTU/hr]	1.1520
Q_cond. [BTU/hr]	1.1520
Q_conv. [BTU/hr]	0.9820
Q_rad. [BTU/hr]	0.1700
Total [BTU/hr]	1.1520
Total heat transfer slab [BTU/hr]	8.8216

Section 11	T1/T4	Air temperature [°F]	540.0	540.7	542.5	543.8	544.9	545.7	546.1	546.2	331.2	338.8	340.6	341.5	342.0	342.3	342.5	342.6
		Air velocity [ft/s]	1.27	1.27	1.28	1.28	1.28	1.28	1.28	1.28	0.76	0.77	0.77	0.77	0.78	0.78	0.78	0.78
	T2/T5	Rod temperature [°F]	588.8	591	593.3	595.1	596.6	597.5	598	597.9	342.4	346.2	348	349.2	349.9	350.4	350.8	350.6
		Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		Slab high temp [°F]	543.0	544.8	546.8	548.4	549.6	550.5	550.9	551.0	-	-	-	-	-	-	-	-
		Slab low temp [°F]	-	-	-	-	-	-	-	-	356.1	362.3	364.1	365.1	365.8	366.2	366.4	366.4
		Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
		Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
		Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
		Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
		Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
		Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
		Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
		Thermal cond. air [BTU/(hr-ft-°F)]	0.0238	0.0238	0.0239	0.0239	0.0239	0.0239	0.0239	0.0239	0.0199	0.0200	0.0200	0.0201	0.0201	0.0201	0.0201	0.0201
		Kynematic visc. air [ft²/s]	0.000484	0.000484	0.000486	0.000487	0.000488	0.000489	0.000489	0.000489	0.000325	0.000330	0.000331	0.000332	0.000332	0.000333	0.000333	0.000333
		Prandt numb. [-]	0.685069	0.685062	0.685047	0.685037	0.685030	0.685025	0.685022	0.685021	0.698960	0.697986	0.697758	0.697648	0.697581	0.697539	0.697515	0.697509
		Reynolds numb. [-]	157.59	163.89	163.69	163.53	163.41	163.32	163.27	163.26	141.20	145.95	145.72	145.61	145.54	145.50	145.47	145.47
		Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
		Conv. heat trsf [BTU/(ft²-°F)]	2.437	2.400	2.401	2.402	2.403	2.404	2.404	2.404	1.914	1.889	1.890	1.891	1.891	1.891	1.892	1.892
		Radiation heat trsf [BTU/(ft²-°F)]	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00	6.9E-01	7.0E-01	7.1E-01	7.1E-01	7.1E-01	7.1E-01	7.2E-01	7.2E-01
	R1	R_convection [(hr-°F)/BTU]	18.4	18.0	18.0	18.0	18.0	18.0	18.0	35.9	-	-	-	-	-	-	-	-
	R2	R_radiation [(hr-°F)/BTU]	31.8	30.5	30.3	30.1	30.0	29.9	29.9	59.8	-	-	-	-	-	-	-	-
	R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
	R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	23.4	22.9	22.8	22.8	22.8	22.8	22.8	45.6
	R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	64.8	61.3	60.9	60.6	60.5	60.4	60.3	120.7
		Slab average temp [°F]	449.5638093	453.5448463	455.470761	456.7530103	457.6952267	458.3242451	458.6740974	458.7011316	-	-	-	-	-	-	-	-
	T6	Slab high temp [°F]	543.0	544.8	546.8	548.4	549.6	550.5	550.9	551.0	-	-	-	-	-	-	-	-
	T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	356.1	362.3	364.1	365.1	365.8	366.2	366.4	366.4
		Heat transfer [BTU/hr]	1.27673	1.29324	1.29507	1.29898	1.30329	1.30617	1.30799	0.65397	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.1653
Q_rad. [BTU/hr]	1.4420
Total [BTU/hr]	1.2767
Q_cond. [BTU/hr]	1.2767
Q_conv. [BTU/hr]	1.0646
Q_rad. [BTU/hr]	0.2122
Total [BTU/hr]	1.2767
Total heat transfer slab [BTU/hr]	8.7354

Section 12	T1/T4	Air temperature [°F]	574.5	574.8	576.4	577.7	578.7	579.4	579.8	579.9	346.1	354.2	356.1	357.1	357.6	358.0	358.2	358.2
		Air velocity [ft/s]	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	0.78	0.79	0.79	0.79	0.79	0.79	0.79	0.79
	T2/T5	Rod temperature [°F]	622.6	624.5	626.5	628.2	629.6	630.5	630.9	630.8	357	360.9	362.9	364	364.8	365.3	365.5	365.5
		Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		Slab high temp [°F]	577.5	579.0	580.8	582.3	583.4	584.3	584.7	584.7	-	-	-	-	-	-	-	-
		Slab low temp [°F]	-	-	-	-	-	-	-	-	372.7	379.2	381.1	382.1	382.8	383.2	383.4	383.4
		Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
		Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
		Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
		Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
		Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
		Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
		Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
		Thermal cond. air [BTU/(hr-ft-°F)]	0.0245	0.0245	0.0245	0.0245	0.0245	0.0246	0.0246	0.0246	0.0201	0.0203	0.0203	0.0204	0.0204	0.0204	0.0204	0.0204
		Kynematic visc. air [ft²/s]	0.000513	0.000513	0.000514	0.000515	0.000516	0.000517	0.000517	0.000517	0.000335	0.000341	0.000342	0.000343	0.000343	0.000344	0.000344	0.000344
		Prandt numb. [-]	0.685034	0.685037	0.685048	0.685058	0.685066	0.685073	0.685077	0.685078	0.697080	0.696111	0.695891	0.695786	0.695723	0.695682	0.695660	0.695654
		Reynolds numb. [-]	153.86	160.07	159.89	159.76	159.65	159.57	159.52	159.51	139.36	144.00	143.76	143.65	143.58	143.53	143.51	143.50
		Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
		Conv. heat trsf [BTU/(ft²-°F)]	2.468	2.429	2.430	2.431	2.432	2.433	2.433	2.433	1.925	1.900	1.901	1.902	1.902	1.903	1.903	1.903
		Radiation heat trsf [BTU/(ft²-°F)]	1.6E+00	1.6E+00	1.6E+00	1.6E+00	1.6E+00	1.6E+00	1.6E+00	1.6E+00	7.3E-01	7.5E-01	7.5E-01	7.5E-01	7.6E-01	7.6E-01	7.6E-01	7.6E-01
	R1	R_convection [(hr-°F)/BTU]	18.1	17.8	17.8	17.8	17.7	17.7	17.7	35.5	-	-	-	-	-	-	-	-
	R2	R_radiation [(hr-°F)/BTU]	28.8	27.6	27.5	27.4	27.3	27.2	27.2	54.3	-	-	-	-	-	-	-	-
	R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
	R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	23.3	22.7	22.7	22.7	22.7	22.7	22.7	45.4
	R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	61.2	57.9	57.5	57.2	57.1	57.0	56.9	113.9
		Slab average temp [°F]	475.1015087	479.0870213	480.9548725	482.1856614	483.0851701	483.7287814	484.0478889	484.0694245	-	-	-	-	-	-	-	-
	T6	Slab high temp [°F]	577.5	579.0	580.8	582.3	583.4	584.3	584.7	584.7	-	-	-	-	-	-	-	-
	T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	372.7	379.2	381.1	382.1	382.8	383.2	383.4	383.4
		Heat transfer [BTU/hr]	1.39971	1.41587	1.41566	1.41900	1.42236	1.42529	1.42675	0.71331	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.1656
Q_rad. [BTU/hr]	1.5653
Total [BTU/hr]	1.3997
Q_cond. [BTU/hr]	1.3997
Q_conv. [BTU/hr]	1.1433
Q_rad. [BTU/hr]	0.2564
Total [BTU/hr]	1.3997
Total heat transfer slab [BTU/hr]	10.6380

Table 3

Section 13

T1/T4	Air temperature [°F]	608.7	608.6	610.0	611.2	612.1	612.7	613.1	613.2	361.1	369.8	371.8	372.7	373.3	373.7	373.9	373.9
	Air velocity [ft/s]	1.36	1.36	1.36	1.36	1.36	1.36	1.37	1.37	0.79	0.80	0.80	0.80	0.81	0.81	0.81	0.81
T2/T5	Rod temperature [°F]	655.9	657.5	659.4	661	662.2	663	663.4	663.4	371.7	375.8	377.8	379	379.8	380.3	380.5	380.5
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	611.7	612.8	614.5	615.9	617.0	617.7	618.1	618.2	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	389.2	396.1	398.0	399.1	399.7	400.1	400.4	400.4
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0251	0.0251	0.0251	0.0251	0.0252	0.0252	0.0252	0.0252	0.0204	0.0206	0.0206	0.0207	0.0207	0.0207	0.0207	0.0207
	Kynematic visc. air [ft²/s]	0.000542	0.000542	0.000543	0.000544	0.000545	0.000546	0.000546	0.000546	0.000346	0.000352	0.000353	0.000354	0.000355	0.000355	0.000355	0.000356
	Prandt numb. [-]	0.685517	0.685516	0.685546	0.685571	0.685592	0.685607	0.685616	0.685618	0.695335	0.694387	0.694177	0.694078	0.694019	0.693981	0.693960	0.693955
	Reynolds numb. [-]	150.35	156.47	156.32	156.20	156.11	156.04	156.00	155.99	137.57	142.09	141.84	141.73	141.66	141.62	141.59	141.59
	Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft²-°F)]	2.498	2.458	2.459	2.460	2.461	2.462	2.462	2.462	1.935	1.911	1.912	1.913	1.914	1.914	1.914	1.914
	Radiation heat trsf [BTU/(ft²-°F)]	1.7E+00	1.7E+00	1.7E+00	1.7E+00	1.7E+00	1.7E+00	1.7E+00	1.7E+00	7.7E-01	7.9E-01	8.0E-01	8.0E-01	8.0E-01	8.0E-01	8.0E-01	8.0E-01
R1	R_convection [(hr-°F)/BTU]	17.9	17.8	17.6	17.5	17.5	17.5	17.5	35.1	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	26.2	25.2	25.1	25.0	24.9	24.8	24.8	49.6	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	23.1	22.6	22.6	22.6	22.6	22.6	22.6	45.1
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	57.8	54.7	54.3	54.1	53.9	53.8	53.8	107.6
	Slab average temp [°F]	500.4478007	504.4510911	506.2767304	507.4796469	508.3410002	508.9256575	509.2380294	509.2775027	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	611.7	612.8	614.5	615.9	617.0	617.7	618.1	618.2	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	389.2	396.1	398.0	399.1	399.7	400.1	400.4	400.4
	Heat transfer [BTU/hr]	1.52008	1.53604	1.53485	1.53709	1.53988	1.54209	1.54341	0.77175	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.1669
Q_rad. [BTU/hr]	1.6869
Total [BTU/hr]	1.5201
Q_cond. [BTU/hr]	1.5201
Q_conv. [BTU/hr]	1.2171
Q_rad. [BTU/hr]	0.3030
Total [BTU/hr]	1.5201

Total heat transfer slab [BTU/hr]	11.5250

Section 14

T1/T4	Air temperature [°F]	642.4	642.0	643.3	644.3	645.1	645.8	646.1	646.2	376.1	385.4	387.5	388.5	389.1	389.4	389.6	389.7
	Air velocity [ft/s]	1.40	1.40	1.40	1.40	1.41	1.41	1.41	1.41	0.81	0.82	0.82	0.82	0.82	0.82	0.82	0.82
T2/T5	Rod temperature [°F]	688.9	690.3	692	693.4	694.6	695.4	695.7	695.7	386.5	390.7	392.8	394	394.8	395.3	395.5	395.5
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	645.5	646.4	648.0	649.2	650.2	650.9	651.3	651.3	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	405.7	412.9	414.9	415.9	416.6	417.0	417.3	417.3
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0257	0.0257	0.0257	0.0258	0.0258	0.0258	0.0258	0.0258	0.0207	0.0209	0.0209	0.0210	0.0210	0.0210	0.0210	0.0210
	Kynematic visc. air [ft²/s]	0.000572	0.000571	0.000572	0.000573	0.000574	0.000575	0.000575	0.000575	0.000357	0.000363	0.000365	0.000366	0.000366	0.000366	0.000366	0.000367
	Prandt numb. [-]	0.686457	0.686442	0.686486	0.686522	0.686552	0.686574	0.686587	0.686589	0.693729	0.692816	0.692618	0.692527	0.692472	0.692437	0.692418	0.692413
	Reynolds numb. [-]	147.06	153.08	152.95	152.85	152.76	152.70	152.67	152.66	135.81	140.22	139.98	139.87	139.80	139.75	139.73	139.72
	Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft²-°F)]	2.527	2.487	2.488	2.489	2.489	2.490	2.490	2.490	1.946	1.922	1.924	1.924	1.925	1.925	1.925	1.925
	Radiation heat trsf [BTU/(ft²-°F)]	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00	1.9E+00	8.2E-01	8.4E-01	8.4E-01	8.4E-01	8.5E-01	8.5E-01	8.5E-01	8.5E-01
R1	R_convection [(hr-°F)/BTU]	17.7	17.4	17.4	17.3	17.3	17.3	17.3	34.7	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	24.0	23.0	22.9	22.8	22.8	22.7	22.7	45.4	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	23.0	22.5	22.4	22.4	22.4	22.4	22.4	44.8
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	54.7	51.7	51.3	51.1	51.0	50.9	50.9	101.8
	Slab average temp [°F]	525.6247738	529.6547139	531.4309071	532.5694528	533.4164079	533.9893858	534.2691921	534.304833	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	645.5	646.4	648.0	649.2	650.2	650.9	651.3	651.3	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	405.7	412.9	414.9	415.9	416.6	417.0	417.3	417.3
	Heat transfer [BTU/hr]	1.63831	1.65480	1.65169	1.65336	1.65568	1.65790	1.65883	0.82944	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.1734
Q_rad. [BTU/hr]	1.8117
Total [BTU/hr]	1.6383
Q_cond. [BTU/hr]	1.6383
Q_conv. [BTU/hr]	1.2865
Q_rad. [BTU/hr]	0.3518
Total [BTU/hr]	1.6383

Total heat transfer slab [BTU/hr]	12.4004

Section 15

T1/T4	Air temperature [°F]	675.8	675.1	676.2	677.2	677.9	678.5	678.9	678.9	391.3	401.1	403.2	404.2	404.8	405.2	405.4	405.5
	Air velocity [ft/s]	1.44	1.44	1.45	1.45	1.45	1.45	1.45	1.45	0.82	0.83	0.83	0.84	0.84	0.84	0.84	0.84
T2/T5	Rod temperature [°F]	721.4	722.7	724.2	725.5	726.5	727.3	727.6	727.5	401.4	405.7	407.9	409.1	409.9	410.4	410.6	410.6
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	679.0	679.7	681.1	682.2	683.1	683.8	684.2	684.1	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	422.2	429.7	431.7	432.8	433.4	433.8	434.1	434.1
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0263	0.0263	0.0263	0.0264	0.0264	0.0264	0.0264	0.0264	0.0210	0.0212	0.0212	0.0213	0.0213	0.0213	0.0213	0.0213
	Kynematic visc. air [ft²/s]	0.000601	0.000601	0.000602	0.000603	0.000603	0.000604	0.000604	0.000604	0.000368	0.000375	0.000377	0.000377	0.000378	0.000378	0.000378	0.000378
	Prandt numb. [-]	0.687800	0.687766	0.687819	0.687862	0.687898	0.687925	0.687941	0.687943	0.692265	0.691400	0.691217	0.691133	0.691083	0.691052	0.691034	0.691030
	Reynolds numb. [-]	143.97	149.88	149.78	149.69	149.62	149.56	149.53	149.53	134.09	138.42	138.18	138.06	138.00	137.95	137.93	137.92
	Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft²-°F)]	2.556	2.515	2.516	2.517	2.517	2.518	2.518	2.518	1.957	1.933	1.935	1.936	1.936	1.936	1.937	1.937
	Radiation heat trsf [BTU/(ft²-°F)]	2.0E+00	2.0E+00	2.1E+00	2.1E+00	2.1E+00	2.1E+00	2.1E+00	2.1E+00	8.6E-01	8.8E-01	8.9E-01	8.9E-01	8.9E-01	9.0E-01	9.0E-01	9.0E-01
R1	R_convection [(hr-°F)/BTU]	17.5	17.2	17.2	17.2	17.1	17.1	17.1	34.3	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	22.0	21.1	21.0	21.0	20.9	20.9	20.9	41.7	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	22.9	22.3	22.3	22.3	22.3	22.3	22.3	44.6
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	51.8	48.9	48.6	48.4	48.3	48.2	48.2	96.3
	Slab average temp [°F]	550.5927167	554.6674141	556.3938604	557.4915948	558.2753825	558.8376577	559.1087828	559.115855	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	679.0	679.7	681.1	682.2	683.1	683.8	684.2	684.1	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	422.2	429.7	431.7	432.8	433.4	433.8	434.1	434.1
	Heat transfer [BTU/hr]	1.75417	1.77183	1.76748	1.76830	1.77000	1.77186	1.77268	0.88620	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.1782
Q_rad. [BTU/hr]	1.9323
Total [BTU/hr]	1.7542
Q_cond. [BTU/hr]	1.7542
Q_conv. [BTU/hr]	1.3519
Q_rad. [BTU/hr]	0.4023
Total [BTU/hr]	1.7542

Total heat transfer slab [BTU/hr]	13.2625

Section 16

T1/T4	Air temperature [°F]	708.8	707.8	708.8	709.6	710.3	710.9	711.2	711.2	406.5	416.7	418.9	419.9	420.5	420.9	421.1	421.2
	Air velocity [ft/s]	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	0.84	0.85	0.85	0.85	0.85	0.85	0.85	0.85
T2/T5	Rod temperature [°F]	753.4	754.5	755.9	757.1	758.1	758.8	759.1	759	416.3	420.8	422.9	424.2	425	425.5	425.7	425.7
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	711.9	712.4	713.8	714.8	715.7	716.3	716.6	716.6	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	438.6	446.3	448.4	449.4	450.1	450.5	450.7	450.8
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0269	0.0269	0.0269	0.0270	0.0270	0.0270	0.0270	0.0270	0.0213	0.0215	0.0215	0.0216	0.0216	0.0216	0.0216	0.0216
	Kynematic visc. air [ft²/s]	0.000632	0.000631	0.000632	0.000632	0.000633	0.000633	0.000634	0.000634	0.000379	0.000387	0.000388	0.000389	0.000389	0.000390	0.000390	0.000390
	Prandt numb. [-]	0.689487	0.689430	0.689488	0.689536	0.689576	0.689606	0.689624	0.689627	0.690945	0.690138	0.689971	0.689895	0.689851	0.689823	0.689807	0.689804
	Reynolds numb. [-]	141.08	146.90	146.80	146.73	146.67	146.62	146.59	146.59	132.43	136.68	136.44	136.33	136.26	136.22	136.20	136.19
	Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft²-°F)]	2.585	2.543	2.544	2.544	2.545	2.545	2.546	2.546	1.968	1.945	1.946	1.947	1.947	1.948	1.948	1.948
	Radiation heat trsf [BTU/(ft²-°F)]	2.2E+00	2.2E+00	2.2E+00	2.2E+00	2.2E+00	2.2E+00	2.2E+00	2.2E+00	9.1E-01	9.3E-01	9.4E-01	9.4E-01	9.4E-01	9.4E-01	9.5E-01	9.5E-01
R1	R_convection [(hr-°F)/BTU]	17.3	17.0	17.0	17.0	17.0	17.0	17.0	33.9	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	20.2	19.5	19.4	19.3	19.3	19.3	19.2	38.5	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	22.7	22.2	22.2	22.2	22.2	22.2	22.2	44.3
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	49.1	46.4	46.0	45.9	45.8	45.7	45.7	91.3
	Slab average temp [°F]	575.280984	579.3877868	581.0599354	582.1314626	582.9017123	583.4280192	583.6910519	583.6943562	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	711.9	712.4	713.8	714.8	715.7	716.3	716.6	716.6	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	438.6	446.3	448.4	449.4	450.1	450.5	450.7	450.8
	Heat transfer [BTU/hr]	1.86754	1.88615	1.88106	1.88108	1.88257	1.88398	1.88471	0.94219	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.1831
Q_rad. [BTU/hr]	2.0506
Total [BTU/hr]	1.8675
Q_cond. [BTU/hr]	1.8675
Q_conv. [BTU/hr]	1.4128
Q_rad. [BTU/hr]	0.4547
Total [BTU/hr]	1.8675

Total heat transfer slab [BTU/hr]	14.1093

Section 17

T1/T4	Air temperature [°F]	741.3	740.0	740.9	741.7	742.4	742.9	743.1	743.2	421.7	432.3	434.6	435.6	436.2	436.6	436.8	436.9
	Air velocity [ft/s]	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	0.85	0.86	0.86	0.87	0.87	0.87	0.87	0.87
T2/T5	Rod temperature [°F]	785.2	786.1	787.4	788.5	789.4	790	790.3	790.3	431.2	435.8	438	439.3	440.1	440.6	440.8	440.8
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	744.6	744.9	746.1	747.1	747.9	748.5	748.8	748.8	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	454.9	462.9	464.9	466.0	466.7	467.1	467.3	467.3
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0275	0.0275	0.0275	0.0275	0.0275	0.0276	0.0276	0.0276	0.0216	0.0218	0.0218	0.0219	0.0219	0.0219	0.0219	0.0219
	Kynematic visc. air [ft²/s]	0.000662	0.000661	0.000661	0.000662	0.000663	0.000663	0.000664	0.000664	0.000390	0.000398	0.000400	0.000401	0.000401	0.000402	0.000402	0.000402
	Prandt numb. [-]	0.691467	0.691387	0.691447	0.691498	0.691540	0.691572	0.691591	0.691594	0.689767	0.689026	0.688876	0.688808	0.688769	0.688744	0.688731	0.688727
	Reynolds numb. [-]	138.37	144.09	144.01	143.95	143.89	143.85	143.83	143.82	130.83	135.00	134.76	134.65	134.58	134.54	134.52	134.51
	Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft²-°F)]	2.613	2.571	2.571	2.572	2.573	2.573	2.573	2.573	1.980	1.956	1.958	1.958	1.959	1.959	1.959	1.959
	Radiation heat trsf [BTU/(ft²-°F)]	2.4E+00	2.4E+00	2.4E+00	2.4E+00	2.4E+00	2.4E+00	2.4E+00	2.4E+00	9.6E-01	9.8E-01	9.9E-01	9.9E-01	9.9E-01	1.0E+00	1.0E+00	1.0E+00
R1	R_convection [(hr-°F)/BTU]	17.1	16.8	16.8	16.8	16.8	16.8	16.8	33.5	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	18.7	18.0	17.9	17.9	17.8	17.8	17.8	35.6	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	22.6	22.1	22.0	22.0	22.0	22.0	22.0	44.1
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	46.6	44.0	43.7	43.5	43.4	43.3	43.3	86.6
	Slab average temp [°F]	599.7704482	603.894155	605.5443565	606.5771514	607.3097538	607.8003254	608.056587	608.0836923	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	744.6	744.9	746.1	747.1	747.9	748.5	748.8	748.8	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	454.9	462.9	464.9	466.0	466.7	467.1	467.3	467.3
	Heat transfer [BTU/hr]	1.97636	1.99931	1.99321	1.99261	1.99359	1.99457	1.99521	0.99758	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.1953
Q_rad. [BTU/hr]	2.1747
Total [BTU/hr]	1.9794
Q_cond. [BTU/hr]	1.9794
Q_conv. [BTU/hr]	1.4700
Q_rad. [BTU/hr]	0.5093
Total [BTU/hr]	1.9794

Total heat transfer slab [BTU/hr]	14.9454

Section 18

T1/T4	Air temperature [°F]	773.4	772.0	772.8	773.5	774.1	774.6	774.8	774.9	436.9	447.9	450.2	451.3	451.9	452.3	452.5	452.6
	Air velocity [ft/s]	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	0.87	0.88	0.88	0.88	0.88	0.88	0.88	0.88
T2/T5	Rod temperature [°F]	816.5	817.3	818.5	819.5	820.3	820.9	821.1	821.1	446.2	450.9	453.1	454.4	455.2	455.7	455.9	455.9
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	776.9	777.1	778.2	779.1	779.8	780.4	780.6	780.6	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	471.2	479.3	481.4	482.5	483.1	483.6	483.8	483.8
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0281	0.0219	0.0221	0.0221	0.0221	0.0222	0.0222	0.0222	0.0222
	Kynematic visc. air [ft²/s]	0.000692	0.000691	0.000692	0.000692	0.000693	0.000693	0.000694	0.000694	0.000402	0.000410	0.000412	0.000413	0.000413	0.000414	0.000414	0.000414
	Prandt numb. [-]	0.693700	0.693595	0.693655	0.693708	0.693751	0.693784	0.693803	0.693806	0.688726	0.688059	0.687926	0.687868	0.687833	0.687812	0.687800	0.687798
	Reynolds numb. [-]	135.82	141.45	141.38	141.32	141.27	141.24	141.22	141.21	129.27	133.36	133.12	133.02	132.95	132.91	132.89	132.89
	Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft²-°F)]	2.641	2.598	2.599	2.599	2.600	2.600	2.600	2.600	1.991	1.967	1.969	1.970	1.970	1.971	1.971	1.971
	Radiation heat trsf [BTU/(ft²-°F)]	2.6E+00	2.6E+00	2.6E+00	2.6E+00	2.6E+00	2.6E+00	2.6E+00	2.6E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
R1	R_convection [(hr-°F)/BTU]	17.0	16.6	16.6	16.6	16.6	16.6	16.6	33.2	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	17.3	16.6	16.6	16.6	16.5	16.5	16.5	33.0	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	22.5	21.9	21.9	21.9	21.9	21.9	21.9	43.8
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	44.3	41.8	41.6	41.3	41.2	41.2	41.2	82.3
	Slab average temp [°F]	624.0277969	628.1885708	629.8023484	630.7970187	631.4921782	631.9745971	632.197179	632.2223056	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	776.9	777.1	778.2	779.1	779.8	780.4	780.6	780.6	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	471.2	479.3	481.4	482.5	483.1	483.6	483.8	483.8
	Heat transfer [BTU/hr]	2.08875	2.11055	2.10367	2.10250	2.10299	2.10385	2.10409	1.05201	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.2040
Q_rad. [BTU/hr]	2.2927
Total [BTU/hr]	2.0887
Q_cond. [BTU/hr]	2.0887
Q_conv. [BTU/hr]	1.5242
Q_rad. [BTU/hr]	0.5646
Total [BTU/hr]	2.0887

Total heat transfer slab [BTU/hr]	15.7684

Table 3

Section 19

T1/T4	Air temperature [°F]	805.1	803.5	804.3	804.9	805.5	805.9	806.1	806.1	452.1	463.5	465.9	466.9	467.6	468.0	468.2	468.2
	Air velocity [ft/s]	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	0.88	0.89	0.89	0.90	0.90	0.90	0.90	0.90
T2/T5	Rod temperature [°F]	847.4	848.1	849.1	850.1	850.8	851.4	851.6	851.6	461.2	465.9	468.2	469.5	470.3	470.8	471	471
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	808.7	808.8	809.8	810.7	811.3	811.9	812.1	812.1	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	487.4	495.6	497.8	498.8	499.5	499.9	500.1	500.1
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0287	0.0288	0.0287	0.0287	0.0287	0.0287	0.0287	0.0287	0.0222	0.0224	0.0224	0.0224	0.0225	0.0225	0.0225	0.0225
	Kynematic visc. air [ft²/s]	0.000723	0.000721	0.000722	0.000723	0.000723	0.000723	0.000724	0.000724	0.000414	0.000422	0.000424	0.000425	0.000426	0.000426	0.000426	0.000426
	Prandt numb. [-]	0.698132	0.698004	0.698064	0.698116	0.698159	0.698192	0.698212	0.698214	0.687821	0.687233	0.687119	0.687069	0.687040	0.687022	0.687012	0.687010
	Reynolds numb. [-]	133.41	138.95	138.90	138.85	138.80	138.77	138.75	138.75	127.74	131.76	131.54	131.43	131.37	131.33	131.31	131.30
	Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft²-°F)]	2.668	2.626	2.626	2.626	2.627	2.627	2.627	2.627	2.002	1.979	1.980	1.981	1.982	1.982	1.982	1.982
	Radiation heat trsf [BTU/(ft²-°F)]	2.8E+00	2.8E+00	2.8E+00	2.8E+00	2.8E+00	2.8E+00	2.8E+00	2.8E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00
R1	R_convection [(hr-°F)/BTU]	16.8	16.4	16.4	16.4	16.4	16.4	16.4	32.9	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	16.1	15.5	15.4	15.4	15.4	15.3	15.3	30.7	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	22.4	21.8	21.8	21.8	21.8	21.8	21.8	43.6
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	42.1	39.7	39.5	39.3	39.2	39.2	39.1	78.3
	Slab average temp [°F]	648.0313552	652.2084839	653.7724486	654.7571141	655.4143118	655.889436	656.1059651	656.1294234	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	808.7	808.8	809.8	810.7	811.3	811.9	812.1	812.1	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	487.4	495.6	497.8	498.8	499.5	499.9	500.1	500.1
	Heat transfer [BTU/hr]	2.19587	2.21991	2.21176	2.21036	2.21037	2.21113	2.21131	1.10561	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.2142
Q_rad. [BTU/hr]	2.4101
Total [BTU/hr]	2.1959
Q_cond. [BTU/hr]	2.1959
Q_conv. [BTU/hr]	1.5744
Q_rad. [BTU/hr]	0.6215
Total [BTU/hr]	2.1959

Total heat transfer slab [BTU/hr]	16.5763

Section 20

T1/T4	Air temperature [°F]	836.4	834.6	835.3	835.9	836.4	836.8	837.0	837.0	467.4	479.1	481.5	482.5	483.2	483.6	483.8	483.8
	Air velocity [ft/s]	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	0.90	0.91	0.91	0.91	0.91	0.91	0.91	0.91
T2/T5	Rod temperature [°F]	877.9	878.5	879.5	880.4	881.1	881.6	881.8	881.8	476.2	481	483.3	484.6	485.4	485.9	486.1	486.1
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	840.1	840.1	841.1	841.9	842.5	843.0	843.2	843.2	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	503.4	511.8	514.0	515.1	515.7	516.1	516.4	516.4
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0292	0.0292	0.0292	0.0292	0.0292	0.0292	0.0292	0.0292	0.0225	0.0227	0.0227	0.0227	0.0228	0.0228	0.0228	0.0228
	Kynematic visc. air [ft²/s]	0.000753	0.000752	0.000752	0.000753	0.000753	0.000754	0.000754	0.000754	0.000425	0.000435	0.000437	0.000437	0.000438	0.000438	0.000438	0.000438
	Prandt numb. [-]	0.698722	0.698573	0.698631	0.698682	0.698725	0.698757	0.698776	0.698779	0.687048	0.686543	0.686448	0.686407	0.686383	0.686369	0.686360	0.686359
	Reynolds numb. [-]	131.15	136.60	136.55	136.51	136.47	136.44	136.42	136.42	126.26	130.24	130.00	129.90	129.84	129.80	129.78	129.77
	Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft²-°F)]	2.696	2.651	2.652	2.652	2.653	2.653	2.653	2.653	2.013	1.990	1.992	1.992	1.993	1.993	1.993	1.993
	Radiation heat trsf [BTU/(ft²-°F)]	3.0E+00	3.0E+00	3.0E+00	3.0E+00	3.0E+00	3.0E+00	3.0E+00	3.0E+00	1.1E+00	1.1E+00	1.1E+00	1.2E+00	1.2E+00	1.2E+00	1.2E+00	1.2E+00
R1	R_convection [(hr-°F)/BTU]	16.6	16.3	16.3	16.3	16.3	16.3	16.3	32.5	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	14.9	14.4	14.4	14.3	14.3	14.3	14.3	28.6	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	22.2	21.7	21.7	21.7	21.7	21.7	21.7	43.3
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	40.0	37.8	37.5	37.4	37.3	37.3	37.2	74.5
	Slab average temp [°F]	671.7817698	676.9831751	677.539033	678.4863977	679.1354074	679.5752922	679.786715	679.8088159	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	840.1	840.1	841.1	841.9	842.5	843.0	843.2	843.2	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	503.4	511.8	514.0	515.1	515.7	516.1	516.4	516.4
	Heat transfer [BTU/hr]	2.30074	2.32697	2.31847	2.31655	2.31643	2.31676	2.31688	1.15839	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.2256
Q_rad. [BTU/hr]	2.5263
Total [BTU/hr]	2.3007
Q_cond. [BTU/hr]	2.3007
Q_conv. [BTU/hr]	1.6208
Q_rad. [BTU/hr]	0.6799
Total [BTU/hr]	2.3007

Total heat transfer slab [BTU/hr]	17.3712

Section 21

T1/T4	Air temperature [°F]	867.3	865.4	866.0	866.6	867.1	867.4	867.6	867.7	482.6	494.6	497.0	498.1	498.7	499.1	499.3	499.3
	Air velocity [ft/s]	1.69	1.68	1.69	1.69	1.69	1.69	1.69	1.69	0.91	0.92	0.92	0.93	0.93	0.93	0.93	0.93
T2/T5	Rod temperature [°F]	908.1	908.6	909.5	910.3	911	911.5	911.7	911.6	491.2	496	498.3	499.6	500.4	501	501.2	501.2
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	871.2	871.1	872.0	872.7	873.4	873.8	874.0	874.0	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	519.4	527.9	530.1	531.2	531.8	532.3	532.5	532.5
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0298	0.0297	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0227	0.0230	0.0230	0.0230	0.0230	0.0231	0.0231	0.0231
	Kynematic visc. air [ft²/s]	0.000784	0.000782	0.000783	0.000783	0.000784	0.000784	0.000784	0.000784	0.000437	0.000447	0.000449	0.000450	0.000450	0.000451	0.000451	0.000451
	Prandt numb. [-]	0.701439	0.701271	0.701325	0.701375	0.701417	0.701449	0.701467	0.701470	0.686404	0.685987	0.685911	0.685876	0.685860	0.685848	0.685842	0.685840
	Reynolds numb. [-]	129.00	134.37	134.33	134.29	134.26	134.23	134.22	134.22	124.82	128.74	128.51	128.41	128.35	128.31	128.29	128.29
	Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft²-°F)]	2.722	2.678	2.678	2.679	2.679	2.679	2.679	2.679	2.025	2.001	2.003	2.004	2.004	2.005	2.005	2.005
	Radiation heat trsf [BTU/(ft²-°F)]	3.2E+00	3.2E+00	3.2E+00	3.2E+00	3.2E+00	3.2E+00	3.2E+00	3.2E+00	1.2E+00	1.2E+00	1.2E+00	1.2E+00	1.2E+00	1.2E+00	1.2E+00	1.2E+00
R1	R_convection [(hr-°F)/BTU]	16.4	16.1	16.1	16.1	16.1	16.1	16.1	32.2	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	14.0	13.4	13.4	13.4	13.4	13.4	13.4	26.7	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	22.1	21.6	21.6	21.5	21.5	21.5	21.5	43.1
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	38.1	36.0	35.8	35.6	35.6	35.5	35.5	71.0
	Slab average temp [°F]	695.3278523	699.5269806	701.0440447	701.9532614	702.5949088	703.0459722	703.2528225	703.2435803	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	871.2	871.1	872.0	872.7	873.4	873.8	874.0	874.0	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	519.4	527.9	530.1	531.2	531.8	532.3	532.5	532.5
	Heat transfer [BTU/hr]	2.40398	2.43277	2.42366	2.42124	2.42102	2.42106	2.42114	1.21034	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.2381
Q_rad. [BTU/hr]	2.6421
Total [BTU/hr]	2.4040
Q_cond. [BTU/hr]	2.4040
Q_conv. [BTU/hr]	1.6842
Q_rad. [BTU/hr]	0.7398
Total [BTU/hr]	2.4040

Total heat transfer slab [BTU/hr]	18.1552

Section 22

T1/T4	Air temperature [°F]	897.8	895.8	896.4	896.9	897.3	897.6	897.8	897.8	497.8	509.9	512.4	513.5	514.1	514.5	514.7	514.8
	Air velocity [ft/s]	1.73	1.72	1.72	1.72	1.73	1.73	1.73	1.73	0.93	0.94	0.94	0.94	0.94	0.94	0.94	0.94
T2/T5	Rod temperature [°F]	937.7	938.2	939	939.8	940.4	940.8	941	941	506.2	511	513.3	514.6	515.4	515.9	516.2	516.2
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	901.8	901.7	902.5	903.2	903.7	904.1	904.3	904.3	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	535.3	543.8	546.0	547.1	547.7	548.1	548.4	548.4
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0303	0.0303	0.0303	0.0303	0.0303	0.0303	0.0303	0.0303	0.0230	0.0233	0.0233	0.0233	0.0233	0.0233	0.0233	0.0233
	Kynematic visc. air [ft²/s]	0.000815	0.000813	0.000813	0.000814	0.000814	0.000815	0.000815	0.000815	0.000450	0.000459	0.000461	0.000462	0.000463	0.000463	0.000463	0.000463
	Prandt numb. [-]	0.704237	0.704052	0.704103	0.704150	0.704191	0.704221	0.704239	0.704241	0.685887	0.685559	0.685502	0.685478	0.685464	0.685456	0.685451	0.685450
	Reynolds numb. [-]	126.98	132.27	132.24	132.20	132.17	132.15	132.14	132.14	123.42	127.30	127.07	126.97	126.91	126.88	126.86	126.85
	Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft²-°F)]	2.748	2.703	2.704	2.704	2.705	2.705	2.705	2.705	2.036	2.012	2.014	2.015	2.015	2.016	2.016	2.016
	Radiation heat trsf [BTU/(ft²-°F)]	3.4E+00	3.4E+00	3.4E+00	3.4E+00	3.4E+00	3.4E+00	3.5E+00	3.5E+00	1.2E+00	1.3E+00	1.3E+00	1.3E+00	1.3E+00	1.3E+00	1.3E+00	1.3E+00
R1	R_convection [(hr-°F)/BTU]	16.3	16.0	16.0	16.0	16.0	16.0	16.0	31.9	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	13.1	12.6	12.6	12.5	12.5	12.5	12.5	25.0	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	22.0	21.4	21.4	21.4	21.4	21.4	21.4	42.8
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	36.4	34.4	34.1	34.0	33.9	33.9	33.9	67.7
	Slab average temp [°F]	718.5380048	722.7546539	724.2322552	725.1336755	725.7379064	726.1358453	726.3559805	726.3758903	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	901.8	901.7	902.5	903.2	903.7	904.1	904.3	904.3	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	535.3	543.8	546.0	547.1	547.7	548.1	548.4	548.4
	Heat transfer [BTU/hr]	2.50434	2.53828	2.52657	2.52402	2.52334	2.52317	2.52298	1.26143	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.2452
Q_rad. [BTU/hr]	2.7495
Total [BTU/hr]	2.5043
Q_cond. [BTU/hr]	2.5043
Q_conv. [BTU/hr]	1.7047
Q_rad. [BTU/hr]	0.7996
Total [BTU/hr]	2.5043

Total heat transfer slab [BTU/hr]	18.8221

Section 23

T1/T4	Air temperature [°F]	927.7	925.6	926.1	926.6	927.0	927.3	927.5	927.5	512.8	525.2	527.6	528.7	529.4	529.7	530.0	530.0
	Air velocity [ft/s]	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	0.94	0.95	0.95	0.96	0.96	0.96	0.96	0.96
T2/T5	Rod temperature [°F]	968.9	967.3	968.1	968.8	969.4	969.8	970	969.9	520.9	525.8	528.1	529.4	530.2	530.7	531	531
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	931.8	931.7	932.4	933.1	933.6	934.0	934.2	934.2	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	550.9	559.5	561.7	562.8	563.4	563.8	564.1	564.1
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0308	0.0308	0.0308	0.0308	0.0308	0.0308	0.0308	0.0308	0.0233	0.0235	0.0236	0.0236	0.0236	0.0236	0.0236	0.0236
	Kynematic visc. air [ft²/s]	0.000845	0.000843	0.000844	0.000844	0.000845	0.000845	0.000845	0.000845	0.000462	0.000472	0.000474	0.000475	0.000475	0.000476	0.000476	0.000476
	Prandt numb. [-]	0.707067	0.706871	0.706919	0.706963	0.707002	0.707031	0.707048	0.707051	0.685494	0.685255	0.685216	0.685200	0.685191	0.685186	0.685183	0.685182
	Reynolds numb. [-]	125.09	130.30	130.27	130.24	130.22	130.20	130.19	130.18	122.08	125.91	125.69	125.58	125.53	125.50	125.48	125.47
	Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft²-°F)]	2.774	2.729	2.729	2.729	2.730	2.730	2.730	2.730	2.047	2.024	2.025	2.026	2.027	2.027	2.027	2.027
	Radiation heat trsf [BTU/(ft²-°F)]	3.7E+00	3.7E+00	3.7E+00	3.7E+00	3.7E+00	3.7E+00	3.7E+00	3.7E+00	1.3E+00	1.3E+00	1.3E+00	1.3E+00	1.3E+00	1.3E+00	1.3E+00	1.3E+00
R1	R_convection [(hr-°F)/BTU]	16.1	15.8	15.8	15.8	15.8	15.8	15.8	31.6	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	12.3	11.8	11.8	11.8	11.8	11.8	11.7	23.5	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	21.9	21.3	21.3	21.3	21.3	21.3	21.3	42.6
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	34.7	32.8	32.6	32.5	32.4	32.4	32.3	64.7
	Slab average temp [°F]	741.3565919	745.5839312	747.0568621	747.9223665	748.5219237	748.9157965	749.1333043	749.1209334	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	931.8	931.7	932.4	933.1	933.6	934.0	934.2	934.2	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	550.9	559.5	561.7	562.8	563.4	563.8	564.1	564.1
	Heat transfer [BTU/hr]	2.60329	2.63777	2.62765	2.62481	2.62405	2.62382	2.62359	1.31155	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.2571
Q_rad. [BTU/hr]	2.8604
Total [BTU/hr]	2.6033
Q_cond. [BTU/hr]	2.6033
Q_conv. [BTU/hr]	1.7407
Q_rad. [BTU/hr]	0.8626
Total [BTU/hr]	2.6033

Total heat transfer slab [BTU/hr]	19.6767

Section 24

T1/T4	Air temperature [°F]	956.6	954.7	955.2	955.6	956.0	956.3	956.5	956.5	527.1	539.9	542.4	543.5	544.2	544.6	544.8	544.8
	Air velocity [ft/s]	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	0.95	0.97	0.97	0.97	0.97	0.97	0.97	0.97
T2/T5	Rod temperature [°F]	994.6	995.1	996	996.8	997.4	997.8	998	998	534.7	539.8	542.2	543.6	544.4	545	545.2	545.2
	Slab to rod area ratio [-]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Slab high temp [°F]	960.6	960.5	961.3	962.1	962.6	963.0	963.2	963.2	-	-	-	-	-	-	-	-
	Slab low temp [°F]	-	-	-	-	-	-	-	-	565.6	574.5	576.7	577.9	578.5	579.0	579.2	579.2
	Rod emissivity [-]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	Slab emissivity [-]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Slab thickness [in]	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906	0.906
	Channel height [in]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Channel width [in]	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278	0.536	0.556	0.556	0.556	0.556	0.556	0.556	0.278
	Hydraulic diameter [in]	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7193	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485	0.7485
	Slab conductivity [BTU/(hr-ft-°F)]	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
	Area heat trsf [ft²]	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012	0.022	0.023	0.023	0.023	0.023	0.023	0.023	0.012
	Thermal cond. air [BTU/(hr-ft-°F)]	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0236	0.0238	0.0239	0.0239	0.0239	0.0239	0.0239	0.0239
	Kynematic visc. air [ft²/s]	0.000875	0.000873	0.000874	0.000874	0.000875	0.000875	0.000875	0.000875	0.000473	0.000484	0.000486	0.000487	0.000487	0.000488	0.000488	0.000488
	Prandt numb. [-]	0.709858	0.709671	0.709719	0.709764	0.709802	0.709831	0.709848	0.709850	0.685224	0.685069	0.685048	0.685039	0.685035	0.685032	0.685031	0.685030
	Reynolds numb. [-]	123.34	128.47	128.44	128.41	128.39	128.37	128.36	128.36	120.83	124.60	124.38	124.28	124.22	124.19	124.17	124.17
	Stefan-Boltzmann c. [BTU/(hr-ft²-R⁴)]	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09	1.7E-09
	Conv. heat trsf [BTU/(ft²-°F)]	2.799	2.753	2.753	2.754	2.754	2.754	2.755	2.755	2.057	2.034	2.036	2.037	2.037	2.038	2.038	2.038
	Radiation heat trsf [BTU/(ft²-°F)]	3.9E+00	3.9E+00	3.9E+00	3.9E+00	3.9E+00	3.9E+00	3.9E+00	3.9E+00	1.3E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00	1.4E+00
R1	R_convection [(hr-°F)/BTU]	16.0	15.7	15.7	15.7	15.7	15.7	15.7	31.3	-	-	-	-	-	-	-	-
R2	R_radiation [(hr-°F)/BTU]	11.6	11.1	11.1	11.1	11.1	11.1	11.1	22.1	-	-	-	-	-	-	-	-
R3	R_conduction [(hr-°F)/BTU]	146.3	141.1	141.1	141.1	141.1	141.1	141.1	282.2	-	-	-	-	-	-	-	-
R4	R_convection [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	21.8	21.2	21.2	21.2	21.2	21.2	21.2	42.4
R5	R_radiation [(hr-°F)/BTU]	-	-	-	-	-	-	-	-	33.3	31.4	31.2	31.1	31.0	31.0	31.0	61.9
	Slab average temp [°F]	763.1013264	767.511524	769.0489367	769.9705908	770.5727484	770.9854837	771.1847794	771.2039869	-	-	-	-	-	-	-	-
T6	Slab high temp [°F]	960.6	960.5	961.3	962.1	962.6	963.0	963.2	963.2	-	-	-	-	-	-	-	-
T7	Slab low temp [°F]	-	-	-	-	-	-	-	-	565.6	574.5	576.7	577.9	578.5	579.0	579.2	579.2
	Heat transfer [BTU/hr]	2.69869	2.73803	2.72607	2.72308	2.72226	2.72175	2.72173	1.36080	-	-	-	-	-	-	-	-

First element check	
Q_conv. [BTU/hr]	-0.2482
Q_rad. [BTU/hr]	2.9468
Total [BTU/hr]	2.6987
Q_cond. [BTU/hr]	2.6987
Q_conv. [BTU/hr]	1.7695
Q_rad. [BTU/hr]	0.9292
Total [BTU/hr]	2.6987

Total heat transfer slab [BTU/hr]	20.4104

Table 4

TOTAL HEAT GENERATED			
	Assembly 1	Assembly 2	Assembly 3
Heat generation per unit volume [MBTU/(hr-ft3)]	0.00549	0.001103	0.001103
Number of rods [-]	179	179	179
Rod diameter [in]	0.422	0.422	0.422
Rod length [ft]	12	12	12
Total heat generation (input) [BTU/hr]	11454.0	2301.2	2301.2

HEAT TRANSFERED TO AIR																	
	Assembly 1					Assembly 2					Assembly 3				
	Average temperature [°F]	Mass flow [lb/s]	Specific heat [BTU/(lb-°F)]	Air temperature rise [°F]	Heat transfer [BTU/hr]	Average temperature [°F]	Mass flow [lb/s]	Specific heat [BTU/(lb-°F)]	Air temperature rise [°F]	Heat transfer [BTU/hr]	Average temperature [°F]	Mass flow [lb/s]	Specific heat [BTU/(lb-°F)]	Air temperature rise [°F]	Heat transfer [BTU/hr]
Sec 1	219.3	0.014	0.241	38.6	485.913	205.4	0.011	0.241	10.7	102.619	205.4	0.011	0.241	10.7	102.622
Sec 2	257.4	0.014	0.242	37.6	474.976	216.0	0.011	0.241	10.5	100.752	216.0	0.011	0.241	10.5	100.757
Sec 3	294.7	0.014	0.243	37.0	468.805	226.6	0.011	0.242	10.6	101.870	226.6	0.011	0.242	10.6	101.878
Sec 4	331.5	0.014	0.243	36.4	462.400	237.3	0.011	0.242	10.8	103.562	237.3	0.011	0.242	10.8	103.574
Sec 5	367.7	0.014	0.244	36.1	459.914	248.2	0.011	0.242	11.0	105.403	248.2	0.011	0.242	11.0	105.418
Sec 6	403.6	0.014	0.245	35.6	455.265	259.3	0.011	0.242	11.2	107.298	259.3	0.011	0.242	11.2	107.316
Sec 7	439.1	0.014	0.246	35.2	451.554	270.6	0.011	0.242	11.4	109.215	270.6	0.011	0.242	11.4	109.237
Sec 8	474.1	0.014	0.247	34.9	449.308	282.1	0.011	0.242	11.6	111.139	282.1	0.011	0.242	11.6	111.164
Sec 9	508.8	0.014	0.247	34.3	443.056	293.7	0.011	0.243	11.8	113.070	293.7	0.011	0.243	11.8	113.097
Sec 10	542.9	0.014	0.248	33.9	439.760	305.5	0.011	0.243	11.8	113.632	305.5	0.011	0.243	11.8	113.657
Sec 11	576.7	0.014	0.249	33.7	437.723	317.4	0.011	0.243	12.0	115.503	317.4	0.011	0.243	12.0	115.532
Sec 12	610.1	0.014	0.250	33.1	431.590	329.5	0.011	0.243	12.2	117.402	329.5	0.011	0.243	12.2	117.431
Sec 13	643.0	0.014	0.251	32.7	428.771	341.8	0.011	0.244	12.4	119.275	341.8	0.011	0.244	12.4	119.304
Sec 14	675.6	0.014	0.252	32.5	426.892	354.2	0.011	0.244	12.5	121.133	354.2	0.011	0.244	12.5	121.162
Sec 15	707.8	0.014	0.253	31.9	421.361	366.8	0.011	0.244	12.7	122.975	366.9	0.011	0.244	12.7	123.004
Sec 16	739.5	0.014	0.254	31.6	418.389	379.6	0.011	0.244	12.9	124.801	379.7	0.011	0.244	12.9	124.829
Sec 17	771.0	0.014	0.255	31.3	416.605	392.6	0.011	0.245	13.1	126.613	392.6	0.011	0.245	13.1	126.641
Sec 18	802.1	0.014	0.256	30.9	412.125	405.7	0.011	0.245	13.1	127.434	405.7	0.011	0.245	13.1	127.455
Sec 19	832.7	0.014	0.257	30.5	408.410	418.9	0.011	0.245	13.3	129.118	418.9	0.011	0.245	13.3	129.142
Sec 20	863.1	0.014	0.258	30.2	406.677	432.3	0.011	0.246	13.4	130.866	432.3	0.011	0.246	13.5	130.889
Sec 21	893.1	0.014	0.259	29.9	403.204	445.8	0.011	0.246	13.6	132.551	445.8	0.011	0.246	13.6	132.574
Sec 22	922.7	0.014	0.260	29.3	396.925	459.5	0.011	0.246	13.7	134.040	459.5	0.011	0.246	13.7	134.061
Sec 23	951.9	0.014	0.261	29.0	394.019	473.2	0.011	0.247	13.8	134.653	473.3	0.011	0.247	13.8	134.674
Sec 24	980.4	0.014	0.261	28.1	383.069	486.8	0.011	0.247	13.4	130.904	486.9	0.011	0.247	13.4	130.923
				Total heat transfer (computed) [BTU/hr]	10376.71				Total heat transfer (computed) [BTU/hr]	2835.83				Total heat transfer (computed) [BTU/hr]	2836.34

HEAT LOSS FROM ASSEMBLY 1 to 2	
Heat transfer [BTU/hr]	0.58
Heat transfer [BTU/hr]	1.41
Heat transfer [BTU/hr]	2.31
Heat transfer [BTU/hr]	3.22
Heat transfer [BTU/hr]	4.15
Heat transfer [BTU/hr]	5.09
Heat transfer [BTU/hr]	6.03
Heat transfer [BTU/hr]	6.96
Heat transfer [BTU/hr]	7.90
Heat transfer [BTU/hr]	8.82
Heat transfer [BTU/hr]	9.74
Heat transfer [BTU/hr]	10.64
Heat transfer [BTU/hr]	11.52
Heat transfer [BTU/hr]	12.40
Heat transfer [BTU/hr]	13.26
Heat transfer [BTU/hr]	14.11
Heat transfer [BTU/hr]	14.95
Heat transfer [BTU/hr]	15.77
Heat transfer [BTU/hr]	16.58
Heat transfer [BTU/hr]	17.37
Heat transfer [BTU/hr]	18.16
Heat transfer [BTU/hr]	18.92
Heat transfer [BTU/hr]	19.68
Heat transfer [BTU/hr]	20.41
Heat loss to 50% of Assembly 2	259.96
Total heat loss (computed) [BTU/hr]	**519.92**

Table 5

Heat Balance			
	Assembly 1	Assembly 2	Assembly 3
Total heat generation [BTU/hr]	11454.0	2301.2	2301.2
Total heat loss to air [BTU/hr]	10376.7	2835.8	2836.3
Total heat loss/gain to other assemblies [BTU/hr]	1039.8	519.9	519.9
Heat unbalance [BTU/hr]	-37.5	14.7	15.2
Heat unbalance [%]	-0.3%	0.6%	0.7%

TEMPERATURE DISTRIBUTION SLAB 1											
	Assembly 1				Assembly 2				Assembly 3		
		Computed	COBRA	|Difference|		Computed	COBRA	|Difference|		Computed	COBRA	|Difference|
Sec 1	Slab average temp [°F]	213.8	229.5	15.8	Slab low temp [°F]	208.3	215.1	6.8	Slab high temp [°F]	219.5	231.8	12.3
Sec 2	Slab average temp [°F]	234.3	245.4	11.1	Slab low temp [°F]	220.9	227.0	6.1	Slab high temp [°F]	248.3	259.9	11.5
Sec 3	Slab average temp [°F]	256.4	266.4	10.0	Slab low temp [°F]	234.6	240.8	6.2	Slab high temp [°F]	279.2	290.5	11.4
Sec 4	Slab average temp [°F]	279.7	289.4	9.7	Slab low temp [°F]	249.2	255.6	6.4	Slab high temp [°F]	311.3	322.5	11.2
Sec 5	Slab average temp [°F]	303.9	313.5	9.6	Slab low temp [°F]	264.6	271.2	6.5	Slab high temp [°F]	344.3	355.4	11.1
Sec 6	Slab average temp [°F]	328.7	338.2	9.5	Slab low temp [°F]	280.6	287.2	6.6	Slab high temp [°F]	378.0	388.9	11.0
Sec 7	Slab average temp [°F]	353.9	363.2	9.3	Slab low temp [°F]	296.9	303.5	6.6	Slab high temp [°F]	412.0	422.8	10.8
Sec 8	Slab average temp [°F]	379.4	388.5	9.1	Slab low temp [°F]	313.6	320.1	6.6	Slab high temp [°F]	446.3	456.9	10.6
Sec 9	Slab average temp [°F]	405.0	413.8	8.8	Slab low temp [°F]	330.3	336.8	6.4	Slab high temp [°F]	480.6	491.0	10.4
Sec 10	Slab average temp [°F]	430.6	439.1	8.6	Slab low temp [°F]	347.2	353.5	6.3	Slab high temp [°F]	514.8	524.9	10.1
Sec 11	Slab average temp [°F]	456.1	464.4	8.3	Slab low temp [°F]	364.1	370.2	6.1	Slab high temp [°F]	548.9	558.7	9.8
Sec 12	Slab average temp [°F]	481.5	489.5	8.0	Slab low temp [°F]	381.0	386.9	5.9	Slab high temp [°F]	582.7	592.3	9.6
Sec 13	Slab average temp [°F]	506.8	514.5	7.7	Slab low temp [°F]	397.9	403.6	5.7	Slab high temp [°F]	616.3	625.6	9.2
Sec 14	Slab average temp [°F]	531.9	539.3	7.4	Slab low temp [°F]	414.7	420.3	5.5	Slab high temp [°F]	649.6	658.6	9.0
Sec 15	Slab average temp [°F]	556.8	563.9	7.1	Slab low temp [°F]	431.5	436.8	5.3	Slab high temp [°F]	682.6	691.3	8.7
Sec 16	Slab average temp [°F]	581.4	588.2	6.8	Slab low temp [°F]	448.1	453.2	5.1	Slab high temp [°F]	715.2	723.5	8.4
Sec 17	Slab average temp [°F]	605.9	612.4	6.5	Slab low temp [°F]	464.6	469.5	4.8	Slab high temp [°F]	747.5	755.6	8.1
Sec 18	Slab average temp [°F]	630.1	636.3	6.2	Slab low temp [°F]	481.1	485.7	4.6	Slab high temp [°F]	779.4	787.2	7.8
Sec 19	Slab average temp [°F]	654.0	660.0	5.9	Slab low temp [°F]	497.4	501.8	4.4	Slab high temp [°F]	811.0	818.5	7.5
Sec 20	Slab average temp [°F]	677.8	683.4	5.6	Slab low temp [°F]	513.6	517.8	4.2	Slab high temp [°F]	842.2	849.4	7.3
Sec 21	Slab average temp [°F]	701.2	706.5	5.3	Slab low temp [°F]	529.7	533.7	4.0	Slab high temp [°F]	873.0	880.0	7.0
Sec 22	Slab average temp [°F]	724.4	729.1	4.6	Slab low temp [°F]	545.6	549.3	3.7	Slab high temp [°F]	903.4	910.1	6.7
Sec 23	Slab average temp [°F]	747.2	750.2	3.0	Slab low temp [°F]	561.3	564.5	3.2	Slab high temp [°F]	933.3	939.6	6.3
Sec 24	Slab average temp [°F]	769.2	766.7	2.5	Slab low temp [°F]	576.3	578.4	2.0	Slab high temp [°F]	962.3	967.7	5.4

Table 6

Guessed

1	217.4	218.8	219.3	219.5	219.6	219.7	219.7	219.7	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	207.6	208.2	208.4	208.4	208.5	208.5	208.5	208.5
2	243.0	246.4	247.8	248.4	248.7	248.9	249.0	249.0	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	218.8	220.5	221.0	221.2	221.4	221.4	221.4	221.5
3	271.5	276.1	278.1	279.2	279.8	280.2	280.4	280.4	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	231.4	233.8	234.7	235.1	235.3	235.4	235.5	235.5
4	302.6	307.3	309.8	311.2	312.1	312.7	313.0	313.0	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	245.1	248.2	249.3	249.8	250.1	250.3	250.4	250.5
5	335.2	339.7	342.4	344.1	345.2	345.9	346.3	346.4	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	259.8	263.3	264.6	265.3	265.7	266.0	266.1	266.1
6	369.0	373.1	375.8	377.6	378.9	379.8	380.2	380.2	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	275.1	279.1	280.5	281.3	281.8	282.1	282.3	282.3
7	403.5	407.1	409.7	411.6	412.9	413.8	414.3	414.4	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	290.9	295.4	296.9	297.7	298.3	298.6	298.8	298.8
8	438.3	441.4	444.0	445.8	447.2	448.1	448.6	448.7	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	307.0	311.9	313.5	314.4	315.0	315.4	315.6	315.6
9	473.3	476.0	478.3	480.1	481.4	482.4	482.9	482.9	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	323.3	328.6	330.3	331.2	331.9	332.3	332.5	332.5
10	508.3	510.4	512.6	514.3	515.6	516.5	517.0	517.0	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	339.7	345.4	347.2	348.1	348.8	349.2	349.4	349.4
11	543.0	544.8	546.8	548.4	549.6	550.5	550.9	551.0	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	356.1	362.3	364.1	365.1	365.8	366.2	366.4	366.4
12	577.5	579.0	580.8	582.3	583.4	584.3	584.7	584.7	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	372.7	379.2	381.1	382.1	382.8	383.2	383.4	383.4
13	611.7	612.8	614.5	615.9	617.0	617.7	618.1	618.2	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	389.2	396.1	398.0	399.1	399.7	400.1	400.4	400.4
14	645.5	646.4	648.0	649.2	650.2	650.9	651.3	651.3	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	405.7	412.9	414.9	415.9	416.6	417.0	417.3	417.3
15	679.0	679.7	681.1	682.2	683.1	683.8	684.2	684.1	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	422.2	429.7	431.7	432.8	433.4	433.8	434.1	434.1
16	711.9	712.4	713.8	714.8	715.7	716.3	716.6	716.6	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	438.6	446.3	448.4	449.4	450.1	450.5	450.7	450.8
17	744.6	744.9	746.1	747.1	747.9	748.5	748.8	748.8	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	454.9	462.9	464.9	466.0	466.7	467.1	467.3	467.3
18	776.9	777.1	778.2	779.1	779.8	780.4	780.6	780.6	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	471.2	479.3	481.4	482.5	483.1	483.6	483.8	483.8
19	808.7	808.8	809.8	810.7	811.3	811.9	812.1	812.1	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	487.4	495.6	497.8	498.8	499.5	499.9	500.1	500.1
20	840.1	840.1	841.1	841.9	842.5	843.0	843.2	843.2	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	503.4	511.8	514.0	515.1	515.7	516.1	516.4	516.4
21	871.2	871.1	872.0	872.7	873.4	873.8	874.0	874.0	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	519.4	527.9	530.1	531.2	531.8	532.3	532.5	532.5
22	901.8	901.7	902.5	903.2	903.7	904.1	904.3	904.3	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	535.3	543.8	546.0	547.1	547.7	548.1	548.4	548.4
23	931.8	931.7	932.4	933.1	933.6	934.0	934.2	934.2	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	550.9	559.5	561.7	562.8	563.4	563.8	564.1	564.1
24	960.6	960.5	961.3	962.1	962.6	963.0	963.2	963.2	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	565.6	574.5	576.7	577.9	578.5	579.0	579.2	579.2

PASTE

Calculated

1	217.4	218.8	219.3	219.5	219.6	219.7	219.7	219.7	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	207.6	208.2	208.4	208.4	208.5	208.5	208.5	208.5
2	243.0	246.4	247.8	248.4	248.7	248.9	249.0	249.0	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	218.8	220.5	221.0	221.2	221.4	221.4	221.4	221.5
3	271.5	276.1	278.1	279.2	279.8	280.2	280.4	280.4	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	231.4	233.8	234.7	235.1	235.3	235.4	235.5	235.5
4	302.6	307.3	309.8	311.2	312.1	312.7	313.0	313.0	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	245.1	248.2	249.3	249.8	250.1	250.3	250.4	250.5
5	335.2	339.7	342.4	344.1	345.2	345.9	346.3	346.4	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	259.8	263.3	264.6	265.3	265.7	266.0	266.1	266.1
6	369.0	373.1	375.8	377.6	378.9	379.8	380.2	380.2	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	275.1	279.1	280.5	281.3	281.8	282.1	282.3	282.3
7	403.5	407.1	409.7	411.6	412.9	413.8	414.3	414.4	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	290.9	295.4	296.9	297.7	298.3	298.6	298.8	298.8
8	438.3	441.4	444.0	445.8	447.2	448.1	448.6	448.7	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	307.0	311.9	313.5	314.4	315.0	315.4	315.6	315.6
9	473.3	476.0	478.3	480.1	481.4	482.4	482.9	482.9	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	323.3	328.6	330.3	331.2	331.9	332.3	332.5	332.5
10	508.3	510.4	512.6	514.3	515.6	516.5	517.0	517.0	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	339.7	345.4	347.2	348.1	348.8	349.2	349.4	349.4
11	543.0	544.8	546.8	548.4	549.6	550.5	550.9	551.0	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	356.1	362.3	364.1	365.1	365.8	366.2	366.4	366.4
12	577.5	579.0	580.8	582.3	583.4	584.3	584.7	584.7	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	372.7	379.2	381.1	382.1	382.8	383.2	383.4	383.4
13	611.7	612.8	614.5	615.9	617.0	617.7	618.1	618.2	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	389.2	396.1	398.0	399.1	399.7	400.1	400.4	400.4
14	645.5	646.4	648.0	649.2	650.2	650.9	651.3	651.3	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	405.7	412.9	414.9	415.9	416.6	417.0	417.3	417.3
15	679.0	679.7	681.1	682.2	683.1	683.8	684.2	684.1	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	422.2	429.7	431.7	432.8	433.4	433.8	434.1	434.1
16	711.9	712.4	713.8	714.8	715.7	716.3	716.6	716.6	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	438.6	446.3	448.4	449.4	450.1	450.5	450.7	450.8
17	744.6	744.9	746.1	747.1	747.9	748.5	748.8	748.8	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	454.9	462.9	464.9	466.0	466.7	467.1	467.3	467.3
18	776.9	777.1	778.2	779.1	779.8	780.4	780.6	780.6	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	471.2	479.3	481.4	482.5	483.1	483.6	483.8	483.8
19	808.7	808.8	809.8	810.7	811.3	811.9	812.1	812.1	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	487.4	495.6	497.8	498.8	499.5	499.9	500.1	500.1
20	840.1	840.1	841.1	841.9	842.5	843.0	843.2	843.2	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	503.4	511.8	514.0	515.1	515.7	516.1	516.4	516.4
21	871.2	871.1	872.0	872.7	873.4	873.8	874.0	874.0	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	519.4	527.9	530.1	531.2	531.8	532.3	532.5	532.5
22	901.8	901.7	902.5	903.2	903.7	904.1	904.3	904.3	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	535.3	543.8	546.0	547.1	547.7	548.1	548.4	548.4
23	931.8	931.7	932.4	933.1	933.6	934.0	934.2	934.2	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	550.9	559.5	561.7	562.8	563.4	563.8	564.1	564.1
24	960.6	960.5	961.3	962.1	962.6	963.0	963.2	963.2	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	565.6	574.5	576.7	577.9	578.5	579.0	579.2	579.2

COPY

6. Results

As seen in Table 5, the total heat generated in Assembly 1 is equal to 11,454 BTU/hr with 10,376.7 BTU/hr removed by the air and 1,039.8 BTU/hr transferred to Assemblies 2 and 3. The total error on the heat balance for Assembly 1 is 0.3%. The total heat generated in Assembly 2 is equal to 2,301.2 BTU/hr and the heat gained from Assembly 1 is equal to 519.9 BTU/hr, for a total of 2,835.8 BTU/hr removed by the air. The total error on the heat balance for Assembly 2 is 0.6%. The total heat generated in Assembly 3 is equal to 2,301.2 BTU/hr and the heat gained from Assembly 1 is equal to 519.9 BTU/hr, for a total of 2,836.3 BTU/hr removed by the air. The total error on the heat balance for Assembly 3 is 0.7%. The total error on the heat balances for Assemblies 1, 2 and 3 is negligible and it is due to the simplification to the computations performed in this attachment as discussed in Section 3. The surface temperatures of Slab 1 calculated in this attachment and computed by COBRA are also in good agreement.

7. Conclusions

The heat transfer from the high to the low heat generation assemblies analyzed in this attachment matches the COBRA output within 1%.

8. References

A15-1. Frank Kreith, Principles of Heat Transfer, 3rd Ed, 1976, IEP, New York, NY

A15-2. Document No. PNL-10782, "COBRA-SFS: A Thermal-Hydraulic Analysis Code for Spent Fuel Storage And Transportation Casks," Prepared for the US DOE by Pacific Northwest Laboratory, September 1995

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Dominion®

Engineering Technical Evaluation Cover Sheet and Body

1. Document Number:	2. Revision Number:	3. Decomm?
ETE-KW-2013-0025	0	☒Yes ☐No

4. Title:
Ventilation Flow Rate Input for S&L Calc 2013-11284 "Maximum Cladding and Fuel Temperature Analysis for Uncovered Spent Fuel Pool". Rev 0

5. ETE Level:	6. Unit(s):	7. Quality Classification:	8. FSRC Approval:
☒Level 1 ☐Level 2	☒Unit 1 ☐ISFSI	☐SR ☐NS ☒NSQ	☐Yes ☒No

9. *Preparation, Review, and Approval Signatures (add or delete rows as needed)*

Prepared by/Affiliation: (Print) Brian D. O'Connell / ENG	Signature:	Date: 11/4/13
Reviewed by/Affiliation: (Print) John P. Schroeder / Engineering	Signature:	Date: 11/4/13
Program/Other Reviewer/Affiliation: (Print) NA	Signature:	Date:
Supervisor Approval/Affiliation: (Print) Dwight Varpaan / SYSTEM ENG. SUPV.	Signature:	Date: 11/4/13
FSRC Approval/Site: (Print) NA	Signature:	Date:

Standard Attachments	Attachment	# of pages	Reviewed/No Impact	Not Req.
10. Design Inputs (CM-KW-DDC-401)			☐	☒
11. Plant Impact List (CM-KW-PIL-101)				☒

12. Considerations and Conditions for Document Updates (check ☒N/A if no document updates are needed.)
☐ All Document updates noted on the Plant Impact List can be initiated immediately
☐ Document updates noted on Plant Impact List are delayed until the following documents/actions are completed (e.g., WO, CR, etc.) (See Plant Impact List Remarks section.)

10 CFR 50.59 Attachments	Attachment	# of pages	Not Req.
13. 10 CFR 50.59/72.48 applicability review forms (CM-KW-400)			☒
14. 10 CFR 50.59/72.48 screen form (CM-KW-400)			☒
15. 10 CFR 50.59/72.48 evaluation form (CM-KW-400)			☒

16. ***Additional Attachments***

Attachment	# of pages	Description

17. ***Distribution***			
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☐	Reviewer	☐	
☐	Supervisor	☐	
☐	Affected Organization	☐	
☐	Program Owners	☐	
☐	System Engineer	☐	

1. Source Document: Information request for Sargent & Lundy Calculation Number 2013-11284 "Maximum Cladding and Fuel Temperature Analysis for Uncovered Spent Fuel Pool" Rev 0.

2. Record of Revision: Original Issue

3. Purpose: This ETE shall document the Auxiliary Building Ventilation System alignment and flow rates for input into the Spent fuel Pool Area to provide Design Input for Sargent & Lundy Calculation Number 2013-11284 "Maximum Cladding and Fuel Temperature Analysis for Uncovered Spent Fuel Pool" Rev 0.

   The ETE shall also document the color of the walls and ceiling of the Auxiliary Building Spent Fuel Pool Area to be used as an input for Sargent & Lundy Calculation Number 2013-11284.

4. Design Inputs and Assumptions:

   4.1 One train of Auxiliary Building Ventilation is operating with One Auxiliary Building Exhaust Fan and one Spent Fuel Pool (SFP) Exhaust Fan operating.
   4.2 The airflow rates on Ref 11.1 are for both trains of fans operating. The Auxiliary Building Exhaust flow rates are assumed to be ½ the indicated flow due to single fan operation. This is conservative as the system resistance will drop increasing the flow of the single fan.
   4.3 The Auxiliary Building Supply Fans are off so the Auxiliary Building Exhaust Fan that is operating will draw air over the pool from doors 85 and 87 the Auxiliary Building Loading Dock Overhead Doors (17' wide by 22' high). Ref 11.11, Ref 11.12
   4.4 R13 and R14 trip functions of Auxiliary Building Ventilation system has been disabled or shown that a loss of all pool water would not result in a trip of R13 or R14.
   4.5 SFP Exhaust Fan A or B – 9000cfm, Ref 11.1
   4.6 Aux Building Exhaust Fan A and B – 72,250cfm, Ref 11.1, and it is assumed then that one fan is 36,125cfm

5. Methodology:

   One train of Auxiliary Building Exhaust Fans and Spent Fuel pool Exhaust Fans shall be utilized to provide ventilation in the area of the Spent Fuel Pool. The Auxiliary Building supply fans will be secured and the Auxiliary Building Loading Dock Over Head Rollup Doors West of the SFP will be opened so outside air is drawn across the top of the pool. Doors between the SFP area and the Zone SV area will be opened to transfer air to the Zone SV area and to the operating Auxiliary Building Exhaust Fan.

   The air for the SFP Exhaust is drawn from the over head doors to the top of the pool where the exhaust registers are located.

6. Discussion:

   The Sargent & Lundy Calculation Number 2013-11284 "Maximum Cladding and Fuel Temperature Analysis for Uncovered Spent Fuel Pool" needs to maximize the ventilation flow

rate at the top of the pool to limit the maximum cladding and fuel temperatures. This ETE shall establish the required ventilation lineup and the flow rate to be used in the calculation.

The Auxiliary Building Supply Fans will be secured and the Auxiliary Building Loading dock doors opened to maximize the outside air that is drawn across the pool for cooling. There are two sets of fans (Auxiliary Building Exhaust and SFP Exhaust) that will draw air from the loading dock overhead doors to the top of the pool:

- The Spent Fuel Pool Exhaust Fans draw air from the top of the pool on the west side. This is the only location the fans draw from so all the flow from one fan can be counted for SFP cooling. (Ref 11.3)

- The Auxiliary Building Exhaust Fans draw air from various areas that do not directly communicate with the SFP area (Ref 11.4, 11.5, 11.6). To maximize flow across the SFP, the loading dock doors shall be opened and the Auxiliary Building Supply Fans secured in the event of loss of SFP water. The shutdown of the supply fans results in the makeup air for the operating SFP Exhaust Fan and Auxiliary Building Exhaust Fan to be drawn through the loading dock overhead doors to the top of the SFP.

6.1 One Aux Building Exhaust Fan is 36,125cfm of airflow. Determine how much of this airflow will be drawn across the pool for cooling flow. The Aux Building Exhaust Fans draw from three separate areas.

- Various areas (vaults, penetration areas etc) from the Non Zone SV area by the SFP
- The Zone SV portion of the Auxiliary Building
- Areas of the Auxiliary Building served by the Auxiliary Building Air Conditioning System (ACC)

6.1.1 Determine flow from Non SV area that can be credited for cooling by the SFP.

Per Ref 11.1 there is 16,450cfm of ducted exhaust flow from the SFP area below the top of the pool. Single fan operation would result in an Exhaust flow of 8,225cfm. During normal operation these areas have supply ventilation so they would not draw air over the top of the SFP. The supply fan will be off so makeup air will be drawn from the open loading dock overhead doors.

The following areas are served by the Aux Building Exhaust Fans: Decon Room, Decontaminated storage room, Penetration area west of SFP elev 608' and 618', Waste Evaporator, Storage Area, Waste Concentrates holdup tank vault, Spent Resin Tank Storage Vault, Waste metering Tank Vault, Concentrates pumps tanks vaults and Drumming station.

Based on the location of the Decon Room and Decon storage room exhaust will draw makeup air from the overhead doors west to east over the pool to elevation 626' (725cfm). Ref 11.4

Based on the location of penetration area, storage area, Concentrates pumps tanks vault and drumming room exhaust will draw makeup air from the loading dock doors to the top of the pool and the air will travel down stairwell K on the South end of the pool elevation to the various exhaust registers in these rooms (6500cfm). (Ref 11.1, 11.5, 11.6, 11.8)

The waste evaporator room draws 500cfm of exhaust. This room is enclosed with a supply duct for makeup air. There is no makeup path with the supply fan off so 0 cfm is counted in the SFP area (Non SV area). The Auxiliary Building Exhaust Fan will try to draw this air from somewhere. The 500cfm will be counted to be pulled from the Exhaust ductwork located within the Zone SV area as this ductwork is at only ½ capacity with one fan operating and will easily handle an additional 500cfm.

The flow from the Waste metering Room, Spent Resin Storage Vault, and Waste Holdup Tank is not counted (500cfm). These areas are directly below the loading dock. There is an unsealed pipe penetration between this area and the loading dock area that allows air to bypass going over the SFP.

Therefore;

725cfm comes in the overhead doors and travels west to east over the pool.

6500cfm comes in through the overhead doors and travels over the pool and down the stairwell on the south end

6.1.2 Determine Flow from Zone SV Area that can be credited for the top of SFP area cooling.

One Aux Building Exhaust fan draws 36,125cfm of flow.

Flow from Zone SV = one fan flow (36,125cfm) – flow from non SV areas

Non SV area flow equals flow from above plus flow from the Auxiliary Building Air conditioning (ACC) System that exhaust to the Aux Building Exhaust System and doesn't communicate with the SFP area so is not counted for cooling.

Exhaust flow from above 725cfm + 6500cfm + 0cfm + 500cfm = 7725cfm

Exhaust flow from the ACC system from Ref 11.1 is the following:

700cfm RPO + 3000cfm Hot Labs filter exhaust + 2800cfm Hot Lab and Counting room + 3250cfm Hot instrument lab = 9750cfm of flow which cannot be counted for SFP cooling.

So Exhaust flow from Zone SV area = 36,125cfm – (7725cfm + 9750cfm) = 18,650cfm

The following doors shall be opened to transfer air from the overhead doors over the pool and to the Zone SV area. There is also a supply duct connecting the two areas that will be open and idle with the supply fan off will which allow flow to transfer between the areas. DCR DC-KW-13-2001 Damper Gagging shall gag open the Zone SV dampers between the SFP area and the Zone SV area. The flow through these openings is assumed to be pulled through at equal flow velocity so the flow will divide evenly based on the size of the opening or smallest door in the path.

Door-13, 586' elev. Ref 11.7. The flow from outside will enter through the loading dock overhead doors up to the pool elevation and then down stairwell K at the top south end of the pool (Ref 11.10) and work its way to Door 13 through the open connected areas to this door.

Doors 187 and 134 626' elev. Ref 11.8. The flow from outside will enter through the loading dock overhead doors up to the pool elevation and head West to East over the pool through the basketball court area to the interlocked doors.

Doors 151, 199, and 144, 642' elev. Ref 11.9. The flow from outside will enter through the loading dock overhead doors up to the pool elevation and head West to East over the pool through the basketball court area to the interlocked doors.

Air will also transfer through the supply ducts on the Basketball court to the Zone SV area Ref 11.3

Each flow opening with doors has at least one door with a minimum size 7' x 3' or 21sqft ref (Door schedule Ref 11.11).

The supply duct branch interconnecting the areas has a minimum size of 34" x 28" or 6.6sqft. Ref 11.3

Total flow area between Zone SV and the SFP area is 21sqft + 21sqft +21sqft + 6.6sqft = 69.61sqft

Determine flow velocity through the openings

Volumetric flow (cfm) = (Flow Velocity) (fpm) x Area (sqft)

Solve for Flow velocity = Volumetric flow/Area

Flow Velocity = 18,650cfm/69.61sqft = 268fpm

Determine flow through each opening

Door-13, 21sqft x 268fpm = 5628cfm Over pool down south end

Doors 187 and 134, 21sqft x 268fpm = 5628cfm Over pool West to East

Doors 151, 199, and 144, 21sqft x 268fpm = 5628cfm Over Pool West to East

Supply duct 18,650cfm – (5628 x 3) = 1766cfm Over Pool West to East

6.1.3 Determine the total airflow rates and the flow paths over the SFP

Flow that enters through the overhead doors travels over the pool and down the south end of the pool = 6500cfm + 5628cfm = 12,128cfm

Flow that enters the overhead doors travels West to East over the pool across the basket ball court through doors or ductwork to Zone SV 5628cfm + 5628cfm + 1766cfm + 725cfm= 13,747cfm

Flow that enters through the overhead doors and is exhausted from the top of the pool on the West side from the SFP exhaust fans = 9000cfm

Total flow = 12,128cfm + 13,747cfm + 9000cfm = 34,875cfm

6.2 Evaluate the affect of flow for the Aux Building Exhaust fan due to no supply flow and drawing air through doors and idle ductwork.

A qualitative review is performed to show that the flow rates developed herein are conservative. The increased flow resistance due to flow through doors and idle ductwork for makeup air is less than the drop in flow resistance in the Aux Exhaust ductwork that is operating with only a single train in operation.

The air flow rates as shown on Ref 11.1 are based on two Aux Building Supply and Exhaust Fans operating. The system configuration for the loss of all water to the spent fuel pool will be one SFP Exhaust Fan and one Aux Building Exhaust Fan operating. The flow rates from Ref 11.1 are based on two train operation. The two trains share common ductwork so the flow resistances are increased with both trains in operation. The individual fans will draw more air with only a single train in operation. The flow rate is 72,250cfm with both trains of Aux Building Exhaust operating. It was assumed one Aux Exhaust Fan would draw 36,125cfm when operating alone.

The flow velocity in the main ductwork exhaust trunks is 3000fpm with both Aux Building Exhaust fans operating. This drops to 1500fpm with a single fan operating.

The flow velocity through the open doors or transfer ductwork is 268fpm.

Pressure drop is exponentially proportional to flow velocity (Ref 11.12) so the change in pressure for going from two fans to one fan will exceed change in pressure from drawing through doors. This will result in fan flow increase from what is indicated on Ref 11.1. So the flow assumption of 36,125cfm with no Aux Supply Fans operating and Zone SV boundary doors open to allow makeup air to be drawn in through the Aux Building loading dock doors is conservative.

7. Conclusion:

34,875cfm total outside air will be drawn to the top of the Spent Fuel Pool.

12,128cfm of the total flow that enters through the overhead doors travels over the pool and down the south end of the pool through stairwell K.

13,747cfm of the total flow that enters the overhead doors travels west to East over the pool across the basket ball court through doors or ductwork to Zone SV and then is drawn into the Aux Building Exhaust ductwork.

9000cfm of the total Flow enters through the overhead doors and is exhausted from the top of the pool on the West side from the SFP exhaust fan.

The system alignment is as follows:

One Aux Building Exhaust Fan and One SFP Exhaust Fan Operating

Both Aux Building Supply Fans have been secured

The following doors are open, Door-13, Door 134, Door 187, Door-144, Door-151, Door-199 and overhead doors 85 and 87 on the Aux Building loading dock.

R13 and R14 trip functions of Auxiliary Building Ventilation system has been disabled or shown that a loss of all pool water would not result in a trip of R13 or R14.

Zone SV Dampers (ASV-20 and ASV-40) are gagged open per DCR DC-KW-13-2001 Damper Gagging

A walk down of the Inside and outside of the SFP area was performed to determine wall colors to be used as input for the Sargent & Lundy Calculation Number 2013-11284.

Inside Walls – off white
Outside walls – white/off white
Ceiling – off white

8. Precautions or Limitations: NONE

9. Required Actions: NONE

10. Recommendations: NONE

11. References:

11.1 OPERM-601 Rev DK, Flow Diagram Turbine and Aux Building Ventilation
11.2 M-626 Rev B, Ventilation – Aux Building elevation 649'
11.3 M-627 Rev AK, Ventilation – Aux Building elevation 657'
11.4 M-629 Rev AS, Ventilation – Aux Building elevation 626'

11.5 M-631 Rev E, Ventilation – Aux Building elevation 606' & 618'
11.6 M-633 Rev L, Ventilation – Aux Building elevation 586'
11.7 A-204 Rev BS, General Arrangement Reactor and Aux Building Basement Floor
11.8 A-208 Rev BY, General Arrangement Reactor and Aux Building
11.9 A-209 Rev AB, General Arrangement Reactor and Aux Building Misc Floor Plans
11.10 A-212 Rev Z, General Arrangement Reactor and Aux Building misc plans and sections
11.11 Door schedule drawings A-586-1-1 Rev K, A-586-2-1 Rev D, A-586-2-3 Rev G, A-586-3-1 Rev G, A-586-3-3 Rev B
11.12 ASHRAE 1981 Fundamentals Chapter 33 Fig C-1 Friction Chart for Average ducts.
11.13 A-206 Rev CC, General Arrangement Reactor and Auxiliary Building Mezzanine Floor

1. Stations:	2. Doc Type:	3. Sub Type:	4. Document Number:	5. Rev.:	6. Add:	7. Decomm?
☐MP ☐SU ☐NA ☒KW ☐CO Note: If both SU and NA, then check CO	ETE	000	ETE-NAF-2013-0077	0	0	☒Yes ☐No

8. Title:
Information for Kewaunee Spent Fuel Pool Postulated Loss of Inventory Calculation

9. ETE Level:	10. Unit(s):	11. Quality Classification:	12. FSRC Approval:
☒Level 1 ☐Level 2	☒Unit 1 ☐Unit 2 ☐Unit 3 ☐ISFSI	☐SR ☐NS ☒NSQ	☐Yes ☒No

13. *Preparation, Review, and Approval Signatures (add or delete rows as needed)*

Prepared by/Affiliation: (Print) M. S. Lico / NAF & J. F. Helfenberger / KPS Reactor Engineering	Signature: for J. Helfenberger per telecon	Date: 7/10/13 7/10/13
Reviewed by/Affiliation: (Print) C. D. Clemens / NAF	Signature:	Date: 7/10/13
Program/Other Reviewer/Affiliation: (Print) N/A	Signature:	Date:
Supervisor Approval/Affiliation: (Print) W. J. Eakin / Supervisor Containment and Radiological Analysis	Signature: for W. Eakin per telecon	Date: 7/10/13
Design Control Engineer (DCE) Approval/Site: (Print) N/A	Signature:	Date:
FSRC Approval/Site: (Print) N/A	Signature:	Date:

Standard Attachments	Attachment	# of pages	Reviewed/No Impact	Not Req.
14. Design Effects and Considerations (DNES-AA-GN-1003)			☐	☒
15. Document Impact Summary (DRUL) (DNES-AA-GN-1002)				☒

16. Considerations and Conditions for Document Updates (check ☒N/A if no document updates are noted on the DRUL)
☐ All Document updates noted on the DRUL can be initiated immediately
☐ Document updates noted on DRUL are delayed until the following documents/actions are completed (e.g., WO, CR, etc.) (See DRUL Remarks section)

10CFR50.59 Attachments	Attachment	# of pages	Not Req.
17. 10CFR50.59/72.48 applicability review forms (CM AA-400)			☒
18. 10CFR50.59/72.48 screen form (CM-AA-400)			☒
19. 10CFR50.59/72.48 evaluation form (CM-AA-400)			☒

20. *Additional Attachments*

Attachment	# of pages	Description
1	2	Fuel Building Heat Sources and Ventilation Capacity
2	5	Spent Fuel Pool Heat Load after Final Shutdown (Whole Pool)
3	4	Spent Fuel Pool Heat Load after Final Shutdown (Cycle 32 Discharge and Hottest Assemblies)
4	60	Spent Fuel Pool Heat Load after Final Shutdown Documentation (per KPS Reactor Engineering Procedure ER-AA-RXE-103)

21. *Distribution*

Primary Recipient(s): R. D. Gerke (Sargent & Lundy)
(Enter Name/Dept. or Location for EACH Primary Recipient in this block.)

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☒	Preparer – M. S. Lico	☒	J. E. Kloecker / NDES
☒	Preparer – J. F. Helfenberger / KPS Rx Engineering	☒	Nuclear Document Management
☒	Reviewer – C. D. Clemens	☒	B. J. Vitiello / NAF
☒	Supervisor – W. J. Eakin	☐	
☒	T. A. Brookmire / NAF	☐	
☒	J. R. Harrell / NAF	☐	

Table of Contents

N/A

Source Document

1. Task Release Traveler # 70157979 "Analysis for a Postulated Spent Fuel Pool Zirconium Fire at the Kewaunee Power Station," June 2013.

Record of Revision

Original Issue

Purpose

This Engineering Technical Evaluation (ETE) provides the following information to Sargent and Lundy (S & L) to support their analysis of the unlikely postulated event of a spent fuel pool (SFP) zirconium fire caused by a loss of SFP inventory at the Kewaunee Power Station (KPS) (Source Document 1):

- fuel assembly loss coefficient
- fuel building heat sources and ventilation capacity
- SFP heat load after final shutdown of KPS (whole pool and hottest assembly).

This ETE only provides information and inputs needed by S & L to perform their analysis per Source Document 1; this information and these inputs will not be used for design changes or to modify controlled documents or programs. In addition, the S & L analysis will be Nonsafety-related and will be performed to their quality program. Thus, this ETE is considered to be Level 1 per CM-AA-ETE-101 Step 2.3.i, and a Design Effects and Consideration review, DRUL, and 10 CFR 50.59 review are not required.

Design Inputs and Assumptions

The design inputs and assumptions below will support S & L's estimates of the heat sources/sinks to consider when determining the SFP heatup rates under the postulated scenarios in Source Document 1.

Design inputs and assumptions come from the following sources:

- fuel assembly form loss coefficient (Reference A)
- fuel building heat sources and ventilation capacity (Attachment 1)
- SFP heat load after final shutdown of KPS (whole pool) (Attachment 4).

The SFP heat load after final shutdown of KPS (hottest assembly) design inputs and assumptions follow:

- The hottest fuel assembly estimate is derived from the peak assembly power taken from the final flux map performed for Cycle 32. The peak assembly's power was 1.449 times the average assembly (Reference B).
- The "Hottest Fuel Assembly" heat load is conservatively assumed to be 1.449 times the average fuel assembly heat load for Cycle 32 (Attachment 4).

Methodology

The methodologies used for the fuel assembly fuel loss coefficient are described in Reference A. The methodologies used for the fuel building and ventilation data are described in Attachment 1. The methodologies used for the SFP heat load estimate are described in Attachment 4.

The SFP heat load methodologies are considered conservative for calculating spent fuel assembly heat loads (Attachment 4).

Discussion

This ETE only provides data needed by S & L to perform their KPS SFP calculation per Source Document 1. (Per Source Document 1 S & L will perform the work as Nonsafety-related to their quality program).

Following is a discussion of each category:

<u>Fuel Assembly Form Loss Coefficient</u>

A fuel assembly form loss coefficient of **30** was calculated for a Reynolds number of 100. This number was conservatively rounded up by approximately 20 percent in order to account for the differences between laminar and turbulent flow (Reference A). Also, per Reference A and as discussed with S & L, this value does not include rod friction. S & L will calculate rod friction.

<u>Fuel Building Heat Sources and Ventilation Capacity</u>

The fuel building heat sources and ventilation capacity information, including the associated references, are contained in Attachment 1.

SFP Heat Load after Final Shutdown of KPS (Whole Pool and Hottest Assembly)

This data is provided in Attachments 2 and 3. It is taken directly from Attachment 4.

Attachment 2 contains the "Total SFP Heat Load." Attachment 3 contains the "Heat Load from Cycle 32 Discharge Assemblies Only" and the "Hottest Fuel Assembly [Heat Load] Estimate."

Cumulative Effects Review

This ETE provides certain data to S & L for the analysis described in Source Document 1. S & L's analysis will be Nonsafety-related and the results will be used for information, and not for design related purposes.

Thus, there are no cumulative effects associated with the information in this ETE.

Conclusions

This ETE provides certain data that S & L requested to support their analysis of the unlikely postulated event of a SFP zirconium fire caused by a loss of SFP inventory (Source Document 1). The information provided in this ETE includes:

- fuel assembly loss coefficient
- fuel building heat sources and ventilation capacity
- SFP heat load after final shutdown of KPS (whole pool and hottest assembly).

This ETE also documents how the above information was obtained. S & L will use it for their analysis, which is Nonsafety-related and will be performed to S & L's quality program.

Precautions and Limitations

NONE

Required Actions

NONE

Recommendations

NONE

References

NOTE: References to support the fuel building heat sources and ventilation capacity are listed in Attachment 1.

A. NAF Calculation SM-1669, Revision 0, "Kewaunee Fuel Assembly Form Loss Coefficients to use in a Spent Fuel Pool Zirc Fire Analysis," B. Vitiello, July 2013.
B. KPS Flux Map KPS-Report-IFM-FLUX MAP 3217, April 2013.

Attachment 1
Fuel Building Heat Sources and Ventilation Capacity
(Page 1 of 2)

NOTE: S & L is asked to assume that KPS personnel will open fuel building doors in the case of a loss of fuel pool inventory. Thus, even if the SFP exhaust fans fail, the fuel building will still be able to exhaust 9,000 cfm through the open doors with the supply fan in service (see page 2 of this attachment).

Spent Fuel Pool (SFP) Supply Fan [from KW-Manual-000-SD-17, "Auxiliary Building Ventilation System (ACA)" (Reference 3)]

The SFP Supply Fan is located in the Aux. Bldg. on the 626'-0" level. The SFP Supply Fan draws air from the Auxiliary Building operating floor and blows air across the SFP toward the exhaust registers. This airflow pattern permits most of the vapor emanating from the SFP to be entrained in the airflow and removed by the SFP exhaust fans. Maximum bulk air temperature in the Auxiliary Building is 120 F (normal condition).

Tech Manual	XK-141422-4
Fan Type	Vane Axial, Direct Motor Driven, Manually Adjustable-Pitch Fan Blades
Fan Capacity	12,000 cfm with 1.2 "wg SP
Fan Speed	860 RPM
Motor Power	5 hp
Electrical Characteristics	460VAC, 60 Hz, 3 phase
Powered from	MCC 1-35D

Design Ambient Conditions:

Indoor Normal and Accident Design Basis Environmental Service Conditions (ESC) at the Kewaunee Power Station for all areas are tabulated in tables contained in Reference 4.

Winter Outdoor Design Criteria (Dry Bulb Temp °F): -15.0°F
Summer Outdoor Design Criteria (Dry Bulb Temp °F): 95.0°F

The above climatic design criteria for Kewaunee Power Station are documented in Reference 5.

Additional Heat Source in SFP Area

Lighting: 60,000 Btu/hr [Maximum for Auxiliary Bldg Mezzanine area (Reference 6)

Reference 3 KW Manual 000-SD-17, "Auxiliary Building Ventilation System (ACA)"

Reference 4 Kewaunee Environmental Qualification Plan

Reference 5 Pioneer Service & Engineering Company Project Design Manual, Section 4, Ventilation System Design Data

Reference 6 Calculation M-1052-1, Rev 3, Auxiliary Building Safety Related Equipment Area Inputs for Transient Analysis

Attachment 1
Fuel Building Heat Sources and Ventilation Capacity
(Page 2 of 2)

Fuel Building Airflow During Postulated Loss of Inventory in Spent Fuel Pool

The airflow from the Spent Fuel Pool (SFP) area to the outside atmosphere though a door is estimated in support of ETE-NAF-2013 0077, Data for Kewaunee SFP Postulated Loss of Inventory Calculation. The loss of inventory calculation (developed by Sargent and Lundy) will assume the SFP supply fan is operating; however, the SFP exhaust fans and dampers will not be credited (fans off, dampers closed; since open dampers would result in additional flow, this is a conservative assumption). Instead, the calculation will assume an open door for a flowpath to the outside atmosphere. The flowrate (cfm) will be estimated using the orifice equation for compressible fluid.

From Reference 1, the flow through an orifice is given by :

$$W = 1891 * Y * (d_1)^2 * C * (\Delta P/V)^{1/2} \text{ lb/hr}$$

Y = Net Expansion Factor, dimensionless

d_1 = Orifice diameter, inches

C = Flow coefficient for square-edge orifice, dimensionless

ΔP = Pressure drop across the orifice, psi

V = Specific volume of fluid, ft^3/lb

For flow in cfm, the above equation is multiplied by : 16.5 ft^3/lb * 1 hr/60 minutes

Assumptions :

For a low pressure ratio ($\Delta P/P_1$), the net expansion factor, Y, is essentially 1 (Table on pg A-21 of Reference 1). As noted below, the ΔP is assumed to be a small number to minimize the calculated flow. For this estimate of flow, the net expansion factor is conservatively assumed to be 0.9.

For a low diameter ratio (d_1/d_2), the flow coefficient, C, is 0.6. This is the lowest value from the table on pg A-20 of Reference 1. The diameter ratio is assumed to be a small number to minimize the calculated flow

The door is assumed to be a 7'x3' door (21 ft^2 area). The diameter of a circle with that area is 62 inches. This is a conservative assumption, since all other doors (double-door or rolling door) would provide a larger area.

For conservatism, the ΔP assumed across the door is 0.1 "wg (0.00361 psi). As noted on page 1 of this Attachment, the static pressure capability of the supply fan is 1.2 "wg at 12,000 cfm.

The air temperature in the SFP area is assumed to be at the maximum allowable supply temperature in the Auxiliary Building (120 F). The specific volume of saturated air at 120 F is 16.5 ft^3/lb (Reference 2).

The estimated flow through the door is :

$$(1891 * 0.9 * (62)^2 * 0.6 * (0.00361 /16.5)^{1/2}) * 16.5 \text{ ft}^3/\text{lb} * 1 \text{ hr/60 minutes} = \underline{\mathbf{16{,}000 \text{ cfm}}}$$

The flow assumed by Sargent and Lundy (9,000 cfm) is well below the expected flow with a door open and the supply fan operating.

Reference 1 Crane Technical Paper 410, 1991 Edition

Reference 2 Fan Engineering, 7th Edition

Preparer: J. E. Kloecker 7/9/13 Review: R. T. Jacobus 7/9/2013

J. E. Kloecker R. T. Jacobus

Run date and time: various				SFP Initial Water Temp = 80 F SFP Initial Air Temp = 80 F		
Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	TOTAL Spent Fuel Pool Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
5/8/13 0:00	34.88		34.88	13.21	10.61	
5/8/13 8:00	30.85		30.85	11.69	9.38	13
5/8/13 16:00	29.24		29.24	11.08	8.89	13
5/9/13 0:00	28.01		28.01	10.61	8.52	14
5/9/13 8:00	26.98		26.98	10.22	8.21	15
5/9/13 16:00	26.07		26.07	9.87	7.93	15
5/10/13 0:00	25.24		25.24	9.56	7.68	16
5/10/13 8:00	24.48		24.48	9.27	7.44	16
5/10/13 16:00	23.77		23.77	9.01	7.23	17
5/11/13 0:00	23.12		23.12	8.76	7.03	17
5/11/13 8:00	22.51		22.51	8.53	6.85	18
5/11/13 16:00	21.95		21.95	8.31	6.68	18
5/12/13 0:00	21.43		21.43	8.12	6.52	18
5/13/13 0:00	20.05		20.05	7.60	6.10	20
5/14/13 0:00	18.91		18.91	7.16	5.75	21
5/15/13 0:00	17.95		17.95	6.80	5.46	22
5/16/13 0:00	17.13		17.13	6.49	5.21	23
5/17/13 0:00	16.42		16.42	6.22	4.99	24
5/18/13 0:00	15.80		15.80	5.98	4.80	25
5/19/13 0:00	15.25		15.25	5.78	4.64	26
5/20/13 0:00	14.76		14.76	5.59	4.49	27
5/21/13 0:00	14.33		14.33	5.43	4.36	28
5/22/13 0:00	13.94		13.94	5.28	4.24	28
5/23/13 0:00	13.58		13.58	5.15	4.13	29
5/24/13 0:00	13.26		13.26	5.02	4.03	30
5/25/13 0:00	12.97		12.97	4.91	3.94	30

Run date and time: various				SFP Initial Water Temp = 80 F SFP Initial Air Temp = 80 F		
Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	TOTAL Spent Fuel Pool Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
5/26/13 0:00	12.70		12.70	4.81	3.86	31
5/27/13 0:00	12.45		12.45	4.72	3.79	32
5/28/13 0:00	12.22		12.22	4.63	3.72	32
5/29/13 0:00	12.01		12.01	4.55	3.65	33
5/30/13 0:00	11.81		11.81	4.47	3.59	33
5/31/13 0:00	11.63		11.63	4.40	3.54	34
6/1/13 0:00	11.46		11.46	4.34	3.48	34
6/3/13 0:00	11.14		11.14	4.22	3.39	35
6/5/13 0:00	10.85		10.85	4.11	3.30	36
6/7/13 0:00	10.60		10.60	4.01	3.22	37
6/9/13 0:00	10.36		10.36	3.92	3.15	38
6/11/13 0:00	10.14		10.14	3.84	3.08	39
6/13/13 0:00	9.93		9.93	3.76	3.02	40
6/15/13 0:00	9.74		9.74	3.69	2.96	41
6/17/13 0:00	9.55		9.55	3.62	2.90	41
6/19/13 0:00	9.38		9.38	3.55	2.85	42
6/21/13 0:00	9.21		9.21	3.49	2.80	43
6/25/13 0:00	8.90		8.90	3.37	2.71	44
6/29/13 0:00	8.63		8.63	3.27	2.62	46
7/3/13 0:00	8.37		8.37	3.17	2.55	47
7/7/13 0:00	8.14		8.14	3.08	2.48	48
7/11/13 0:00	7.93		7.93	3.00	2.41	50
7/15/13 0:00	7.73		7.73	2.93	2.35	51
7/19/13 0:00	7.55		7.55	2.86	2.30	52
7/23/13 0:00	7.38		7.38	2.79	2.24	53
7/27/13 0:00	7.22		7.22	2.73	2.20	55

Run date and time: various				SFP Initial Water Temp = 80 F SFP Initial Air Temp = 80 F		
Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	TOTAL Spent Fuel Pool Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
8/6/13 0:00	6.86		6.86	2.60	2.09	57
8/16/13 0:00	6.56		6.56	2.48	1.99	60
8/26/13 0:00	6.29		6.29	2.38	1.91	63
9/5/13 0:00	6.05		6.05	2.29	1.84	65
9/15/13 0:00	5.83		5.83	2.21	1.77	68
9/25/13 0:00	5.64		5.64	2.13	1.71	70
10/5/13 0:00	5.46		5.46	2.07	1.66	72
10/15/13 0:00	5.29		5.29	2.00	1.61	75
10/25/13 0:00	5.14		5.14	1.95	1.56	77
11/4/13 0:00	4.99		4.99	1.89	1.52	79
11/24/13 0:00	4.74		4.74	1.80	1.44	83
12/14/13 0:00	4.52		4.52	1.71	1.37	87
1/3/14 0:00	4.32		4.32	1.64	1.32	91
1/23/14 0:00	4.15		4.15	1.57	1.26	95
2/12/14 0:00	4.01		4.01	1.52	1.22	99
3/4/14 0:00	3.87		3.87	1.47	1.18	102
3/24/14 0:00	3.75		3.75	1.42	1.14	105
4/13/14 0:00	3.65		3.65	1.38	1.11	108
5/3/14 0:00	3.55		3.55	1.35	1.08	111
5/23/14 0:00	3.46		3.46	1.31	1.05	114
6/12/14 0:00	3.38		3.38	1.28	1.03	117
7/2/14 0:00	3.30		3.30	1.25	1.00	119
7/22/14 0:00	3.23		3.23	1.22	0.98	122
8/11/14 0:00	3.17		3.17	1.20	0.96	125
8/31/14 0:00	3.10		3.10	1.18	0.94	127
9/20/14 0:00	3.04		3.04	1.15	0.93	130

Run date and time: various				SFP Initial Water Temp = 80 F SFP Initial Air Temp = 80 F		
Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	TOTAL Spent Fuel Pool Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
10/10/14 0:00	2.99		2.99	1.13	0.91	132
10/30/14 0:00	2.93		2.93	1.11	0.89	135
11/19/14 0:00	2.88		2.88	1.09	0.88	137
12/9/14 0:00	2.83		2.83	1.07	0.86	139
12/29/14 0:00	2.79		2.79	1.06	0.85	142
1/18/15 0:00	2.74		2.74	1.04	0.83	144
2/7/15 0:00	2.70		2.70	1.02	0.82	146
2/27/15 0:00	2.66		2.66	1.01	0.81	148
3/19/15 0:00	2.63		2.63	0.99	0.80	150
4/8/15 0:00	2.59		2.59	0.98	0.79	152
4/28/15 0:00	2.56		2.56	0.97	0.78	154
5/18/15 0:00	2.52		2.52	0.96	0.77	156
6/7/15 0:00	2.49		2.49	0.94	0.76	158
6/27/15 0:00	2.46		2.46	0.93	0.75	160
7/17/15 0:00	2.43		2.43	0.92	0.74	162
8/6/15 0:00	2.40		2.40	0.91	0.73	164
8/26/15 0:00	2.38		2.38	0.90	0.72	166
9/15/15 0:00	2.35		2.35	0.89	0.71	168
10/5/15 0:00	2.33		2.33	0.88	0.71	170
10/25/15 0:00	2.30		2.30	0.87	0.70	171
11/14/15 0:00	2.28		2.28	0.86	0.69	173
12/4/15 0:00	2.26		2.26	0.85	0.69	175
12/24/15 0:00	2.23		2.23	0.85	0.68	177
1/13/16 0:00	2.21		2.21	0.84	0.67	178
2/2/16 0:00	2.19		2.19	0.83	0.67	180
2/22/16 0:00	2.17		2.17	0.82	0.66	181

Run date and time: various				SFP Initial Water Temp = 80 F SFP Initial Air Temp = 80 F		
Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	TOTAL Spent Fuel Pool Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
3/13/16 0:00	2.15		2.15	0.82	0.66	183
4/2/16 0:00	2.14		2.14	0.81	0.65	185
4/22/16 0:00	2.12		2.12	0.80	0.64	186

Same date and timesteps with only the Cycle 32 Discharged Core

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Heat Load from Cycle 32 Discharge Assemblies Only (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)	Hottest Fuel Assembly Estimate (Mbtu/hr) **	** Hottest fuel assembly approximation includes fraction of one assembly to core (1/121) x highest power fraction of last fluxmap, 1.449 (C-08, map K1C32M17)
5/8/13 0:00	32.25		32.25	12.22	9.81	12.2	0.386	
5/8/13 8:00	28.23		28.23	10.69	8.58	14.0	0.338	
5/8/13 16:00	26.62		26.62	10.08	8.10	14.8	0.319	
5/9/13 0:00	25.39		25.39	9.62	7.72	15.5	0.304	
5/9/13 8:00	24.36		24.36	9.23	7.41	16.2	0.292	
5/9/13 16:00	23.45		23.45	8.88	7.13	16.8	0.281	
5/10/13 0:00	22.62		22.62	8.57	6.88	17.4	0.271	
5/10/13 8:00	21.86		21.86	8.28	6.65	18.1	0.262	
5/10/13 16:00	21.15		21.15	8.01	6.43	18.7	0.253	
5/11/13 0:00	20.50		20.50	7.77	6.24	19.2	0.246	
5/11/13 8:00	19.90		19.90	7.54	6.05	19.8	0.238	
5/11/13 16:00	19.33		19.33	7.32	5.88	20.4	0.232	
5/12/13 0:00	18.81		18.81	7.12	5.72	21.0	0.225	
5/13/13 0:00	17.44		17.44	6.61	5.30	22.6	0.209	
5/14/13 0:00	16.30		16.30	6.17	4.96	24.2	0.195	
5/15/13 0:00	15.34		15.34	5.81	4.67	25.7	0.184	
5/16/13 0:00	14.52		14.52	5.50	4.42	27.2	0.174	
5/17/13 0:00	13.81		13.81	5.23	4.20	28.6	0.165	
5/18/13 0:00	13.19		13.19	5.00	4.01	29.9	0.158	
5/19/13 0:00	12.65		12.65	4.79	3.85	31.2	0.151	
5/20/13 0:00	12.16		12.16	4.61	3.70	32.4	0.146	
5/21/13 0:00	11.73		11.73	4.44	3.57	33.6	0.140	
5/22/13 0:00	11.34		11.34	4.30	3.45	34.8	0.136	
5/23/13 0:00	10.99		10.99	4.16	3.34	35.9	0.132	
5/24/13 0:00	10.67		10.67	4.04	3.25	37.0	0.128	
5/25/13 0:00	10.38		10.38	3.93	3.16	38.0	0.124	
5/26/13 0:00	10.11		10.11	3.83	3.08	39.0	0.121	
5/27/13 0:00	9.87		9.87	3.74	3.00	40.0	0.118	
5/28/13 0:00	9.64		9.64	3.65	2.93	40.9	0.115	
5/29/13 0:00	9.43		9.43	3.57	2.87	41.8	0.113	
5/30/13 0:00	9.24		9.24	3.50	2.81	42.7	0.111	

Same date and timesteps with only the Cycle 32 Discharged Core

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Heat Load from Cycle 32 Discharge Assemblies Only (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)	Hottest Fuel Assembly Estimate (Mbtu/hr) **	** Hottest fuel assembly approximation includes fraction of one assembly to core (1/121) x highest power fraction of last fluxmap, 1.449 (C-08, map K1C32M17)
5/31/13 0:00	9.06		9.06	3.43	2.75	43.6	0.108	
6/1/13 0:00	8.88		8.88	3.37	2.70	44.4	0.106	
6/3/13 0:00	8.57		8.57	3.25	2.61	46.0	0.103	
6/5/13 0:00	8.29		8.29	3.14	2.52	47.6	0.099	
6/7/13 0:00	8.04		8.04	3.04	2.44	49.1	0.096	
6/9/13 0:00	7.80		7.80	2.96	2.37	50.6	0.093	
6/11/13 0:00	7.59		7.59	2.87	2.31	52.0	0.091	
6/13/13 0:00	7.38		7.38	2.80	2.25	53.4	0.088	
6/15/13 0:00	7.19		7.19	2.72	2.19	54.9	0.086	
6/17/13 0:00	7.01		7.01	2.66	2.13	56.3	0.084	
6/19/13 0:00	6.84		6.84	2.59	2.08	57.7	0.082	
6/21/13 0:00	6.68		6.68	2.53	2.03	59.1	0.080	
6/25/13 0:00	6.38		6.38	2.42	1.94	61.9	0.076	
6/29/13 0:00	6.11		6.11	2.31	1.86	64.6	0.073	
7/3/13 0:00	5.86		5.86	2.22	1.78	67.3	0.070	
7/7/13 0:00	5.64		5.64	2.14	1.72	70.0	0.068	
7/11/13 0:00	5.43		5.43	2.06	1.65	72.6	0.065	
7/15/13 0:00	5.24		5.24	1.99	1.59	75.2	0.063	
7/19/13 0:00	5.07		5.07	1.92	1.54	77.8	0.061	
7/23/13 0:00	4.91		4.91	1.86	1.49	80.4	0.059	
7/27/13 0:00	4.76		4.76	1.80	1.45	83.0	0.057	
8/6/13 0:00	4.42		4.42	1.67	1.34	89.3	0.053	
8/16/13 0:00	4.13		4.13	1.56	1.26	95.5	0.049	
8/26/13 0:00	3.88		3.88	1.47	1.18	101.7	0.046	
9/5/13 0:00	3.66		3.66	1.38	1.11	107.9	0.044	
9/15/13 0:00	3.46		3.46	1.31	1.05	114.2	0.041	
9/25/13 0:00	3.27		3.27	1.24	1.00	120.5	0.039	
10/5/13 0:00	3.11		3.11	1.18	0.95	126.9	0.037	
10/15/13 0:00	2.96		2.96	1.12	0.90	133.4	0.035	
10/25/13 0:00	2.82		2.82	1.07	0.86	140.0	0.034	
11/4/13 0:00	2.69		2.69	1.02	0.82	146.6	0.032	

Same date and timesteps with only the Cycle 32 Discharged Core

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Heat Load from Cycle 32 Discharge Assemblies Only (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)	Hottest Fuel Assembly Estimate (Mbtu/hr) **	** Hottest fuel assembly approximation includes fraction of one assembly to core (1/121) x highest power fraction of last fluxmap, 1.449 (C-08, map K1C32M17)
11/24/13 0:00	2.46		2.46	0.93	0.75	160.1	0.030	
12/14/13 0:00	2.27		2.27	0.86	0.69	173.7	0.027	
1/3/14 0:00	2.10		2.10	0.80	0.64	187.5	0.025	
1/23/14 0:00	1.96		1.96	0.74	0.60	201.3	0.023	
2/12/14 0:00	1.84		1.84	0.70	0.56	215.0	0.022	
3/4/14 0:00	1.73		1.73	0.65	0.52	228.6	0.021	
3/24/14 0:00	1.63		1.63	0.62	0.50	242.2	0.020	
4/13/14 0:00	1.54		1.54	0.58	0.47	255.6	0.018	
5/3/14 0:00	1.47		1.47	0.56	0.45	269.1	0.018	
5/23/14 0:00	1.40		1.40	0.53	0.42	282.5	0.017	
6/12/14 0:00	1.33		1.33	0.51	0.41	295.9	0.016	
7/2/14 0:00	1.28		1.28	0.48	0.39	309.4	0.015	
7/22/14 0:00	1.22		1.22	0.46	0.37	323.0	0.015	
8/11/14 0:00	1.17		1.17	0.44	0.36	336.7	0.014	
8/31/14 0:00	1.13		1.13	0.43	0.34	350.6	0.013	
9/20/14 0:00	1.08		1.08	0.41	0.33	364.8	0.013	
10/10/14 0:00	1.04		1.04	0.39	0.32	379.2	0.012	
10/30/14 0:00	1.00		1.00	0.38	0.30	394.0	0.012	
11/19/14 0:00	0.97		0.97	0.37	0.29	408.5	0.012	
12/9/14 0:00	0.93		0.93	0.35	0.28	423.1	0.011	
12/29/14 0:00	0.90		0.90	0.34	0.27	438.1	0.011	
1/18/15 0:00	0.87		0.87	0.33	0.26	453.3	0.010	
2/7/15 0:00	0.84		0.84	0.32	0.26	468.6	0.010	
2/27/15 0:00	0.81		0.81	0.31	0.25	484.2	0.010	
3/19/15 0:00	0.79		0.79	0.30	0.24	500.0	0.009	
4/8/15 0:00	0.76		0.76	0.29	0.23	516.1	0.009	
4/28/15 0:00	0.74		0.74	0.28	0.23	532.4	0.009	
5/18/15 0:00	0.72		0.72	0.27	0.22	549.0	0.009	
6/7/15 0:00	0.70		0.70	0.26	0.21	565.8	0.008	
6/27/15 0:00	0.68		0.68	0.26	0.21	582.8	0.008	
7/17/15 0:00	0.66		0.66	0.25	0.20	600.0	0.008	

Same date and timesteps with only the Cycle 32 Discharged Core

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Heat Load from Cycle 32 Discharge Assemblies Only (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)	Hottest Fuel Assembly Estimate (Mbtu/hr) **	** Hottest fuel assembly approximation includes fraction of one assembly to core (1/121) x highest power fraction of last fluxmap, 1.449 (C-08, map K1C32M17)
8/6/15 0:00	0.64		0.64	0.24	0.19	617.5	0.008	
8/26/15 0:00	0.62		0.62	0.24	0.19	635.1	0.007	
9/15/15 0:00	0.60		0.60	0.23	0.18	653.0	0.007	
10/5/15 0:00	0.59		0.59	0.22	0.18	671.1	0.007	
10/25/15 0:00	0.57		0.57	0.22	0.17	689.4	0.007	
11/14/15 0:00	0.56		0.56	0.21	0.17	707.9	0.007	
12/4/15 0:00	0.54		0.54	0.21	0.17	726.6	0.007	
12/24/15 0:00	0.53		0.53	0.20	0.16	745.5	0.006	
1/13/16 0:00	0.52		0.52	0.20	0.16	764.7	0.006	
2/2/16 0:00	0.50		0.50	0.19	0.15	784.0	0.006	
2/22/16 0:00	0.49		0.49	0.19	0.15	803.6	0.006	
3/13/16 0:00	0.48		0.48	0.18	0.15	823.4	0.006	
4/2/16 0:00	0.47		0.47	0.18	0.14	843.3	0.006	
4/22/16 0:00	0.46		0.46	0.17	0.14	863.5	0.005	

Attachment 4

Spent Fuel Pool Heat Load after Final Shutdown Documentation (per KPS Reactor Engineering Procedure ER-AA-RXE-103)

(59 pages attached)

List of Contents:

- Procedure ER-AA-RXE-103 Spent Fuel Pool Heatup
- HEATUP code runs for all fuel assemblies residing in the SFP (1079 fuel assemblies): One run starts 5/8/2013, next run starts 10/30/2014
- K1EOC32b.PRT input file
- Data table with both runs of data merged (5/8/13 run and the 10/30/14 run)
- HEATUP code runs for only the recently discharged (121) fuel assemblies residing in the SFP (Cycle 32 Core Offload): One run starts 5/8/2013, next run starts 10/30/2014
- C32Disch.PRT input file
- Data table with both runs of data merged (5/8/13 run and the 10/30/14 run)
- Table of Comparison of Decay Heat Values

7-9-2013

Dominion®

Nuclear Fleet

Administrative Procedure

Title: Spent Fuel Pool Heatup

Procedure Number	Revision Number	Effective Date and Approvals On File
ER-AA-RXE-103	1	

Revision Summary

Revised to add the following that did not transfer from NF-AA-RXE-103:

- 3.1 NOTE - "Performance of Step 3.1.4 is optional in the performance of Subsection 3.1."
- Added Step 3.1.3 - "Transfer of fuel from ISFSI to spent fuel pool - update should be performed prior to transferring fuel to spent fuel pool, raises decay heat load."
- Added Step 3.1.4 - "Transfer of fuel to ISFSI (or off-site) - update optional, lowers decay heat load."

2 runs for data comparisons:

- C32Disch.PRT (contains only 121 Cycle 32 fuel assemblies)
- KIEOC32b.PRT (contains all 1079 fuel assemblies in the SFP)

Functional Area Manager: Manager Nuclear Systems Engineering

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1.0 PURPOSE

The purpose of this document is to provide guidance to Reactor Engineers for the generation of the spent fuel pool (SFP) heatup plots as required for the response to INPO IER L1-11-2, Recommendation 3.

INPO IER L1-11-2, Recommendation 3, requires the following:

Establish, for all plant conditions, the time for the SFP to reach 200°F (bulk temperature) in the event that normal cooling is lost. Maintain this information in a format that is readily available in the control room and emergency response facilities. This time is intended for information purposes only in case a sustained loss of SFP cooling or inventory occurs.

2.0 SCOPE

This procedure is only applicable for the generation of spent fuel pool heatup plots as required for the response to INPO L1-IER 11-2, Recommendation 3.

3.0 INSTRUCTIONS

NOTE: Non-irradiated new fuel assemblies have **NO** decay heat. Therefore, it is **NOT** necessary to update the spent fuel pool heatup plot when new fuel assemblies are added to the pool.

NOTE: Removal of spent fuel assemblies from the pool results in a lower decay heat loading and a longer (more conservative) heatup time. Therefore, it is **NOT** required to update the spent fuel pool heatup plot when fuel is removed from the pool.

NOTE: Performance of Step 3.1.4 is optional in the performance of Subsection 3.1.

Reactor Engineer

3.1 **WHEN** any of the following events occur, **THEN UPDATE** the spent fuel pool heatup plot:

3.1.1 Refueling - update required prior to core offload or core shuffle, raises decay heat load.

3.1.2 Mid-cycle core offload - update should be performed prior to core offload, raises decay heat load.

3.1.3 Transfer of fuel from ISFSI to spent fuel pool - update should be performed prior to transferring fuel to spent fuel pool, raises decay heat load.

3.1.4 Transfer of fuel to ISFSI (or off-site) - update optional, lowers decay heat load.

3.2 **CREATE** the ShuffleWorks input (.PRT) file using site specific guidance in Attachment 1 or 2 as appropriate.

NOTE: The decay heat load from the Millstone 2 consolidated fuel storage boxes have been previously evaluated as insignificant (Ref. 5.4.2). It is **NOT** necessary to include the consolidated fuel storage boxes in the input (.PRT) file.

3.2.1 **REVIEW** the input (.PRT) file for the following attributes:

a. Configuration file (.FIG) is correct.

b. Date and Time are correct.

c. Irradiated fuel assembly discharge date, burnup or enrichment are **NOT** "NIL."

d. Compare a sample (e.g., 20 to 25) of different batch fuel assembly burnup values to a controlled document (i.e., a calculation or engineering technical evaluation) to ensure that measured burnup values are correct.

3.3 **SELECT** HEATUP_P01.xlsm and **CLICK** "Open".

3.4 **CLICK** the "Read Only" button when prompted for a password.

3.5 **CLICK** the "OK" button when the "Make sure EXCEL has macros enabled" message appears.

3.6 **ENSURE** that the "Version Check" says "Version OK."

NOTE: A "CHECK VERSION" message will appear if the HEATUP last saved date and time does **NOT** agree within 12 hours of the date and time embedded in the code at the time of code release, or if the file name is **NOT** HEATUP_P01.xlsm. This may mean that the user saved a personal version of the HEATUP spreadsheet and reopened it later. The HEATUP code can **NOT** verify that the code version is valid unless the name and save date and times match.

3.7 **IF** a "CHECK VERSION" message appears, **THEN CLOSE** the EXCEL spreadsheet and **OBTAIN** a copy of the HEATUP_P01.xlsm spreadsheet from a controlled source (i.e., Nuclear Core Design).

3.8 **SELECT** the fuel pool to be updated in the "Select Fuel Pool" list.

3.9 **ENTER** "User Input Data" as follows:

> **NOTE:** The start date and time is entered in cell F15 in the HEATUP_P01 spreadsheet in the format M/D/YY hh:mm.
>
> **NOTE:** The default start time is the date and time when the HEATUP spreadsheet was opened.
>
> **NOTE:** The start date and time is important if modeling the refueling outage core offload and onload.

3.9.1 **ENTER** the start date and time for the start of the 540 day look-ahead resident fuel decay heat calculation.

> **NOTE:** Temperature values less than 60°F and greater than 150°F will cause a "CHECK VALUE" message to appear.
>
> **NOTE:** The initial pool temperature and initial air temperature values affect the information in the "Heatup_Rate_Plot" and "Heatup_Plot_2" plots.

3.9.2 **IF** desired, **THEN ENTER** the initial pool temperature value (default value is 80°F).

3.9.3 **IF** desired, **THEN ENTER** the initial air temperature value (default value is 80°F).

3.10 **CLICK** on the "Read Fuel File and Calculate" button. A Windows Explorer pop-up menu will appear.

3.10.1 **SELECT** the directory containing the ShuffleWorks input (.PRT) file that was created using the appropriate attachment.

> **NOTE:** If the input (.PRT) file is successfully read, a screen will appear that shows the progress of the heat load calculation.

> **CAUTION:** HEATUP_P01 does **NOT** perform any checks to verify that the fuel file matches the spent fuel pool selected.

3.10.2 **SELECT** the ShuffleWorks input (.PRT) file that was created using the appropriate attachment.

3.10.3 IF the selected input file contains invalid data ("Error in Pool file data" error message will appear), THEN **PERFORM** the following:

a. **CLICK** on the "OK" button to clear the error message.

b. **REVIEW** the input (.PRT) file to determine and correct the invalid data.

NOTE: The default values for the core offload and onload parameters are estimates and are different for each plant.

NOTE: The core offload is modeled such that fuel movement starts at the date and time entered for the start of the pool decay heat calculation (Step 3.9.1). The decay time prior to offload starts before the start date and time. The shutdown date and time is the start date and time minus the decay time prior to offload and is shown in the blue header bar.

NOTE: Any changes to the start date and time values will require that the "Read Fuel File and Calculate" step be repeated (Step 3.10).

3.11 IF desired to model the core offload and onload, THEN **PERFORM** the following: N/A

3.11.1 **REQUEST** Nuclear Core Design to provide the following information:

- Discharge batch enrichment (in w/o U-235)
- End-of-Cycle discharge batch burnup (in MWD/MTU)
- Core average enrichment (in w/o U-235)
- End-of-Cycle core average batch burnup (in MWD/MTU)

3.11.2 **ENTER** the expected decay time prior to core offload.

3.11.3 **ADJUST** the start date and time as required to make the core shutdown date and time agree with the actual core shutdown date and time.

3.11.4 **ENTER** the HIGHEST expected fuel pool temperature for the core offload in the "initial pool temperature" field.

3.11.5 **ENTER** the values for the remaining refueling outage parameters.

3.11.6 **CLICK** on the "Simulate Refueling Outage" button.

3.12 **REVIEW** the "Input File Data" for the following:

3.12.1 "Input File Date/Time" is consistent with the date and time of the ShuffleWorks input (.PRT) file that was created using the appropriate attachment.

NOTE The number of burned assemblies may **NOT** include all fuel items stored in the spent fuel pool (e.g., failed rod storage baskets, consolidated fuel storage boxes).

3.12.2 "Burned Assemblies" value agrees with the number of fuel assemblies currently stored in the spent fuel pool.

3.12.3 "Minimum cooling time" and "Maximum cooling time" values are reasonable considering the start date and time, and the discharge times of fuel assemblies stored in the fuel pool.

3.13 **REVIEW** the output data and plots for reasonable behavior by comparison against previously approved output data and plots.

3.14 **CHECK** that the labeling of the HEATUP plots are correct for the selected unit.

3.15 **PERFORM** ONE of the following:

3.15.1 **IF** modeling core offload and reload, **THEN PRINT** "Heatup_Plot_2".

3.15.2 **IF** performing non-core offload update, **THEN PRINT** "Heatup_Plot_1".

3.16 **SIGN** and **DATE** "Heatup_Plot_1" or "Heatup_Plot_2".

3.17 **REQUEST** that a second reactor engineer perform a Peer Review of the inputs and outputs of the HEATUP calculation in accordance with DNES-AA-GN-1001, Engineering Reviews.

Peer Reviewer 3.18 **SIGN** and **DATE** "Heatup_Plot_1" or "Heatup_Plot_2" as reviewer.

Reactor Engineer 3.19 **DISTRIBUTE** signed and dated copies of "Heatup_Plot_1" or "Heatup_Plot_2" to:

- Main Control Room to INNS for ETE
- Technical Support Center
- Emergency Operations Facility

4.0 **RECORDS**

4.1 The following record(s) completed as a result of this procedure are required to be transmitted to Nuclear Document Management (NDM). The records have been identified and retention requirements established for the Nuclear Records Retention Schedule (NRRS) per RM-AA-101, Record Creation, Transmittal, and Retrieval.

4.1.1 **Quality Assurance Records**

- "Heatup_Plot_1" or "Heatup_Plot_2"
- Site-Specific Heat-up Curves

4.1.2 **Non-Quality Assurance Records**

None

4.2 The following record(s) completed as a result of this procedure are **NOT** required to be transmitted to Nuclear Document Management (NDM), but are required to be retained as indicated below. The NRRS has been updated and Alternate Storage approved per RM-AA-101 for Quality Assurance Records.

4.2.1 **Quality Assurance Records**

None

4.2.2 **Non-Quality Assurance Records**

None

4.3 The following item(s) completed as a result of this procedure are **NOT** records and are **NOT** required to be transmitted to Nuclear Document Management (NDM).

None

5.0 ADMINISTRATIVE INFORMATION

5.1 Commitments

None

5.2 Responsibilities

5.2.1 **Reactor Engineers**

Reactor Engineers are responsible to apply the guidance in this procedure to generate the updated spent fuel pool heatup plots when specified by this procedure.

5.2.2 **Nuclear Analysis and Fuel**

Nuclear Analysis and Fuel is responsible to maintain and update the HEATUP computer code and to ensure that the ShuffleWorks neutronics data files accurately reflect the inventory, discharge dates, initial enrichments and measured burnup values of spent fuel assemblies stored in the spent fuel pool.

5.3 Definitions

None

5.4 References

5.4.1 INPO Event Report L1-11-2, dated 4/25/2011, Fukushima Daiichi Nuclear Station Spent Fuel Pool Loss of Cooling and Makeup

5.4.2 Calculation No. PM-1442, Rev. 1, HEATUP Version 1 Spent Fuel Pool Heatup Computer Code

5.4.3 ETE-NAF-2011-0104, HEATUPP01 Code Release

5.4.4 DNES-AA-GN-1001, Engineering Reviews

ATTACHMENT 1

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Millstone and Kewaunee Power Station PRT file Generation Guidance

NOTE: ShuffleWorks version 5.0.050106 (or later) is required to create the input (.PRT) file.

NOTE: Performance of this procedure requires a good working level of knowledge of the ShuffleWorks program.

NOTE: The "General Assembly Information" (.GAI) file and the 'Configuration' (.FIG) file are used by ShuffleWorks to create the input (.PRT) file at MPS.

NOTE: The "General Assembly Information" (.GAI) file may contain additional data, in addition to the required data specified below.

1. Ensure that a ShuffleWorks "General Assembly Information" (.GAI) file is available that contains at a minimum the following information for all irradiated fuel assemblies stored in the spent fuel pool for the desired plant:
   a. Fuel assembly identification serial number.
   b. Offload date when fuel assembly was discharged from core.
   c. Fuel assembly initial enrichment (weight percent U-235).

CAUTION: The measured fuel assembly burnup values used to generate the input (.PRT) file must NOT be reduced to account for measurement uncertainties.

   d. Measured fuel assembly Burnup.
2. Start ShuffleWorks.
3. Load the data file for the desired plant and current operating cycle.
4. Display the current spent fuel pool.

CAUTION: Failure to select all spent fuel assemblies stored in the spent fuel pool will result in a non-conservative decay heat load calculation.

5. Using the "Utility" function, highlight all fuel assemblies in the spent fuel pool.
6. Select the "Reports" function.
7. Select the "Save User Report" option.
8. Enter a descriptive file name in the pop-up box (e.g., SPS Pool Data July 2011 or KPSC30 July 2011).
9. Select the plant specific "Assembly data for HEATUP code" report option to create the input (.PRT) file.
10. Open the input (.PRT) file created in step 9 with a text editor (e.g., Wordpad or Notepad) or Excel. GO TO Step 3.2.1.

ATTACHMENT 2

(Page 1 of 2)

North Anna and Surry Power Stations PRT file Generation Guidance

NOTE: ShuffleWorks version 5.0.050106 (or later) is required to create the input (.PRT) file.

NOTE: Performance of this portion of the procedure requires a good working level of knowledge of the ShuffleWorks program.

NOTE: The "General Assembly Information" (.GAI) file, "Neutronics Information" (.NEU) File and the 'Configuration' (.FIG) file are used by ShuffleWorks to create the input (.PRT) file at the Virginia Units.

NOTE: The "General Assembly Information" (.GAI) file may contain additional data, in addition to the required data specified below.

1. Ensure that the status of the Configuration (.FIG) file is appropriate for determining the SFP fuel inventory.
2. Ensure that a ShuffleWorks "General Assembly Information" (.GAI) file is available that contains at a minimum the following information for all irradiated fuel assemblies stored in the spent fuel pool for the desired plant:
   a. Fuel assembly identification serial number.
   b. Shutdown date when fuel assembly was discharged from core.
3. Ensure that a ShuffleWorks "Neutronics Information" (.NEU) File is available that contains at a minimum the following information for all irradiated fuel assemblies stored in the spent fuel pool for the desired plant:
   a. Fuel assembly identification serial number.
   b. Fuel assembly initial enrichment (weight percent U-235).
   c. Measured (best estimate) fuel assembly Burnup.
4. Start ShuffleWorks.
5. Load the data and plant information files for the desired plant and current operating cycle.

CAUTION: Failure to select all spent fuel assemblies stored in the spent fuel pool will result in a non-conservative decay heat load calculation.

6. Select the "Reports" function.
7. Select the "Save User Report" option.
8. Enter a descriptive file name in the pop-up box (e.g., SPS Pool Data July 2011 or KPSC30 July 2011).
9. Select the plant specific "Assembly data for HEATUP code" report option to create the input (.PRT) file.

ATTACHMENT 2

(Page 2 of 2)

North Anna and Surry Power Stations PRT file Generation Guidance

10. When Prompted to select assemblies for this report, select yes.
11. Choose to select items interactively.
12. Select the Spent Fuel Pool ICA.
13. Right click in the Spent Fuel Pool Display.
14. Choose 'Select Region'.
15. Left click and hold in the Spent Fuel Pool Display to drag a box around all items in the Spent Fuel Pool.
16. When all items are selected, select done.
17. When Prompted to save the items to a file, click no.
18. Open the input (.PRT) file created by the performance of this attachment with a text editor (e.g., Wordpad or Notepad) or Excel. GO TO Step 3.2.1.

Select Fuel Pool	Select Fuel Pool File	Simulate Refueling Outage	Version Check
Surry North Anna Millstone 2 Millstone 3 Kewaunee			7/6/2011 11:09 HEATUP_P01.xlsm Version OK

This is a HEATUP Version 1 Kewaunee calculation

User Input Data

Fuel in Pool Heat Load Input		
Date and Time for Start of Pool Decay Heat Calculation	5/8/13 0:00	
Initial Pool Temperature for Time to 200 °F Calculation	80	°F
Initial Air Temperature for Time to 200 °F Calculation	80	°F
Refueling Outage Simulation Input — Core shutdown date & time =	5/1/13 18:00	
Decay time prior to offload	150	Hours
Time to offload	60	Hours
Outage length at onload	13	Days
Time to onload	60	Hours
Batch size to discharge	45	Fuel Assemblies
Discharge batch enrichment	4.80	w/o U-235
Discharge batch burnup	50000	MWD/MTU
Core average enrichment	4.80	w/o U-235
Core average burnup	39000	MWD/MTU

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLE32.fig	
Print File:	K1EOC32b.PRT	
Burned Assemblies:	1079	
Minimum cooling time:	1.0	Days
Maximum cooling time:	37.2	Years

Run date and time: 7/10/2013 8:18:45 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
5/8/13 0:00	34.88		34.88	13.21	10.61	11.3
5/8/13 8:00	30.85		30.85	11.69	9.38	12.8
5/8/13 16:00	29.24		29.24	11.08	8.89	13.5
5/9/13 0:00	28.01		28.01	10.61	8.52	14.1
5/9/13 8:00	26.98		26.98	10.22	8.21	14.6
5/9/13 16:00	26.07		26.07	9.87	7.93	15.1
5/10/13 0:00	25.24		25.24	9.56	7.68	15.6
5/10/13 8:00	24.48		24.48	9.27	7.44	16.1
5/10/13 16:00	23.77		23.77	9.01	7.23	16.6
5/11/13 0:00	23.12		23.12	8.76	7.03	17.1

HEATUP Version 1 Output Data

Input File Data	
File Date/Time:	11/28/12 8:26
Fig File:	CYCLE32.fig
Print File:	K1EOC32b.PRT
Burned Assemblies:	1079
Minimum cooling time:	1.0 Days
Maximum cooling time:	37.2 Years

Run date and time: 7/10/2013 8:18:45 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
5/11/13 8:00	22.51		22.51	8.53	6.85	17.5
5/11/13 16:00	21.95		21.95	8.31	6.68	18.0
5/12/13 0:00	21.43		21.43	8.12	6.52	18.4
5/13/13 0:00	20.05		20.05	7.60	6.10	19.7
5/14/13 0:00	18.91		18.91	7.16	5.75	20.9
5/15/13 0:00	17.95		17.95	6.80	5.46	22.0
5/16/13 0:00	17.13		17.13	6.49	5.21	23.0
5/17/13 0:00	16.42		16.42	6.22	4.99	24.0
5/18/13 0:00	15.80		15.80	5.98	4.80	25.0
5/19/13 0:00	15.25		15.25	5.78	4.64	25.9
5/20/13 0:00	14.76		14.76	5.59	4.49	26.7
5/21/13 0:00	14.33		14.33	5.43	4.36	27.5
5/22/13 0:00	13.94		13.94	5.28	4.24	28.3
5/23/13 0:00	13.58		13.58	5.15	4.13	29.0
5/24/13 0:00	13.26		13.26	5.02	4.03	29.8
5/25/13 0:00	12.97		12.97	4.91	3.94	30.4
5/26/13 0:00	12.70		12.70	4.81	3.86	31.1
5/27/13 0:00	12.45		12.45	4.72	3.79	31.7
5/28/13 0:00	12.22		12.22	4.63	3.72	32.3
5/29/13 0:00	12.01		12.01	4.55	3.65	32.9
5/30/13 0:00	11.81		11.81	4.47	3.59	33.4
5/31/13 0:00	11.63		11.63	4.40	3.54	33.9
6/1/13 0:00	11.46		11.46	4.34	3.48	34.4
6/3/13 0:00	11.14		11.14	4.22	3.39	35.4
6/5/13 0:00	10.85		10.85	4.11	3.30	36.4
6/7/13 0:00	10.60		10.60	4.01	3.22	37.2
6/9/13 0:00	10.36		10.36	3.92	3.15	38.1
6/11/13 0:00	10.14		10.14	3.84	3.08	38.9
6/13/13 0:00	9.93		9.93	3.76	3.02	39.7
6/15/13 0:00	9.74		9.74	3.69	2.96	40.5
6/17/13 0:00	9.55		9.55	3.62	2.90	41.3
6/19/13 0:00	9.38		9.38	3.55	2.85	42.1
6/21/13 0:00	9.21		9.21	3.49	2.80	42.8
6/25/13 0:00	8.90		8.90	3.37	2.71	44.3
6/29/13 0:00	8.63		8.63	3.27	2.62	45.7
7/3/13 0:00	8.37		8.37	3.17	2.55	47.1
7/7/13 0:00	8.14		8.14	3.08	2.48	48.5
7/11/13 0:00	7.93		7.93	3.00	2.41	49.8
7/15/13 0:00	7.73		7.73	2.93	2.35	51.0
7/19/13 0:00	7.55		7.55	2.86	2.30	52.3
7/23/13 0:00	7.38		7.38	2.79	2.24	53.5
7/27/13 0:00	7.22		7.22	2.73	2.20	54.7
8/6/13 0:00	6.86		6.86	2.60	2.09	57.5
8/16/13 0:00	6.56		6.56	2.48	1.99	60.2
8/26/13 0:00	6.29		6.29	2.38	1.91	62.8
9/5/13 0:00	6.05		6.05	2.29	1.84	65.2

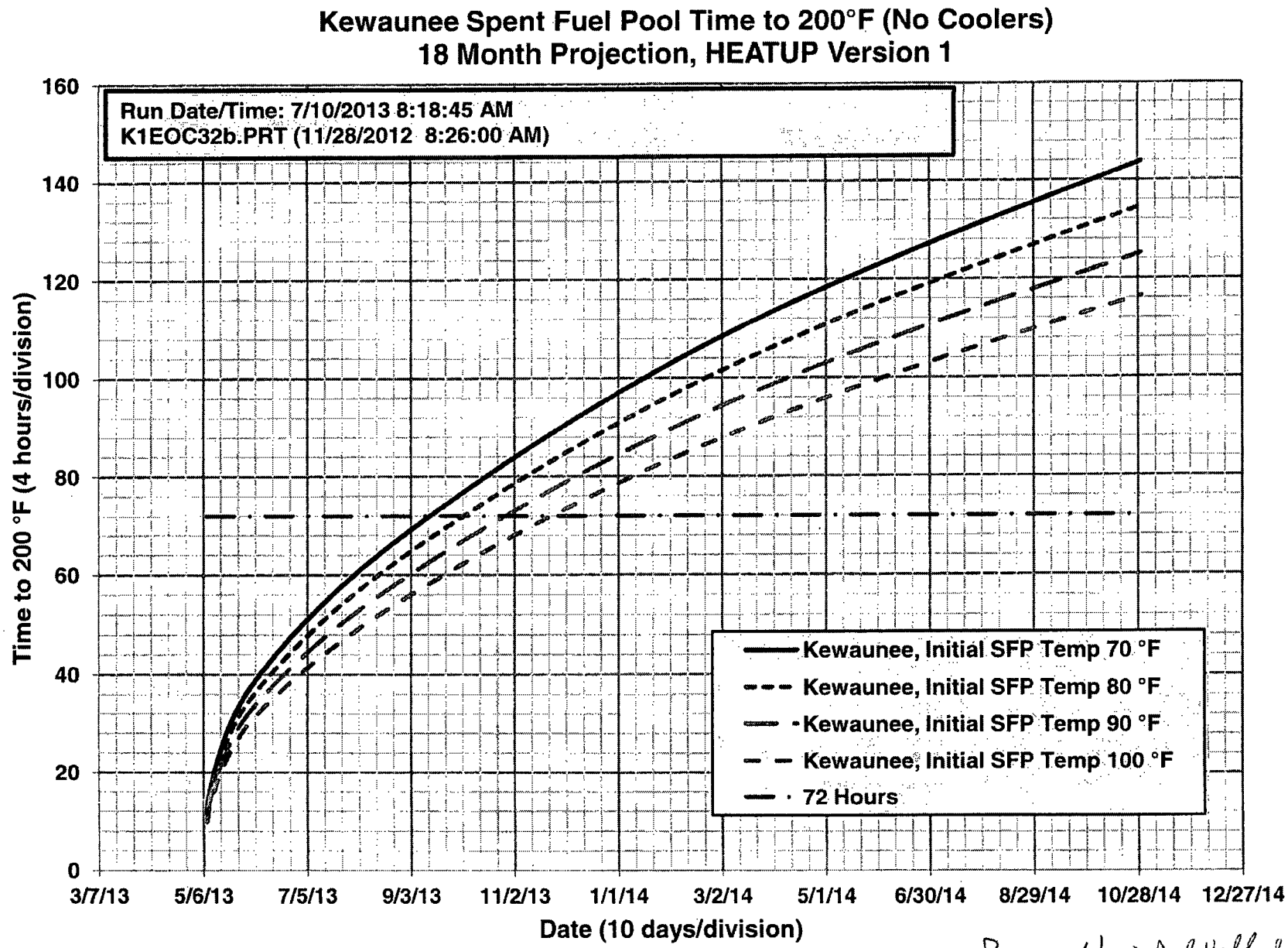
HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLE32.fig	
Print File:	K1EOC32b.PRT	
Burned Assemblies:	1079	
Minimum cooling time:	1.0	Days
Maximum cooling time:	37.2	Years

Run date and time: 7/10/2013 8:18:45 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
9/15/13 0:00	5.83		5.83	2.21	1.77	67.6
9/25/13 0:00	5.64		5.64	2.13	1.71	70.0
10/5/13 0:00	5.46		5.46	2.07	1.66	72.3
10/15/13 0:00	5.29		5.29	2.00	1.61	74.6
10/25/13 0:00	5.14		5.14	1.95	1.56	76.8
11/4/13 0:00	4.99		4.99	1.89	1.52	79.0
11/24/13 0:00	4.74		4.74	1.80	1.44	83.3
12/14/13 0:00	4.52		4.52	1.71	1.37	87.3
1/3/14 0:00	4.32		4.32	1.64	1.32	91.2
1/23/14 0:00	4.15		4.15	1.57	1.26	95.0
2/12/14 0:00	4.01		4.01	1.52	1.22	98.5
3/4/14 0:00	3.87		3.87	1.47	1.18	101.9
3/24/14 0:00	3.75		3.75	1.42	1.14	105.1
4/13/14 0:00	3.65		3.65	1.38	1.11	108.2
5/3/14 0:00	3.55		3.55	1.35	1.08	111.1
5/23/14 0:00	3.46		3.46	1.31	1.05	114.0
6/12/14 0:00	3.38		3.38	1.28	1.03	116.7
7/2/14 0:00	3.30		3.30	1.25	1.00	119.4
7/22/14 0:00	3.23		3.23	1.22	0.98	122.0
8/11/14 0:00	3.17		3.17	1.20	0.96	124.6
8/31/14 0:00	3.10		3.10	1.18	0.94	127.1
9/20/14 0:00	3.04		3.04	1.15	0.93	129.6
10/10/14 0:00	2.99		2.99	1.13	0.91	132.1
10/30/14 0:00	2.93		2.93	1.11	0.89	134.6



Prepared by: Bob Helfenbein 7-10-13

Reviewed by: Dave Pearson 7-10-13
per email approval
Bob Helfenbein

Select Fuel Pool	Select Fuel Pool File	Simulate Refueling Outage	Version Check
Surry North Anna Millstone 2 Millstone 3 Kewaunee			7/6/2011 11:09 HEATUP_P01.xlsm Version OK

This is a HEATUP Version 1 Kewaunee calculation

User Input Data

Fuel in Pool Heat Load Input		
Date and Time for Start of Pool Decay Heat Calculation	10/30/14 0:00	
Initial Pool Temperature for Time to 200 °F Calculation	80	°F
Initial Air Temperature for Time to 200 °F Calculation	80	°F
Refueling Outage Simulation Input — Core shutdown date & time =	10/23/14 18:00	
Decay time prior to offload	150	Hours
Time to offload	60	Hours
Outage length at onload	13	Days
Time to onload	60	Hours
Batch size to discharge	45	Fuel Assemblies
Discharge batch enrichment	4.80	w/o U-235
Discharge batch burnup	50000	MWD/MTU
Core average enrichment	4.80	w/o U-235
Core average burnup	39000	MWD/MTU

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLE32.fig	
Print File:	K1EOC32b.PRT	
Burned Assemblies:	1079	
Minimum cooling time:	541.0	Days
Maximum cooling time:	38.7	Years

Run date and time: 7/10/2013 8:20:10 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
10/30/14 0:00	2.93		2.93	1.11	0.89	134.6
10/30/14 8:00	2.93		2.93	1.11	0.89	134.7
10/30/14 16:00	2.93		2.93	1.11	0.89	134.7
10/31/14 0:00	2.93		2.93	1.11	0.89	134.8
10/31/14 8:00	2.93		2.93	1.11	0.89	134.8
10/31/14 16:00	2.93		2.93	1.11	0.89	134.8
11/1/14 0:00	2.93		2.93	1.11	0.89	134.9
11/1/14 8:00	2.92		2.92	1.11	0.89	134.9
11/1/14 16:00	2.92		2.92	1.11	0.89	135.0
11/2/14 0:00	2.92		2.92	1.11	0.89	135.0

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLE32.fig	
Print File:	K1EOC32b.PRT	
Burned Assemblies:	1079	
Minimum cooling time:	541.0	Days
Maximum cooling time:	38.7	Years

Run date and time: 7/10/2013 8:20:10 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
11/2/14 8:00	2.92		2.92	1.11	0.89	135.0
11/2/14 16:00	2.92		2.92	1.11	0.89	135.1
11/3/14 0:00	2.92		2.92	1.11	0.89	135.1
11/4/14 0:00	2.92		2.92	1.11	0.89	135.2
11/5/14 0:00	2.92		2.92	1.10	0.89	135.3
11/6/14 0:00	2.91		2.91	1.10	0.89	135.5
11/7/14 0:00	2.91		2.91	1.10	0.89	135.6
11/8/14 0:00	2.91		2.91	1.10	0.88	135.7
11/9/14 0:00	2.91		2.91	1.10	0.88	135.8
11/10/14 0:00	2.90		2.90	1.10	0.88	135.9
11/11/14 0:00	2.90		2.90	1.10	0.88	136.0
11/12/14 0:00	2.90		2.90	1.10	0.88	136.2
11/13/14 0:00	2.90		2.90	1.10	0.88	136.3
11/14/14 0:00	2.89		2.89	1.10	0.88	136.4
11/15/14 0:00	2.89		2.89	1.09	0.88	136.5
11/16/14 0:00	2.89		2.89	1.09	0.88	136.6
11/17/14 0:00	2.89		2.89	1.09	0.88	136.7
11/18/14 0:00	2.88		2.88	1.09	0.88	136.8
11/19/14 0:00	2.88		2.88	1.09	0.88	137.0
11/20/14 0:00	2.88		2.88	1.09	0.88	137.1
11/21/14 0:00	2.88		2.88	1.09	0.87	137.2
11/22/14 0:00	2.87		2.87	1.09	0.87	137.3
11/23/14 0:00	2.87		2.87	1.09	0.87	137.4
11/25/14 0:00	2.87		2.87	1.09	0.87	137.7
11/27/14 0:00	2.86		2.86	1.08	0.87	137.9
11/29/14 0:00	2.86		2.86	1.08	0.87	138.1
12/1/14 0:00	2.85		2.85	1.08	0.87	138.3
12/3/14 0:00	2.85		2.85	1.08	0.87	138.6
12/5/14 0:00	2.84		2.84	1.08	0.86	138.8
12/7/14 0:00	2.84		2.84	1.08	0.86	139.0
12/9/14 0:00	2.83		2.83	1.07	0.86	139.3
12/11/14 0:00	2.83		2.83	1.07	0.86	139.5
12/13/14 0:00	2.82		2.82	1.07	0.86	139.7
12/17/14 0:00	2.82		2.82	1.07	0.86	140.2
12/21/14 0:00	2.81		2.81	1.06	0.85	140.6
12/25/14 0:00	2.80		2.80	1.06	0.85	141.1
12/29/14 0:00	2.79		2.79	1.06	0.85	141.5
1/2/15 0:00	2.78		2.78	1.05	0.85	142.0
1/6/15 0:00	2.77		2.77	1.05	0.84	142.4
1/10/15 0:00	2.76		2.76	1.05	0.84	142.9
1/14/15 0:00	2.75		2.75	1.04	0.84	143.3
1/18/15 0:00	2.74		2.74	1.04	0.83	143.7
1/28/15 0:00	2.72		2.72	1.03	0.83	144.8
2/7/15 0:00	2.70		2.70	1.02	0.82	145.9
2/17/15 0:00	2.68		2.68	1.02	0.82	147.0
2/27/15 0:00	2.66		2.66	1.01	0.81	148.1

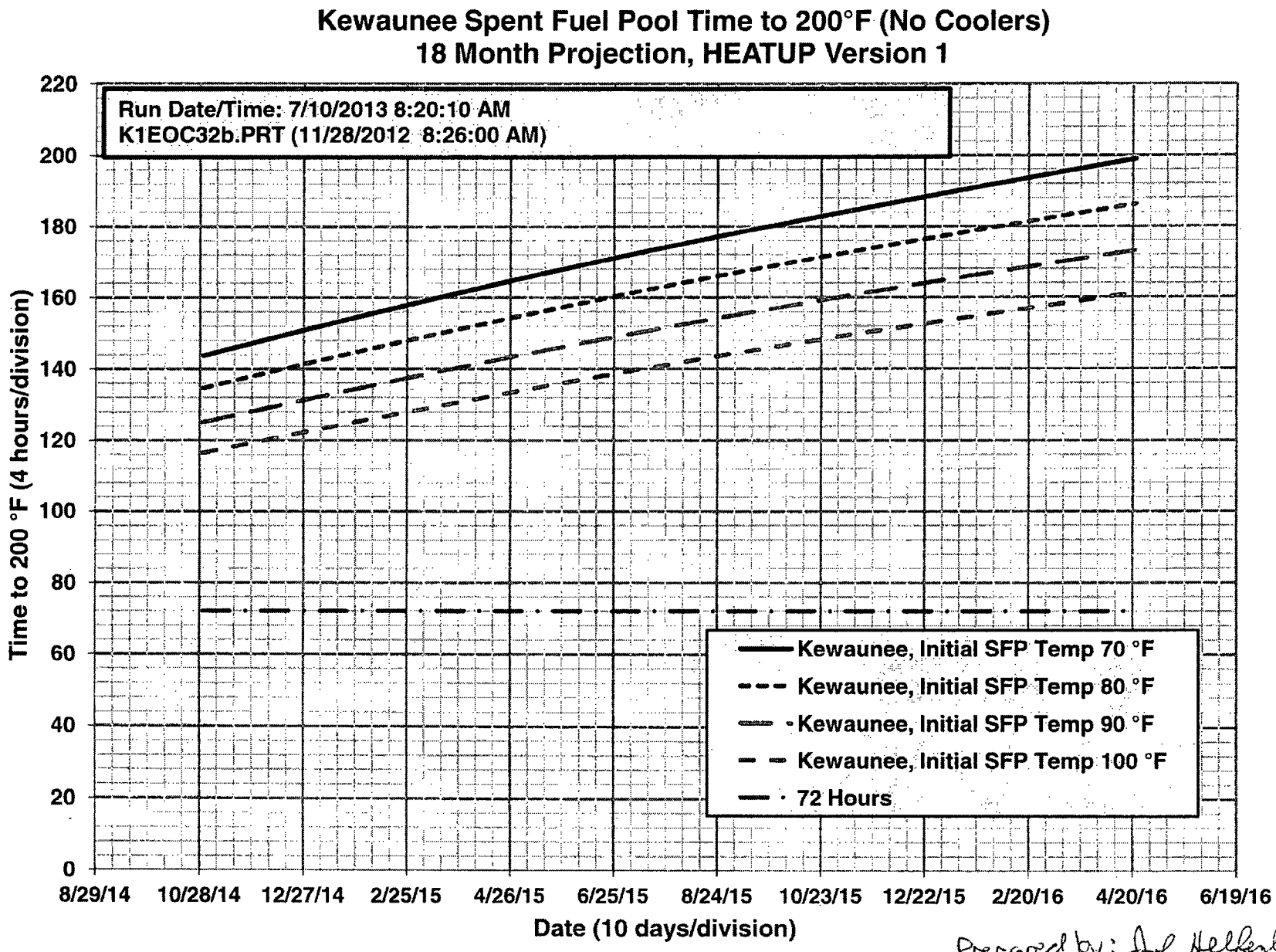
HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLE32.fig	
Print File:	K1EOC32b.PRT	
Burned Assemblies:	1079	
Minimum cooling time:	541.0	Days
Maximum cooling time:	38.7	Years

Run date and time: 7/10/2013 8:20:10 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
3/9/15 0:00	2.65		2.65	1.00	0.80	149.2
3/19/15 0:00	2.63		2.63	0.99	0.80	150.2
3/29/15 0:00	2.61		2.61	0.99	0.79	151.3
4/8/15 0:00	2.59		2.59	0.98	0.79	152.3
4/18/15 0:00	2.57		2.57	0.97	0.78	153.4
4/28/15 0:00	2.56		2.56	0.97	0.78	154.4
5/18/15 0:00	2.52		2.52	0.96	0.77	156.4
6/7/15 0:00	2.49		2.49	0.94	0.76	158.4
6/27/15 0:00	2.46		2.46	0.93	0.75	160.4
7/17/15 0:00	2.43		2.43	0.92	0.74	162.3
8/6/15 0:00	2.40		2.40	0.91	0.73	164.2
8/26/15 0:00	2.38		2.38	0.90	0.72	166.1
9/15/15 0:00	2.35		2.35	0.89	0.71	167.9
10/5/15 0:00	2.33		2.33	0.88	0.71	169.7
10/25/15 0:00	2.30		2.30	0.87	0.70	171.4
11/14/15 0:00	2.28		2.28	0.86	0.69	173.2
12/4/15 0:00	2.26		2.26	0.85	0.69	174.9
12/24/15 0:00	2.23		2.23	0.85	0.68	176.5
1/13/16 0:00	2.21		2.21	0.84	0.67	178.2
2/2/16 0:00	2.19		2.19	0.83	0.67	179.9
2/22/16 0:00	2.17		2.17	0.82	0.66	181.5
3/13/16 0:00	2.15		2.15	0.82	0.66	183.1
4/2/16 0:00	2.14		2.14	0.81	0.65	184.7
4/22/16 0:00	2.12		2.12	0.80	0.64	186.3



Prepared by: Joh Helfenlign 7-10-13

Reviewed by: Dave Pearson 7-10-13
per email approval
Joh Helfenlign

(:ORIENTATION :PORTRAIT :CC T :TYPE :ASSEMBLY :TIME-STATE NIL :REPORT "Assembly Data for HEATUP Code")
KPS Pool - Assembly Data for HEATUP Code

Fig File: CYCLE32.fig
Print File: K1EOC32b.PRT
Date: 11/28/2012 Time: 08:26

Assy ID	Discharge	Burnup	Enrich
A01	01/17/1977	25.044	2.270
A02	03/17/1983	28.598	2.270
A03	04/20/1981	28.645	2.270
A04	04/09/1982	29.567	2.270
A05	01/17/1977	25.197	2.270
A06	04/09/1982	28.671	2.270
A07	04/09/1982	29.535	2.270
A08	01/17/1977	25.077	2.270
A09	02/14/1976	18.577	2.270
A10	04/09/1982	29.463	2.270
A11	04/20/1981	27.001	2.270
A12	05/26/1979	29.365	2.270
A13	02/14/1976	19.123	2.270
A14	02/14/1976	18.623	2.270
A15	03/16/1984	27.943	2.270
A16	02/14/1976	18.660	2.270
A17	01/17/1977	24.483	2.270
A18	02/14/1976	18.388	2.270
A19	05/09/1980	26.996	2.270
A20	04/20/1981	27.145	2.270
A21	02/14/1976	19.119	2.270
A22	01/17/1977	24.631	2.270
A23	03/17/1983	29.054	2.270
A24	03/17/1983	29.003	2.270
A25	01/17/1977	24.611	2.270
A26	02/14/1976	18.664	2.270
A27	04/20/1981	27.019	2.270
A28	02/14/1976	18.404	2.270
A29	04/20/1981	27.055	2.270
A30	02/14/1976	18.643	2.270
A31	04/21/1978	29.274	2.270
A32	01/17/1977	24.611	2.270
A33	03/17/1983	27.910	2.270
A34	02/14/1976	18.635	2.270
A35	01/17/1977	25.105	2.270
A36	02/14/1976	19.136	2.270
A37	02/08/1985	28.389	2.270
A38	04/09/1982	29.581	2.270
A39	02/28/1986	30.492	2.270
A40	03/17/1983	28.952	2.270
A41	01/17/1977	25.011	2.270
A51	10/16/1998	39.914	3.800
A52	10/16/1998	40.708	3.800
A53	10/16/1998	40.585	3.800
A54	10/16/1998	38.751	3.800
A55	10/16/1998	40.390	3.800
A56	04/21/2000	48.199	3.800
A57	10/16/1998	40.258	3.800
A58	10/16/1998	38.762	3.800
A59	10/16/1998	39.762	3.800
A60	10/16/1998	38.754	3.800
A61	10/16/1998	40.318	3.800

A62	04/21/2000	48.204	3.800
A63	10/16/1998	40.592	3.800
A64	10/16/1998	39.922	3.800
A65	04/21/2000	48.037	3.800
A66	10/16/1998	38.832	3.800
A67	10/16/1998	40.723	3.800
A68	10/16/1998	40.496	3.800
A69	04/21/2000	48.261	3.800
A70	10/16/1998	39.927	3.800
A72	04/21/2000	56.311	4.100
A74	04/21/2000	56.256	4.100
A77	09/23/2001	52.198	4.100
A79	04/21/2000	46.188	4.100
A80	04/21/2000	46.331	4.100
A81	04/21/2000	46.273	4.100
A83	09/23/2001	52.264	4.100
A84	09/23/2001	52.317	4.100
A85	09/23/2001	52.198	4.100
A88	04/21/2000	56.285	4.100
A89	04/21/2000	56.328	4.100
A90	04/21/2000	46.248	4.100
A91	04/21/2000	47.541	4.100
A92	04/21/2000	47.549	4.100
A93	04/21/2000	47.509	4.100
A94	04/21/2000	47.635	4.100
A95	04/21/2000	47.514	4.100
A96	04/21/2000	47.525	4.100
A97	04/21/2000	47.534	4.100
A98	04/21/2000	47.421	4.100
B01	01/17/1977	26.771	3.040
B02	01/17/1977	29.334	3.040
B03	01/17/1977	26.839	3.040
B04	01/17/1977	27.224	3.040
B05	01/17/1977	27.639	3.040
B06	01/17/1977	26.773	3.040
B07	01/17/1977	27.804	3.040
B08	01/17/1977	27.533	3.040
B09	01/17/1977	28.944	3.040
B10	01/17/1977	27.221	3.040
B11	01/17/1977	27.183	3.040
B12	01/17/1977	26.852	3.040
B13	01/17/1977	29.327	3.040
B14	01/17/1977	28.479	3.040
B15	03/16/1984	35.750	3.040
B16	01/17/1977	27.790	3.040
B17	01/17/1977	28.406	3.040
B18	01/17/1977	28.464	3.040
B19	01/17/1977	27.738	3.040
B20	01/17/1977	27.237	3.040
B21	01/17/1977	27.227	3.040
B22	01/17/1977	26.791	3.040
B23	01/17/1977	29.374	3.040
B24	03/16/1984	35.743	3.040
B25	01/17/1977	27.145	3.040
B26	01/17/1977	26.865	3.040
B27	01/17/1977	27.122	3.040
B28	03/16/1984	35.795	3.040
B29	01/17/1977	28.504	3.040
B30	01/17/1977	26.888	3.040
B31	01/17/1977	27.748	3.040
B32	01/17/1977	26.882	3.040

B33	01/17/1977	27.762	3.040
B34	01/17/1977	28.949	3.040
B35	01/17/1977	27.176	3.040
B36	01/17/1977	28.920	3.040
B37	01/17/1977	27.664	3.040
B38	01/17/1977	28.903	3.040
B39	01/17/1977	29.375	3.040
B40	03/16/1984	35.827	3.040
B51	09/23/2001	47.425	4.100
B56	09/23/2001	39.194	4.100
B57	09/23/2001	47.452	4.100
B58	09/23/2001	47.493	4.100
B59	09/23/2001	47.461	4.100
B60	04/21/2000	39.699	4.100
B61	09/23/2001	39.349	4.100
B64	04/21/2000	39.554	4.100
B66	09/23/2001	47.446	4.100
B67	04/21/2000	39.705	4.100
B68	09/23/2001	47.376	4.100
B70	04/21/2000	39.612	4.100
B71	09/23/2001	47.437	4.100
B72	09/23/2001	47.309	4.100
B73	09/23/2001	39.278	4.100
B74	09/23/2001	39.273	4.100
B75	09/23/2001	43.287	4.500
B76	09/23/2001	43.362	4.500
B77	09/23/2001	43.252	4.500
B78	09/23/2001	43.396	4.500
B79	09/23/2001	43.303	4.500
B80	09/23/2001	53.657	4.500
B81	09/23/2001	43.261	4.500
B82	09/23/2001	43.354	4.500
B83	09/23/2001	43.235	4.500
B84	09/23/2001	53.581	4.500
B85	09/23/2001	53.675	4.500
B86	09/23/2001	53.563	4.500
B87	09/23/2001	53.952	4.500
B88	09/23/2001	53.951	4.500
B89	09/23/2001	53.952	4.500
B90	09/23/2001	52.519	4.500
B91	09/23/2001	52.500	4.500
B92	09/23/2001	53.956	4.500
B93	09/23/2001	52.488	4.500
B94	09/23/2001	52.481	4.500
C01	04/21/1978	31.468	3.410
C02	04/21/1978	36.930	3.410
C03	04/21/1978	34.252	3.410
C04	04/21/1978	35.478	3.410
C05	04/21/1978	31.534	3.410
C06	04/21/1978	34.006	3.410
C07	04/21/1978	31.684	3.410
C08	04/21/1978	31.694	3.410
C09	04/21/1978	34.140	3.410
C10	04/21/1978	34.087	3.410
C11	04/21/1978	34.381	3.410
C12	04/21/1978	33.638	3.410
C13	04/21/1978	35.429	3.410
C14	04/21/1978	34.087	3.410
C15	04/21/1978	33.543	3.410
C16	04/21/1978	34.027	3.410
C17	04/21/1978	34.034	3.410

C18	04/21/1978	36.680	3.410
C19	04/21/1978	31.450	3.410
C20	04/21/1978	35.380	3.410
C21	04/21/1978	34.039	3.410
C22	04/21/1978	34.268	3.410
C23	04/21/1978	34.057	3.410
C24	04/21/1978	37.091	3.410
C25	04/21/1978	31.693	3.410
C26	04/21/1978	34.403	3.410
C27	04/21/1978	34.086	3.410
C28	04/21/1978	37.085	3.410
C29	04/21/1978	36.963	3.410
C30	04/21/1978	33.669	3.410
C31	04/21/1978	34.041	3.410
C32	04/21/1978	33.544	3.410
C33	04/21/1978	34.391	3.410
C34	04/21/1978	35.492	3.410
C35	04/21/1978	34.125	3.410
C36	04/21/1978	37.140	3.410
C37	04/21/1978	31.784	3.410
C38	04/21/1978	37.173	3.410
C39	04/21/1978	31.629	3.410
C40	04/21/1978	36.802	3.410
C51	10/08/2004	42.399	4.040
C52	10/08/2004	51.224	4.040
C53	10/08/2004	42.275	4.040
C54	04/04/2003	36.163	4.040
C55	04/04/2003	36.043	4.040
C56	10/08/2004	42.269	4.040
C57	04/04/2003	36.061	4.040
C58	10/08/2004	42.267	4.040
C59	04/04/2003	46.056	4.000
C60	04/04/2003	46.126	4.010
C61	04/04/2003	46.079	4.010
C62	04/04/2003	46.080	4.010
C63	09/23/2001	36.187	4.010
C64	04/04/2003	44.534	4.000
C65	04/04/2003	44.524	4.000
C66	09/23/2001	36.283	4.000
C67	09/23/2001	36.260	4.000
C68	04/04/2003	44.604	4.000
C69	04/04/2003	49.984	4.010
C70	04/04/2003	44.556	4.010
C71	04/04/2003	51.442	4.480
C72	04/04/2003	51.424	4.490
C73	04/04/2003	51.447	4.490
C74	04/04/2003	51.454	4.480
C75	04/04/2003	51.447	4.480
C76	04/04/2003	51.435	4.490
C77	04/04/2003	51.450	4.480
C78	04/04/2003	51.420	4.490
C79	04/04/2003	53.584	4.460
C80	04/04/2003	52.524	4.460
C81	04/04/2003	53.561	4.460
C84	04/04/2003	53.538	4.470
C85	04/04/2003	52.500	4.460
C86	04/04/2003	53.588	4.460
C87	04/04/2003	47.703	4.430
C88	04/04/2003	47.703	4.430
C89	04/04/2003	47.673	4.430
C90	04/04/2003	47.682	4.430

C91	04/04/2003	47.691	4.430
C92	04/04/2003	47.646	4.430
C93	04/04/2003	47.637	4.430
C94	04/04/2003	47.668	4.430
C95	04/04/2003	52.629	4.460
C96	04/04/2003	52.627	4.460
D01	05/26/1979	36.254	3.280
D02	03/16/1984	34.475	3.280
D03	03/16/1984	34.452	3.280
D04	05/09/1980	34.553	3.280
D05	03/17/1983	33.832	3.280
D06	03/17/1983	33.745	3.280
D07	03/17/1983	34.006	3.280
D08	04/20/1981	31.378	3.280
D09	04/20/1981	31.523	3.280
D10	04/20/1981	31.522	3.280
D11	05/26/1979	33.476	3.280
D12	04/20/1981	31.409	3.280
D13	05/09/1980	34.524	3.280
D14	04/20/1981	31.303	3.280
D15	04/20/1981	31.285	3.280
D16	05/26/1979	33.518	3.280
D17	05/09/1980	34.665	3.280
D18	03/17/1983	33.824	3.280
D19	03/17/1983	33.803	3.280
D20	05/09/1980	34.577	3.280
D21	05/26/1979	32.993	3.280
D22	03/17/1983	33.899	3.280
D23	05/26/1979	33.505	3.280
D24	05/26/1979	36.151	3.280
D25	05/09/1980	34.731	3.280
D26	03/16/1984	34.572	3.280
D27	05/26/1979	33.034	3.280
D28	04/20/1981	31.498	3.280
D29	03/17/1983	33.779	3.280
D30	05/26/1979	32.967	3.280
D31	03/17/1983	33.824	3.280
D32	05/09/1980	34.603	3.280
D33	03/16/1984	34.644	3.280
D34	04/20/1981	31.529	3.280
D35	05/09/1980	34.671	3.280
D36	05/26/1979	36.321	3.280
D37	05/26/1979	32.974	3.280
D38	05/26/1979	36.405	3.280
D39	05/09/1980	34.672	3.280
D40	05/26/1979	33.527	3.280
D51	10/08/2004	35.232	4.040
D52	04/04/2003	37.517	4.030
D53	04/04/2003	37.529	4.030
D54	10/08/2004	35.744	4.040
D55	04/04/2003	37.519	4.030
D56	04/04/2003	37.525	4.040
D57	10/08/2004	46.331	4.040
D58	10/08/2004	46.392	4.040
D59	10/08/2004	46.388	4.030
D60	10/08/2004	46.433	4.040
D61	04/04/2003	37.482	4.030
D62	04/04/2003	37.468	4.040
D63	10/08/2004	46.369	4.040
D64	10/08/2004	46.431	4.030
D65	10/08/2004	46.150	4.050

D66	10/08/2004	35.811	4.040
D67	10/08/2004	46.402	4.030
D68	04/04/2003	37.471	4.040
D69	04/04/2003	37.450	4.050
D70	10/08/2004	35.395	4.040
D71	10/08/2004	41.798	4.480
D72	10/08/2004	41.563	4.480
D73	10/08/2004	41.537	4.480
D74	10/08/2004	41.582	4.480
D75	10/08/2004	41.542	4.470
D76	10/08/2004	41.885	4.470
D77	10/08/2004	41.539	4.470
D78	10/08/2004	41.609	4.460
D79	10/08/2004	44.449	4.450
D80	10/08/2004	44.728	4.460
D81	10/08/2004	44.851	4.460
D82	10/08/2004	44.865	4.450
D83	10/08/2004	44.250	4.420
D84	10/08/2004	40.732	4.420
D85	10/08/2004	40.974	4.420
D86	10/08/2004	44.019	4.430
D87	10/08/2004	44.146	4.420
D88	10/08/2004	44.242	4.430
D89	10/08/2004	40.726	4.420
D90	10/08/2004	41.095	4.430
E01	05/09/1980	30.574	3.300
E02	04/09/1982	33.164	3.300
E03	05/09/1980	31.686	3.300
E04	04/09/1982	33.186	3.300
E05	05/09/1980	36.646	3.300
E06	05/09/1980	30.627	3.300
E07	04/09/1982	39.723	3.300
E08	05/09/1980	36.525	3.300
E09	05/09/1980	30.420	3.300
E10	05/09/1980	30.535	3.300
E11	05/09/1980	30.337	3.300
E12	05/09/1980	31.609	3.300
E13	04/09/1982	32.940	3.300
E14	04/09/1982	39.401	3.300
E15	05/09/1980	30.499	3.300
E16	05/09/1980	36.357	3.300
E17	04/09/1982	39.489	3.300
E18	05/09/1980	30.304	3.300
E19	05/09/1980	32.782	3.300
E20	04/09/1982	39.155	3.300
E21	05/09/1980	36.373	3.300
E22	04/09/1982	32.912	3.300
E23	04/09/1982	39.172	3.300
E24	05/09/1980	32.710	3.300
E25	05/09/1980	30.388	3.300
E26	05/09/1980	32.759	3.300
E27	04/09/1982	32.926	3.300
E28	05/09/1980	36.541	3.300
E29	04/09/1982	33.048	3.300
E30	04/09/1982	39.284	3.300
E31	04/09/1982	32.926	3.300
E32	05/09/1980	32.702	3.300
E33	04/09/1982	39.155	3.300
E34	05/09/1980	31.564	3.300
E35	05/09/1980	36.517	3.300
E36	04/09/1982	39.489	3.300

E37	05/09/1980	36.469	3.300
E38	04/09/1982	33.040	3.300
E39	05/09/1980	36.541	3.300
E40	05/09/1980	31.569	3.300
E51	09/02/2006	46.237	4.470
E52	09/02/2006	44.235	4.470
E53	09/02/2006	48.212	4.470
E54	09/02/2006	46.246	4.470
E55	09/02/2006	44.352	4.470
E56	09/02/2006	44.275	4.480
E57	09/02/2006	44.782	4.470
E58	09/02/2006	48.471	4.470
E59	09/02/2006	48.726	4.470
E60	09/02/2006	48.742	4.460
E61	09/02/2006	46.025	4.460
E62	09/02/2006	48.784	4.470
E63	09/02/2006	45.974	4.460
E64	09/02/2006	48.090	4.460
E65	09/02/2006	48.252	4.470
E66	09/02/2006	47.915	4.460
E67	10/08/2004	41.760	4.420
E68	09/02/2006	47.109	4.430
E69	09/02/2006	46.864	4.420
E70	09/02/2006	47.229	4.430
E71	10/08/2004	41.561	4.420
E72	09/02/2006	47.332	4.430
E73	09/02/2006	46.828	4.430
E74	09/02/2006	47.188	4.430
E75	09/02/2006	46.741	4.430
E76	09/02/2006	46.750	4.420
E77	09/02/2006	47.226	4.430
E78	09/02/2006	47.080	4.430
E79	09/02/2006	46.865	4.430
E80	09/02/2006	47.048	4.420
E81	10/08/2004	41.619	4.430
E82	09/02/2006	47.328	4.430
E83	09/02/2006	47.114	4.430
E84	09/02/2006	47.463	4.430
E85	09/02/2006	46.767	4.430
E86	10/08/2004	41.670	4.430
E87	10/08/2004	27.455	3.300
E88	03/31/2008	42.752	3.300
E89	09/02/2006	42.491	3.300
E90	10/08/2004	27.013	3.300
F01	03/17/1983	37.904	3.100
F02	03/16/1984	38.883	3.100
F03	04/20/1981	31.890	3.100
F04	04/20/1981	33.702	3.100
F05	04/20/1981	34.353	3.100
F06	03/16/1984	38.907	3.100
F07	04/20/1981	34.365	3.100
F08	03/17/1983	37.746	3.100
F09	03/16/1984	38.993	3.100
F10	04/20/1981	34.350	3.100
F11	04/20/1981	33.398	3.100
F12	04/20/1981	33.825	3.100
F13	03/17/1983	37.687	3.100
F14	03/17/1983	37.588	3.100
F15	04/20/1981	33.393	3.100
F16	04/20/1981	29.307	3.100
F17	04/20/1981	29.315	3.100

F18	04/20/1981	31.820	3.100
F19	03/17/1983	37.746	3.100
F20	04/20/1981	29.127	3.100
F21	04/20/1981	33.456	3.100
F22	04/20/1981	34.149	3.100
F23	04/20/1981	34.157	3.100
F24	04/20/1981	34.383	3.100
F25	03/16/1984	38.857	3.100
F26	03/17/1983	37.605	3.100
F27	04/20/1981	33.791	3.100
F28	04/20/1981	31.811	3.100
F29	04/20/1981	34.095	3.100
F30	04/20/1981	31.832	3.100
F31	04/20/1981	31.784	3.100
F32	04/20/1981	33.766	3.100
F33	04/20/1981	34.343	3.100
F34	04/20/1981	31.778	3.100
F35	04/20/1981	33.276	3.100
F36	03/17/1983	37.812	3.100
F37	03/17/1983	37.878	3.100
F38	04/20/1981	32.016	3.100
F39	04/20/1981	29.231	3.100
F40	04/20/1981	31.825	3.100
F51	09/02/2006	42.898	4.330
F52	09/02/2006	42.968	4.330
F53	09/02/2006	43.609	4.330
F54	09/02/2006	43.727	4.330
F55	09/02/2006	43.470	4.360
F56	09/02/2006	43.297	4.370
F57	09/02/2006	43.791	4.370
F58	09/02/2006	43.287	4.370
F59	03/31/2008	50.763	4.400
F60	09/02/2006	42.374	4.410
F61	03/31/2008	50.464	4.410
F62	03/31/2008	51.330	4.410
F63	03/31/2008	50.846	4.410
F64	03/31/2008	50.646	4.400
F65	03/31/2008	50.797	4.410
F66	09/02/2006	43.004	4.400
F67	09/02/2006	43.128	4.400
F68	09/02/2006	42.818	4.400
F69	03/31/2008	50.826	4.410
F70	03/31/2008	51.054	4.410
F71	03/31/2008	52.802	4.420
F72	03/31/2008	53.167	4.420
F73	03/31/2008	53.295	4.420
F74	03/31/2008	53.028	4.420
F75	03/31/2008	53.317	4.420
F76	03/31/2008	53.628	4.420
F77	03/31/2008	52.999	4.420
F78	03/31/2008	52.823	4.420
F79	03/31/2008	50.754	4.770
F80	03/31/2008	48.603	4.780
F81	03/31/2008	49.146	4.780
F82	03/31/2008	49.194	4.780
F83	03/31/2008	48.316	4.780
F84	03/31/2008	50.113	4.780
F85	03/31/2008	48.515	4.780
F86	03/31/2008	48.449	4.780
F87	03/31/2008	48.619	4.780
F88	03/31/2008	47.953	4.780

F89	03/31/2008	49.141	4.780
F90	03/31/2008	50.263	4.790
F91	03/31/2008	49.359	4.780
F92	03/31/2008	48.359	4.780
F93	03/31/2008	48.358	4.780
F94	03/31/2008	50.448	4.780
G01	04/09/1982	31.486	3.200
G02	02/08/1985	32.337	3.200
G04	04/09/1982	33.340	3.200
G05	04/09/1982	31.463	3.200
G06	04/09/1982	34.365	3.200
G11	02/28/1986	33.373	3.200
G13	04/09/1982	31.518	3.200
G16	04/09/1982	34.275	3.200
G19	02/08/1985	32.413	3.200
G20	04/09/1982	33.537	3.200
G21	04/09/1982	31.539	3.200
G22	04/09/1982	31.405	3.200
G23	02/08/1985	32.467	3.200
G24	02/08/1985	32.430	3.200
G26	04/09/1982	34.423	3.200
G27	02/08/1985	32.444	3.200
G28	04/09/1982	31.497	3.200
G29	02/08/1985	32.509	3.200
G30	04/09/1982	33.554	3.200
G31	02/08/1985	32.457	3.200
G32	04/09/1982	31.423	3.200
G33	04/09/1982	33.361	3.200
G34	04/09/1982	31.456	3.200
G36	04/09/1982	34.370	3.200
G51	09/26/2009	49.820	4.300
G52	09/26/2009	49.565	4.290
G53	09/26/2009	49.539	4.290
G54	09/26/2009	49.567	4.300
G55	03/31/2008	41.564	4.290
G56	09/26/2009	49.370	4.300
G57	03/31/2008	41.255	4.290
G58	03/31/2008	40.743	4.290
G59	09/26/2009	48.982	4.290
G60	09/26/2009	49.372	4.290
G61	09/26/2009	49.383	4.290
G62	09/26/2009	49.433	4.280
G63	09/26/2009	49.343	4.280
G64	03/31/2008	40.756	4.280
G65	09/26/2009	49.386	4.290
G66	09/26/2009	48.903	4.290
G67	03/31/2008	41.929	4.440
G68	03/31/2008	42.087	4.440
G69	03/31/2008	42.431	4.440
G70	03/31/2008	42.410	4.430
G71	03/31/2008	41.120	4.470
G72	09/26/2009	51.132	4.470
G73	09/26/2009	48.455	4.470
G74	09/26/2009	48.755	4.470
G75	09/26/2009	51.031	4.470
G76	03/31/2008	39.884	4.470
G77	09/26/2009	51.215	4.480
G78	09/26/2009	51.074	4.480
G79	09/26/2009	51.457	4.470
G80	09/26/2009	51.399	4.480
G81	09/26/2009	48.068	4.480

G82	03/31/2008	41.103	4.470
G83	09/26/2009	48.787	4.470
G84	09/26/2009	50.929	4.470
G85	09/26/2009	50.627	4.480
G86	03/31/2008	40.232	4.470
G87	09/26/2009	48.979	4.680
G88	09/26/2009	48.740	4.680
G89	09/26/2009	49.173	4.670
G90	09/26/2009	48.325	4.680
G91	09/26/2009	48.516	4.680
G92	09/26/2009	49.202	4.680
G93	09/26/2009	48.571	4.670
G94	09/26/2009	49.264	4.670
H02	03/16/1984	34.848	3.200
H03	03/16/1984	31.532	3.200
H05	03/16/1984	31.525	3.200
H06	03/16/1984	34.854	3.200
H08	03/17/1983	30.871	3.200
H09	03/17/1983	30.329	3.200
H10	03/16/1984	34.836	3.200
H12	03/16/1984	34.944	3.200
H14	03/16/1984	31.514	3.200
H15	03/17/1983	30.314	3.200
H16	03/16/1984	31.524	3.200
H17	03/16/1984	34.911	3.200
H18	03/16/1984	31.527	3.200
H20	03/16/1984	35.385	3.200
H21	03/16/1984	31.477	3.200
H22	03/16/1984	35.275	3.200
H23	03/17/1983	30.768	3.200
H25	03/17/1983	30.731	3.200
H26	03/16/1984	34.720	3.200
H27	03/16/1984	34.846	3.200
H28	03/16/1984	31.527	3.200
H29	03/17/1983	30.340	3.200
H31	03/16/1984	31.519	3.200
H32	03/17/1983	30.698	3.200
H33	03/16/1984	34.756	3.200
H34	03/17/1983	30.342	3.200
H35	03/16/1984	35.320	3.200
H36	03/16/1984	35.309	3.200
H51	09/26/2009	45.132	4.610
H52	02/26/2011	51.992	4.610
H53	09/26/2009	44.776	4.610
H54	09/26/2009	45.347	4.610
H55	09/26/2009	44.181	4.610
H56	09/26/2009	44.574	4.610
H57	09/26/2009	44.284	4.600
H58	09/26/2009	44.000	4.610
H59	02/26/2011	51.566	4.610
H60	09/26/2009	45.330	4.610
H61	09/26/2009	44.749	4.610
H62	02/26/2011	51.979	4.610
H63	09/26/2009	46.040	4.610
H64	09/26/2009	44.422	4.610
H65	09/26/2009	45.044	4.600
H66	02/26/2011	51.289	4.600
H67	02/26/2011	52.208	4.710
H68	02/26/2011	51.271	4.710
H69	02/26/2011	52.482	4.710
H70	02/26/2011	50.785	4.720

H71	02/26/2011	51.862	4.710
H72	02/26/2011	51.736	4.720
H73	02/26/2011	51.398	4.720
H74	02/26/2011	52.209	4.720
H75	02/26/2011	52.063	4.740
H76	02/26/2011	52.107	4.740
H77	02/26/2011	53.099	4.740
H78	02/26/2011	53.672	4.740
H79	02/26/2011	50.777	4.800
H80	02/26/2011	54.246	4.800
H81	02/26/2011	50.177	4.800
H82	02/26/2011	51.223	4.800
H83	02/26/2011	54.479	4.790
H84	02/26/2011	49.236	4.790
H85	02/26/2011	55.302	4.800
H86	02/26/2011	53.641	4.810
H87	02/26/2011	53.951	4.810
H88	02/26/2011	54.625	4.790
H89	02/26/2011	50.577	4.790
H90	02/26/2011	50.009	4.800
H91	02/26/2011	51.924	4.800
H92	02/26/2011	54.079	4.800
H93	02/26/2011	53.821	4.800
H94	02/26/2011	49.746	4.800
I05	03/16/1984	30.842	3.200
I06	03/06/1992	32.729	3.200
I08	03/16/1984	30.789	3.200
I09	03/16/1984	32.321	3.200
I10	03/16/1984	30.918	3.200
I12	03/16/1984	30.826	3.200
I13	03/16/1984	32.472	3.200
I14	02/08/1985	36.208	3.200
I15	03/16/1984	30.939	3.200
I16	03/16/1984	30.793	3.200
I17	03/16/1984	30.916	3.200
I18	03/16/1984	31.925	3.200
I20	03/16/1984	31.926	3.200
I23	03/06/1992	32.789	3.200
I24	03/06/1992	32.804	3.200
I25	03/06/1992	32.726	3.200
I26	03/16/1984	30.793	3.200
I27	03/16/1984	32.017	3.200
I28	03/16/1984	32.341	3.200
I29	03/16/1984	32.356	3.200
I31	03/16/1984	32.132	3.200
J01	02/28/1986	31.387	3.200
J03	02/08/1985	30.189	3.200
J04	02/20/1989	40.702	3.200
J06	02/20/1989	39.533	3.200
J08	02/20/1989	39.470	3.200
J10	02/20/1989	39.677	3.200
J12	03/02/1988	35.294	3.200
J13	02/08/1985	34.219	3.200
J14	02/28/1986	31.396	3.200
J16	02/08/1985	33.396	3.200
J17	03/02/1988	41.546	3.200
J18	02/08/1985	33.423	3.200
J19	02/28/1986	31.422	3.200
J20	02/08/1985	30.139	3.200
J21	02/08/1985	30.149	3.200
J22	02/08/1985	33.497	3.200

J23	02/20/1989	39.672	3.200
J24	02/08/1985	33.415	3.200
J30	02/24/1987	40.075	3.200
J32	02/08/1985	34.273	3.200
J33	02/08/1985	33.392	3.200
J34	02/08/1985	33.535	3.200
J36	02/08/1985	30.259	3.200
J51	04/06/2012	47.420	3.910
J52	04/06/2012	47.785	3.920
J53	04/06/2012	47.654	3.920
J54	04/06/2012	48.084	3.910
J55	02/26/2011	44.156	3.910
J56	02/26/2011	44.028	3.910
J57	02/26/2011	43.928	3.920
J58	02/26/2011	42.615	3.920
J59	04/06/2012	47.623	3.920
J60	02/26/2011	43.876	3.920
J61	04/06/2012	47.983	3.920
J62	04/06/2012	47.527	3.920
J63	02/26/2011	43.843	3.910
J64	02/26/2011	42.757	3.910
J65	02/26/2011	42.651	3.920
J66	02/26/2011	44.068	3.920
J67	02/26/2011	44.533	3.920
J68	04/06/2012	47.860	3.920
J69	02/26/2011	42.745	3.910
J70	02/26/2011	43.782	3.910
J71	04/06/2012	55.251	4.290
J72	04/06/2012	54.204	4.290
J73	04/06/2012	54.337	4.290
J74	04/06/2012	54.597	4.290
J75	04/06/2012	54.368	4.290
J76	04/06/2012	54.662	4.290
J77	04/06/2012	55.025	4.290
J78	04/06/2012	54.372	4.290
J79	04/06/2012	54.449	4.290
J80	04/06/2012	54.245	4.290
J81	04/06/2012	54.634	4.290
J82	04/06/2012	54.691	4.290
J83	04/06/2012	55.255	4.290
J84	04/06/2012	54.493	4.290
J85	04/06/2012	54.235	4.290
J86	04/06/2012	54.775	4.290
J87	04/06/2012	48.492	4.280
J88	04/06/2012	48.518	4.280
J89	04/06/2012	48.867	4.280
J90	04/06/2012	48.384	4.280
J91	04/06/2012	49.007	4.280
J92	04/06/2012	48.599	4.280
J93	04/06/2012	48.687	4.280
J94	04/06/2012	49.045	4.280
J95	02/26/2011	43.327	4.290
K02	03/05/1993	36.492	3.400
K04	02/28/1986	37.244	3.400
K05	03/02/1990	35.400	3.400
K07	03/02/1990	35.314	3.400
K09	02/28/1986	37.262	3.400
K16	03/02/1990	35.245	3.400
K18	03/02/1990	35.243	3.400
K26	02/28/1986	37.232	3.400
K28	02/28/1986	37.317	3.400

K29	02/28/1986	37.269	3.400
K30	03/02/1990	35.336	3.400
K31	03/02/1990	35.200	3.400
K32	03/05/1993	36.508	3.400
K33	02/28/1986	37.178	3.400
K51	04/06/2012	41.068	4.470
K52	04/06/2012	41.611	4.470
K53	04/06/2012	41.150	4.470
K54	04/06/2012	39.238	4.470
K55	04/06/2012	39.246	4.470
K56	04/06/2012	41.350	4.470
K57	04/06/2012	41.627	4.470
K58	04/06/2012	39.254	4.470
K59	04/06/2012	39.325	4.470
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K61	04/06/2012	41.369	4.470
K62	04/06/2012	41.181	4.470
K63	05/07/2013	37.826	4.740
K64	05/07/2013	44.567	4.750
K65	05/07/2013	36.217	4.740
K66	05/07/2013	40.742	4.740
K67	05/07/2013	40.752	4.740
K68	05/07/2013	40.755	4.740
K69	05/07/2013	40.741	4.740
K70	05/07/2013	36.215	4.740
K71	05/07/2013	37.824	4.740
K72	05/07/2013	44.567	4.740
K73	05/07/2013	44.565	4.740
K74	05/07/2013	37.825	4.740
K75	05/07/2013	36.215	4.750
K76	05/07/2013	40.742	4.750
K77	05/07/2013	40.752	4.750
K78	05/07/2013	40.753	4.750
K79	05/07/2013	40.740	4.750
K80	05/07/2013	36.217	4.750
K81	05/07/2013	44.565	4.750
K82	05/07/2013	37.826	4.750
K83	05/07/2013	45.747	4.750
K84	05/07/2013	45.792	4.750
K85	05/07/2013	45.553	4.750
K86	05/07/2013	45.552	4.750
K87	05/07/2013	45.793	4.750
K88	05/07/2013	45.745	4.750
K89	05/07/2013	45.745	4.750
K90	05/07/2013	45.790	4.750
K91	05/07/2013	45.552	4.750
K92	05/07/2013	45.550	4.750
K93	05/07/2013	45.791	4.750
K94	05/07/2013	45.743	4.750
L01	03/02/1988	36.268	3.200
L07	03/02/1988	36.287	3.200
L08	02/24/1987	32.825	3.200
L09	03/02/1988	36.237	3.200
L10	02/24/1987	31.755	3.200
L11	02/24/1987	31.618	3.200
L12	02/24/1987	35.316	3.200
L13	02/24/1987	37.405	3.200
L14	02/24/1987	37.339	3.200
L15	03/02/1988	36.338	3.200
L16	02/24/1987	35.265	3.200
L17	03/02/1988	36.271	3.200

L20	03/02/1988	36.251	3.200
L21	02/24/1987	35.585	3.200
L22	02/24/1987	32.958	3.200
L23	02/24/1987	36.251	3.200
L24	02/24/1987	31.640	3.200
L25	02/24/1987	32.969	3.200
L26	03/02/1988	36.259	3.200
L27	02/24/1987	35.208	3.200
L28	02/24/1987	35.512	3.200
L29	02/24/1987	36.234	3.200
L30	02/24/1987	35.250	3.200
L31	02/24/1987	35.550	3.200
L32	02/24/1987	36.256	3.200
L33	02/24/1987	35.275	3.200
L34	02/24/1987	35.513	3.200
L35	02/24/1987	37.419	3.200
L36	02/24/1987	35.317	3.200
L51	05/07/2013	29.855	3.210
L52	05/07/2013	29.852	3.210
L53	05/07/2013	28.934	3.210
L54	05/07/2013	29.853	3.210
L55	05/07/2013	29.855	3.210
L56	05/07/2013	29.789	3.630
L57	05/07/2013	29.788	3.630
L58	05/07/2013	29.782	3.640
L59	05/07/2013	29.787	3.630
L60	05/07/2013	29.782	3.640
L61	05/07/2013	29.781	3.640
L62	05/07/2013	29.781	3.620
L63	05/07/2013	29.788	3.620
L64	05/07/2013	30.144	3.620
L65	05/07/2013	30.145	3.620
L66	05/07/2013	30.145	3.620
L67	05/07/2013	30.145	3.620
L68	05/07/2013	29.550	3.610
L69	05/07/2013	29.549	3.630
L70	05/07/2013	29.550	3.620
L71	05/07/2013	29.550	3.630
L72	05/07/2013	31.584	3.630
L73	05/07/2013	31.585	3.630
L74	05/07/2013	31.588	3.630
L75	05/07/2013	31.588	3.620
L76	05/07/2013	32.143	3.620
L77	05/07/2013	31.977	3.630
L78	05/07/2013	32.141	3.620
L79	05/07/2013	32.141	3.620
L80	05/07/2013	32.135	3.630
L81	05/07/2013	31.980	3.620
L82	05/07/2013	32.138	3.620
L83	05/07/2013	32.135	3.630
L84	05/07/2013	32.140	3.630
L85	05/07/2013	31.981	3.610
L86	05/07/2013	32.135	3.620
L87	05/07/2013	31.978	3.630
L88	05/07/2013	33.082	3.630
L89	05/07/2013	33.080	3.630
L90	05/07/2013	33.153	3.630
L91	05/07/2013	33.154	3.630
L92	05/07/2013	33.152	3.630
L93	05/07/2013	33.155	3.630
L94	05/07/2013	33.080	3.630

L95	05/07/2013	33.082	3.630
M01	04/01/1995	45.668	3.400
M04	04/02/1994	43.167	3.400
M06	02/20/1989	35.312	3.400
M09	02/20/1989	35.096	3.400
M10	02/20/1989	35.093	3.400
M11	03/02/1988	35.178	3.400
M12	03/02/1988	36.664	3.400
M14	03/02/1988	37.172	3.400
M15	02/20/1989	35.314	3.400
M16	02/20/1989	35.237	3.400
M17	03/02/1988	36.725	3.400
M18	03/02/1988	35.336	3.400
M19	02/20/1989	35.056	3.400
M20	02/20/1989	35.303	3.400
M21	03/02/1988	35.282	3.400
M24	03/09/1991	44.300	3.400
M26	02/20/1989	35.073	3.400
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M36	02/20/1989	35.130	3.400
M51	05/07/2013	16.918	4.564
M52	05/07/2013	18.055	4.564
M53	05/07/2013	18.056	4.564
M54	05/07/2013	18.047	4.564
M55	05/07/2013	18.045	4.564
M56	05/07/2013	18.021	4.564
M57	05/07/2013	16.918	4.564
M58	05/07/2013	18.020	4.564
M59	05/07/2013	18.021	4.564
M60	05/07/2013	16.918	4.564
M61	05/07/2013	18.044	4.564
M62	05/07/2013	18.021	4.564
M63	05/07/2013	16.918	4.564
M64	05/07/2013	18.045	4.564
M65	05/07/2013	18.055	4.564
M66	05/07/2013	18.056	4.564
M67	05/07/2013	15.595	4.751
M68	05/07/2013	15.594	4.751
M69	05/07/2013	16.755	4.751
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M71	05/07/2013	15.606	4.751
M72	05/07/2013	15.606	4.751
M73	05/07/2013	15.595	4.751
M74	05/07/2013	15.593	4.751
M75	05/07/2013	16.760	4.751
M76	05/07/2013	16.758	4.751
M77	05/07/2013	15.605	4.751
M78	05/07/2013	15.607	4.751
M79	05/07/2013	14.391	4.751
M80	05/07/2013	14.392	4.751
M81	05/07/2013	17.211	4.751
M82	05/07/2013	17.209	4.751
M83	05/07/2013	14.390	4.751
M84	05/07/2013	17.208	4.751
M85	05/07/2013	14.368	4.751
M86	05/07/2013	14.393	4.751

M87	05/07/2013	17.210	4.751
M88	05/07/2013	17.224	4.751
M89	05/07/2013	17.225	4.751
M90	05/07/2013	17.226	4.751
M91	05/07/2013	17.225	4.751
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M94	05/07/2013	14.368	4.751
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N03	02/20/1989	37.630	3.400
N04	02/20/1989	38.061	3.400
N05	02/20/1989	34.350	3.400
N06	02/20/1989	36.756	3.400
N07	02/20/1989	34.417	3.400
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N10	02/20/1989	36.761	3.400
N11	02/20/1989	37.543	3.400
N12	02/20/1989	31.421	3.400
N13	02/20/1989	37.533	3.400
N14	02/20/1989	37.529	3.400
N15	02/20/1989	31.387	3.400
N16	03/02/1990	36.069	3.400
N17	02/20/1989	34.347	3.400
N18	03/02/1990	36.027	3.400
N19	02/20/1989	37.996	3.400
N20	02/20/1989	37.941	3.400
N21	02/20/1989	37.509	3.400
N22	02/20/1989	31.380	3.400
N23	02/20/1989	36.781	3.400
N24	02/20/1989	31.377	3.400
N25	02/20/1989	37.996	3.400
N26	02/20/1989	31.392	3.400
N27	03/02/1990	36.082	3.400
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N29	02/20/1989	31.452	3.400
N30	02/20/1989	34.387	3.400
N31	03/02/1990	36.121	3.400
N32	02/20/1989	37.538	3.400
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O06	03/02/1990	36.529	3.400
O14	03/02/1990	36.513	3.400
O15	03/02/1990	37.409	3.400
O16	03/02/1990	36.548	3.400
O17	03/09/1991	35.493	3.400
O18	03/09/1991	35.657	3.400
O19	03/02/1990	36.846	3.400
O20	03/09/1991	35.629	3.400
O21	03/02/1990	36.491	3.400
O22	03/09/1991	35.629	3.400
O24	03/09/1991	34.321	3.400
O25	03/09/1991	39.023	3.400
O26	03/09/1991	35.653	3.400
O27	03/09/1991	35.538	3.400
O28	03/09/1991	35.582	3.400
O29	03/09/1991	35.538	3.400
O30	03/09/1991	38.959	3.400
O31	03/09/1991	35.584	3.400

O32	03/09/1991	35.517	3.400
O36	03/02/1990	36.437	3.400
P02	03/06/1992	36.425	3.400
P05	03/06/1992	36.023	3.400
P08	03/09/1991	37.421	3.400
P13	03/06/1992	36.024	3.400
S05	03/05/1993	38.046	3.500
S08	04/02/1994	34.525	3.500
S19	03/05/1993	38.094	3.500
S20	04/02/1994	34.469	3.500
S28	03/06/1992	38.155	3.500
T05	03/05/1993	36.985	3.500
T16	03/05/1993	38.262	3.500
T32	04/01/1995	35.182	3.400
T33	04/01/1995	35.200	3.400
T35	04/01/1995	35.237	3.400
U01	04/02/1994	39.412	3.460
U02	04/02/1994	37.170	3.460
U03	04/02/1994	38.700	3.460
U04	04/02/1994	36.895	3.460
U05	04/02/1994	37.201	3.460
U06	04/02/1994	39.403	3.460
U07	04/02/1994	36.910	3.460
U08	04/02/1994	38.679	3.460
U09	04/02/1994	36.875	3.460
U11	04/02/1994	38.687	3.460
U12	04/02/1994	36.740	3.460
U13	04/02/1994	36.735	3.460
U14	04/02/1994	37.178	3.460
U15	04/02/1994	39.453	3.460
U16	04/02/1994	38.890	3.460
U17	04/02/1994	38.628	3.460
U18	04/02/1994	38.666	3.460
U19	04/02/1994	36.793	3.460
U20	04/02/1994	37.170	3.460
U21	04/02/1994	38.691	3.460
U22	04/02/1994	38.957	3.460
U23	04/02/1994	38.858	3.460
U24	04/02/1994	38.716	3.460
U25	04/02/1994	38.682	3.460
U26	04/02/1994	38.885	3.460
U27	04/02/1994	36.763	3.460
U28	04/02/1994	39.354	3.460
W01	04/01/1995	39.891	3.400
W02	04/01/1995	37.913	3.400
W04	09/29/1996	49.154	3.400
W05	09/29/1996	48.969	3.400
W07	09/29/1996	43.084	3.400
W12	04/01/1995	37.544	3.400
W21	09/29/1996	48.964	3.400
W23	04/01/1995	37.550	3.400
W24	04/01/1995	37.998	3.400
W26	09/29/1996	49.256	3.400
W27	04/01/1995	39.957	3.400
W28	04/01/1995	39.955	3.400
W29	04/21/2000	42.779	3.400
W30	09/23/2001	41.167	3.400
X01	09/29/1996	33.636	3.400
X02	09/29/1996	33.602	3.400
X03	09/29/1996	44.311	3.400
X04	09/29/1996	36.725	3.400

X05	09/29/1996	36.679	3.400
X06	04/01/1995	25.004	3.400
X07	09/29/1996	44.406	3.400
X08	09/29/1996	44.242	3.400
X09	09/29/1996	33.576	3.400
X10	09/29/1996	36.689	3.400
X12	09/29/1996	36.654	3.400
X13	09/29/1996	44.327	3.400
X14	09/29/1996	33.733	3.400
X16	09/29/1996	44.232	3.400
X17	09/29/1996	42.513	3.400
X18	09/29/1996	42.468	3.400
X19	09/29/1996	42.491	3.400
X20	09/29/1996	36.635	3.400
X21	09/29/1996	36.699	3.400
X22	09/29/1996	44.399	3.400
X23	04/01/1995	24.979	3.400
X24	04/01/1995	24.961	3.400
X25	09/29/1996	36.614	3.400
X26	04/01/1995	24.975	3.400
X27	09/29/1996	36.638	3.400
X28	09/29/1996	42.500	3.400
X29	09/29/1996	44.266	3.400
X30	09/29/1996	44.321	3.400
X33	09/29/1996	31.543	3.100
X34	09/29/1996	31.534	3.100
X35	09/29/1996	31.617	3.100
X36	09/29/1996	31.608	3.100
Z01	09/29/1996	35.320	3.500
Z06	09/29/1996	35.299	3.500
Z07	09/29/1996	34.806	3.500
Z08	09/29/1996	35.319	3.500
Z10	09/29/1996	34.836	3.500
Z11	09/29/1996	35.366	3.500
Z14	10/16/1998	46.204	3.700
Z15	04/21/2000	40.877	3.700
Z16	10/16/1998	39.923	3.700
Z20	04/21/2000	40.861	3.700
Z21	04/21/2000	40.832	3.700
Z23	04/21/2000	40.828	3.700
Z25	10/16/1998	46.297	3.700
Z26	10/16/1998	46.337	3.700
Z28	04/21/2000	40.918	3.700
Z29	10/16/1998	39.994	3.700
Z30	10/16/1998	39.997	3.700
Z31	10/16/1998	39.977	3.700
Z32	10/16/1998	39.845	3.700
Z33	10/16/1998	39.867	3.700
Z34	10/16/1998	46.248	3.700
Z35	10/16/1998	39.943	3.700
Z36	10/16/1998	39.967	3.700

Run date and time: various				SFP Initial Water Temp = 80 F SFP Initial Air Temp = 80 F		
Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	TOTAL Spent Fuel Pool Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
5/8/13 0:00	34.88		34.88	13.21	10.61	
5/8/13 8:00	30.85		30.85	11.69	9.38	13
5/8/13 16:00	29.24		29.24	11.08	8.89	13
5/9/13 0:00	28.01		28.01	10.61	8.52	14
5/9/13 8:00	26.98		26.98	10.22	8.21	15
5/9/13 16:00	26.07		26.07	9.87	7.93	15
5/10/13 0:00	25.24		25.24	9.56	7.68	16
5/10/13 8:00	24.48		24.48	9.27	7.44	16
5/10/13 16:00	23.77		23.77	9.01	7.23	17
5/11/13 0:00	23.12		23.12	8.76	7.03	17
5/11/13 8:00	22.51		22.51	8.53	6.85	18
5/11/13 16:00	21.95		21.95	8.31	6.68	18
5/12/13 0:00	21.43		21.43	8.12	6.52	18
5/13/13 0:00	20.05		20.05	7.60	6.10	20
5/14/13 0:00	18.91		18.91	7.16	5.75	21
5/15/13 0:00	17.95		17.95	6.80	5.46	22
5/16/13 0:00	17.13		17.13	6.49	5.21	23
5/17/13 0:00	16.42		16.42	6.22	4.99	24
5/18/13 0:00	15.80		15.80	5.98	4.80	25
5/19/13 0:00	15.25		15.25	5.78	4.64	26
5/20/13 0:00	14.76		14.76	5.59	4.49	27
5/21/13 0:00	14.33		14.33	5.43	4.36	28
5/22/13 0:00	13.94		13.94	5.28	4.24	28
5/23/13 0:00	13.58		13.58	5.15	4.13	29
5/24/13 0:00	13.26		13.26	5.02	4.03	30
5/25/13 0:00	12.97		12.97	4.91	3.94	30

Run date and time: various				SFP Initial Water Temp = 80 F SFP Initial Air Temp = 80 F		
Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	TOTAL Spent Fuel Pool Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
5/26/13 0:00	12.70		12.70	4.81	3.86	31
5/27/13 0:00	12.45		12.45	4.72	3.79	32
5/28/13 0:00	12.22		12.22	4.63	3.72	32
5/29/13 0:00	12.01		12.01	4.55	3.65	33
5/30/13 0:00	11.81		11.81	4.47	3.59	33
5/31/13 0:00	11.63		11.63	4.40	3.54	34
6/1/13 0:00	11.46		11.46	4.34	3.48	34
6/3/13 0:00	11.14		11.14	4.22	3.39	35
6/5/13 0:00	10.85		10.85	4.11	3.30	36
6/7/13 0:00	10.60		10.60	4.01	3.22	37
6/9/13 0:00	10.36		10.36	3.92	3.15	38
6/11/13 0:00	10.14		10.14	3.84	3.08	39
6/13/13 0:00	9.93		9.93	3.76	3.02	40
6/15/13 0:00	9.74		9.74	3.69	2.96	41
6/17/13 0:00	9.55		9.55	3.62	2.90	41
6/19/13 0:00	9.38		9.38	3.55	2.85	42
6/21/13 0:00	9.21		9.21	3.49	2.80	43
6/25/13 0:00	8.90		8.90	3.37	2.71	44
6/29/13 0:00	8.63		8.63	3.27	2.62	46
7/3/13 0:00	8.37		8.37	3.17	2.55	47
7/7/13 0:00	8.14		8.14	3.08	2.48	48
7/11/13 0:00	7.93		7.93	3.00	2.41	50
7/15/13 0:00	7.73		7.73	2.93	2.35	51
7/19/13 0:00	7.55		7.55	2.86	2.30	52
7/23/13 0:00	7.38		7.38	2.79	2.24	53
7/27/13 0:00	7.22		7.22	2.73	2.20	55

Run date and time: various				SFP Initial Water Temp = 80 F SFP Initial Air Temp = 80 F		
Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	TOTAL Spent Fuel Pool Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
8/6/13 0:00	6.86		6.86	2.60	2.09	57
8/16/13 0:00	6.56		6.56	2.48	1.99	60
8/26/13 0:00	6.29		6.29	2.38	1.91	63
9/5/13 0:00	6.05		6.05	2.29	1.84	65
9/15/13 0:00	5.83		5.83	2.21	1.77	68
9/25/13 0:00	5.64		5.64	2.13	1.71	70
10/5/13 0:00	5.46		5.46	2.07	1.66	72
10/15/13 0:00	5.29		5.29	2.00	1.61	75
10/25/13 0:00	5.14		5.14	1.95	1.56	77
11/4/13 0:00	4.99		4.99	1.89	1.52	79
11/24/13 0:00	4.74		4.74	1.80	1.44	83
12/14/13 0:00	4.52		4.52	1.71	1.37	87
1/3/14 0:00	4.32		4.32	1.64	1.32	91
1/23/14 0:00	4.15		4.15	1.57	1.26	95
2/12/14 0:00	4.01		4.01	1.52	1.22	99
3/4/14 0:00	3.87		3.87	1.47	1.18	102
3/24/14 0:00	3.75		3.75	1.42	1.14	105
4/13/14 0:00	3.65		3.65	1.38	1.11	108
5/3/14 0:00	3.55		3.55	1.35	1.08	111
5/23/14 0:00	3.46		3.46	1.31	1.05	114
6/12/14 0:00	3.38		3.38	1.28	1.03	117
7/2/14 0:00	3.30		3.30	1.25	1.00	119
7/22/14 0:00	3.23		3.23	1.22	0.98	122
8/11/14 0:00	3.17		3.17	1.20	0.96	125
8/31/14 0:00	3.10		3.10	1.18	0.94	127
9/20/14 0:00	3.04		3.04	1.15	0.93	130

Run date and time: various				SFP Initial Water Temp = 80 F SFP Initial Air Temp = 80 F		
Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	TOTAL Spent Fuel Pool Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
10/10/14 0:00	2.99		2.99	1.13	0.91	132
10/30/14 0:00	2.93		2.93	1.11	0.89	135
11/19/14 0:00	2.88		2.88	1.09	0.88	137
12/9/14 0:00	2.83		2.83	1.07	0.86	139
12/29/14 0:00	2.79		2.79	1.06	0.85	142
1/18/15 0:00	2.74		2.74	1.04	0.83	144
2/7/15 0:00	2.70		2.70	1.02	0.82	146
2/27/15 0:00	2.66		2.66	1.01	0.81	148
3/19/15 0:00	2.63		2.63	0.99	0.80	150
4/8/15 0:00	2.59		2.59	0.98	0.79	152
4/28/15 0:00	2.56		2.56	0.97	0.78	154
5/18/15 0:00	2.52		2.52	0.96	0.77	156
6/7/15 0:00	2.49		2.49	0.94	0.76	158
6/27/15 0:00	2.46		2.46	0.93	0.75	160
7/17/15 0:00	2.43		2.43	0.92	0.74	162
8/6/15 0:00	2.40		2.40	0.91	0.73	164
8/26/15 0:00	2.38		2.38	0.90	0.72	166
9/15/15 0:00	2.35		2.35	0.89	0.71	168
10/5/15 0:00	2.33		2.33	0.88	0.71	170
10/25/15 0:00	2.30		2.30	0.87	0.70	171
11/14/15 0:00	2.28		2.28	0.86	0.69	173
12/4/15 0:00	2.26		2.26	0.85	0.69	175
12/24/15 0:00	2.23		2.23	0.85	0.68	177
1/13/16 0:00	2.21		2.21	0.84	0.67	178
2/2/16 0:00	2.19		2.19	0.83	0.67	180
2/22/16 0:00	2.17		2.17	0.82	0.66	181

Run date and time: various				SFP Initial Water Temp = 80 F SFP Initial Air Temp = 80 F		
Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	TOTAL Spent Fuel Pool Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
3/13/16 0:00	2.15		2.15	0.82	0.66	183
4/2/16 0:00	2.14		2.14	0.81	0.65	185
4/22/16 0:00	2.12		2.12	0.80	0.64	186

Select Fuel Pool	Select Fuel Pool File	Simulate Refueling Outage	Version Check
Surry North Anna Millstone 2 Millstone 3 Kewaunee			7/6/2011 11:09 HEATUP_P01.xlsm Version OK

This is a HEATUP Version 1 Kewaunee calculation

User Input Data

Fuel in Pool Heat Load Input		
Date and Time for Start of Pool Decay Heat Calculation	5/8/13 0:00	
Initial Pool Temperature for Time to 200 °F Calculation	80	°F
Initial Air Temperature for Time to 200 °F Calculation	80	°F
Refueling Outage Simulation Input — Core shutdown date & time =	5/1/13 18:00	
Decay time prior to offload	150	Hours
Time to offload	60	Hours
Outage length at onload	13	Days
Time to onload	60	Hours
Batch size to discharge	45	Fuel Assemblies
Discharge batch enrichment	4.80	w/o U-235
Discharge batch burnup	50000	MWD/MTU
Core average enrichment	4.80	w/o U-235
Core average burnup	39000	MWD/MTU

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	05/28/13	12:56
Fig File:	CYCLE32.fig	
Print File:	C32Disch.PRT	
Burned Assemblies:	121	
Minimum cooling time:	1.0	Days
Maximum cooling time:	0.0	Years

Run date and time: 7/10/2013 8:26:43 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
5/8/13 0:00	32.25		32.25	12.22	9.81	12.2
5/8/13 8:00	28.23		28.23	10.69	8.58	14.0
5/8/13 16:00	26.62		26.62	10.08	8.10	14.8
5/9/13 0:00	25.39		25.39	9.62	7.72	15.5
5/9/13 8:00	24.36		24.36	9.23	7.41	16.2
5/9/13 16:00	23.45		23.45	8.88	7.13	16.8
5/10/13 0:00	22.62		22.62	8.57	6.88	17.4
5/10/13 8:00	21.86		21.86	8.28	6.65	18.1
5/10/13 16:00	21.15		21.15	8.01	6.43	18.7
5/11/13 0:00	20.50		20.50	7.77	6.24	19.2

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	05/28/13	12:56
Fig File:	CYCLE32.fig	
Print File:	C32Disch.PRT	
Burned Assemblies:	121	
Minimum cooling time:	1.0	Days
Maximum cooling time:	0.0	Years

Run date and time: 7/10/2013 8:26:43 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
5/11/13 8:00	19.90		19.90	7.54	6.05	19.8
5/11/13 16:00	19.33		19.33	7.32	5.88	20.4
5/12/13 0:00	18.81		18.81	7.12	5.72	21.0
5/13/13 0:00	17.44		17.44	6.61	5.30	22.6
5/14/13 0:00	16.30		16.30	6.17	4.96	24.2
5/15/13 0:00	15.34		15.34	5.81	4.67	25.7
5/16/13 0:00	14.52		14.52	5.50	4.42	27.2
5/17/13 0:00	13.81		13.81	5.23	4.20	28.6
5/18/13 0:00	13.19		13.19	5.00	4.01	29.9
5/19/13 0:00	12.65		12.65	4.79	3.85	31.2
5/20/13 0:00	12.16		12.16	4.61	3.70	32.4
5/21/13 0:00	11.73		11.73	4.44	3.57	33.6
5/22/13 0:00	11.34		11.34	4.30	3.45	34.8
5/23/13 0:00	10.99		10.99	4.16	3.34	35.9
5/24/13 0:00	10.67		10.67	4.04	3.25	37.0
5/25/13 0:00	10.38		10.38	3.93	3.16	38.0
5/26/13 0:00	10.11		10.11	3.83	3.08	39.0
5/27/13 0:00	9.87		9.87	3.74	3.00	40.0
5/28/13 0:00	9.64		9.64	3.65	2.93	40.9
5/29/13 0:00	9.43		9.43	3.57	2.87	41.8
5/30/13 0:00	9.24		9.24	3.50	2.81	42.7
5/31/13 0:00	9.06		9.06	3.43	2.75	43.6
6/1/13 0:00	8.88		8.88	3.37	2.70	44.4
6/3/13 0:00	8.57		8.57	3.25	2.61	46.0
6/5/13 0:00	8.29		8.29	3.14	2.52	47.6
6/7/13 0:00	8.04		8.04	3.04	2.44	49.1
6/9/13 0:00	7.80		7.80	2.96	2.37	50.6
6/11/13 0:00	7.59		7.59	2.87	2.31	52.0
6/13/13 0:00	7.38		7.38	2.80	2.25	53.4
6/15/13 0:00	7.19		7.19	2.72	2.19	54.9
6/17/13 0:00	7.01		7.01	2.66	2.13	56.3
6/19/13 0:00	6.84		6.84	2.59	2.08	57.7
6/21/13 0:00	6.68		6.68	2.53	2.03	59.1
6/25/13 0:00	6.38		6.38	2.42	1.94	61.9
6/29/13 0:00	6.11		6.11	2.31	1.86	64.6
7/3/13 0:00	5.86		5.86	2.22	1.78	67.3
7/7/13 0:00	5.64		5.64	2.14	1.72	70.0
7/11/13 0:00	5.43		5.43	2.06	1.65	72.6
7/15/13 0:00	5.24		5.24	1.99	1.59	75.2
7/19/13 0:00	5.07		5.07	1.92	1.54	77.8
7/23/13 0:00	4.91		4.91	1.86	1.49	80.4
7/27/13 0:00	4.76		4.76	1.80	1.45	83.0
8/6/13 0:00	4.42		4.42	1.67	1.34	89.3
8/16/13 0:00	4.13		4.13	1.56	1.26	95.5
8/26/13 0:00	3.88		3.88	1.47	1.18	101.7
9/5/13 0:00	3.66		3.66	1.38	1.11	107.9

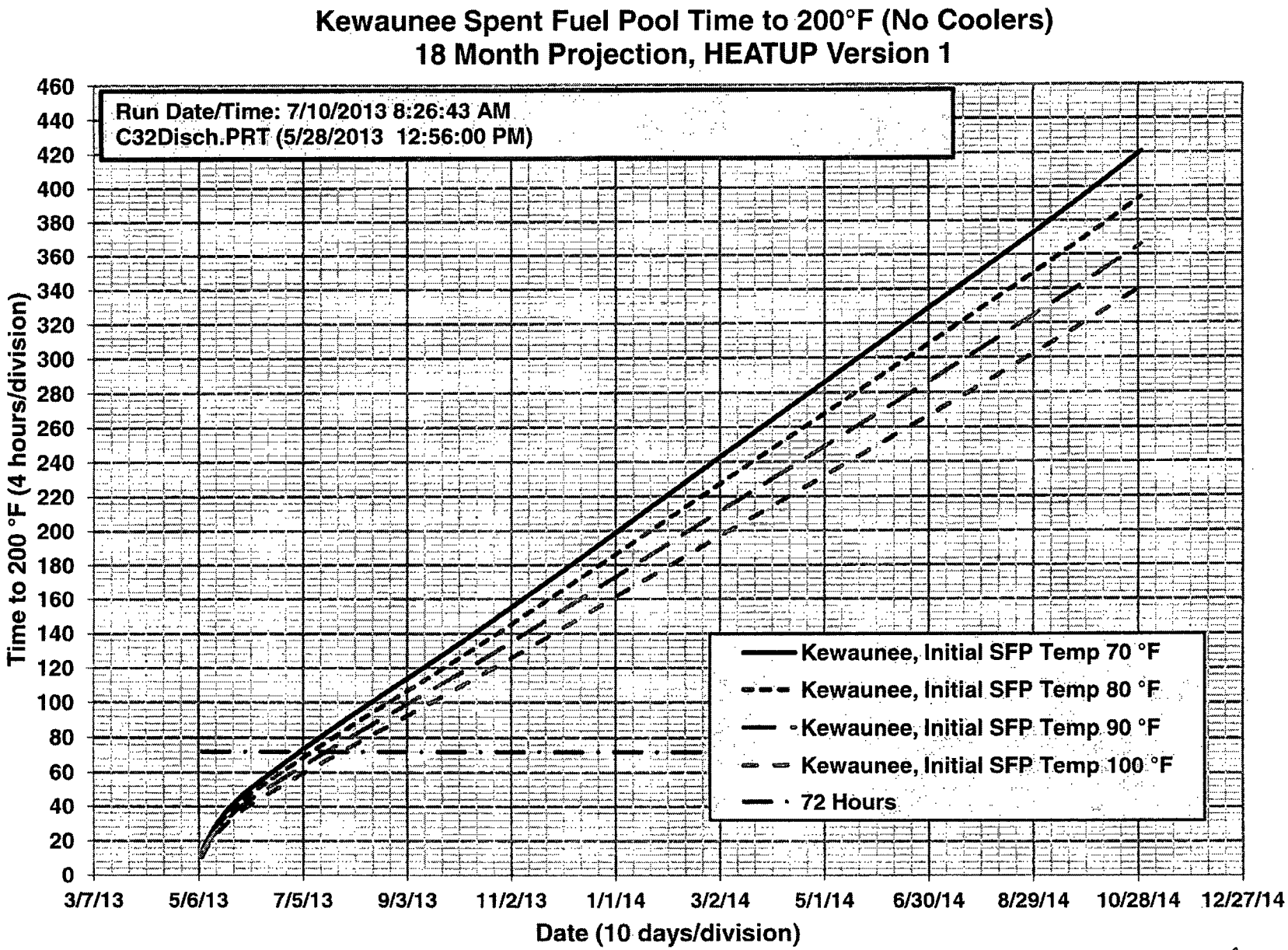
HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	05/28/13	12:56
Fig File:	CYCLE32.fig	
Print File:	C32Disch.PRT	
Burned Assemblies:	121	
Minimum cooling time:	1.0	Days
Maximum cooling time:	0.0	Years

Run date and time: 7/10/2013 8:26:43 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
9/15/13 0:00	3.46		3.46	1.31	1.05	114.2
9/25/13 0:00	3.27		3.27	1.24	1.00	120.5
10/5/13 0:00	3.11		3.11	1.18	0.95	126.9
10/15/13 0:00	2.96		2.96	1.12	0.90	133.4
10/25/13 0:00	2.82		2.82	1.07	0.86	140.0
11/4/13 0:00	2.69		2.69	1.02	0.82	146.6
11/24/13 0:00	2.46		2.46	0.93	0.75	160.1
12/14/13 0:00	2.27		2.27	0.86	0.69	173.7
1/3/14 0:00	2.10		2.10	0.80	0.64	187.5
1/23/14 0:00	1.96		1.96	0.74	0.60	201.3
2/12/14 0:00	1.84		1.84	0.70	0.56	215.0
3/4/14 0:00	1.73		1.73	0.65	0.52	228.6
3/24/14 0:00	1.63		1.63	0.62	0.50	242.2
4/13/14 0:00	1.54		1.54	0.58	0.47	255.6
5/3/14 0:00	1.47		1.47	0.56	0.45	269.1
5/23/14 0:00	1.40		1.40	0.53	0.42	282.5
6/12/14 0:00	1.33		1.33	0.51	0.41	295.9
7/2/14 0:00	1.28		1.28	0.48	0.39	309.4
7/22/14 0:00	1.22		1.22	0.46	0.37	323.0
8/11/14 0:00	1.17		1.17	0.44	0.36	336.7
8/31/14 0:00	1.13		1.13	0.43	0.34	350.6
9/20/14 0:00	1.08		1.08	0.41	0.33	364.8
10/10/14 0:00	1.04		1.04	0.39	0.32	379.2
10/30/14 0:00	1.00		1.00	0.38	0.30	394.0



Prepared by: Joel Helfenbein 7-10-13
Reviewed by: Dave Pearson 7-10-13
per email approval
Joel Helfenbein

Select Fuel Pool	Select Fuel Pool File	Simulate Refueling Outage	Version Check
Surry North Anna Millstone 2 Millstone 3 Kewaunee			7/6/2011 11:09 HEATUP_P01.xlsm Version OK

This is a HEATUP Version 1 Kewaunee calculation

User Input Data

Fuel in Pool Heat Load Input		
Date and Time for Start of Pool Decay Heat Calculation	10/30/14 0:00	
Initial Pool Temperature for Time to 200 °F Calculation	80	°F
Initial Air Temperature for Time to 200 °F Calculation	80	°F
Refueling Outage Simulation Input — Core shutdown date & time =	10/23/14 18:00	
Decay time prior to offload	150	Hours
Time to offload	60	Hours
Outage length at onload	13	Days
Time to onload	60	Hours
Batch size to discharge	45	Fuel Assemblies
Discharge batch enrichment	4.80	w/o U-235
Discharge batch burnup	50000	MWD/MTU
Core average enrichment	4.80	w/o U-235
Core average burnup	39000	MWD/MTU

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	05/28/13	12:56
Fig File:	CYCLE32.fig	
Print File:	C32Disch.PRT	
Burned Assemblies:	121	
Minimum cooling time:	541.0	Days
Maximum cooling time:	1.5	Years

Run date and time: 7/10/2013 8:27:35 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
10/30/14 0:00	1.00		1.00	0.38	0.30	394.0
10/30/14 8:00	1.00		1.00	0.38	0.30	394.4
10/30/14 16:00	1.00		1.00	0.38	0.30	394.6
10/31/14 0:00	1.00		1.00	0.38	0.30	394.8
10/31/14 8:00	1.00		1.00	0.38	0.30	395.0
10/31/14 16:00	1.00		1.00	0.38	0.30	395.2
11/1/14 0:00	1.00		1.00	0.38	0.30	395.5
11/1/14 8:00	1.00		1.00	0.38	0.30	395.7
11/1/14 16:00	1.00		1.00	0.38	0.30	395.9
11/2/14 0:00	1.00		1.00	0.38	0.30	396.2

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	05/28/13	12:56
Fig File:	CYCLE32.fig	
Print File:	C32Disch.PRT	
Burned Assemblies:	121	
Minimum cooling time:	541.0	Days
Maximum cooling time:	1.5	Years

Run date and time: 7/10/2013 8:27:35 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
11/2/14 8:00	1.00		1.00	0.38	0.30	396.4
11/2/14 16:00	0.99		0.99	0.38	0.30	396.7
11/3/14 0:00	0.99		0.99	0.38	0.30	396.9
11/4/14 0:00	0.99		0.99	0.38	0.30	397.7
11/5/14 0:00	0.99		0.99	0.38	0.30	398.4
11/6/14 0:00	0.99		0.99	0.37	0.30	399.1
11/7/14 0:00	0.99		0.99	0.37	0.30	399.8
11/8/14 0:00	0.99		0.99	0.37	0.30	400.6
11/9/14 0:00	0.98		0.98	0.37	0.30	401.3
11/10/14 0:00	0.98		0.98	0.37	0.30	402.0
11/11/14 0:00	0.98		0.98	0.37	0.30	402.7
11/12/14 0:00	0.98		0.98	0.37	0.30	403.4
11/13/14 0:00	0.98		0.98	0.37	0.30	404.2
11/14/14 0:00	0.97		0.97	0.37	0.30	404.9
11/15/14 0:00	0.97		0.97	0.37	0.30	405.6
11/16/14 0:00	0.97		0.97	0.37	0.30	406.3
11/17/14 0:00	0.97		0.97	0.37	0.29	407.0
11/18/14 0:00	0.97		0.97	0.37	0.29	407.8
11/19/14 0:00	0.97		0.97	0.37	0.29	408.5
11/20/14 0:00	0.96		0.96	0.37	0.29	409.2
11/21/14 0:00	0.96		0.96	0.36	0.29	409.9
11/22/14 0:00	0.96		0.96	0.36	0.29	410.6
11/23/14 0:00	0.96		0.96	0.36	0.29	411.4
11/25/14 0:00	0.96		0.96	0.36	0.29	412.8
11/27/14 0:00	0.95		0.95	0.36	0.29	414.3
11/29/14 0:00	0.95		0.95	0.36	0.29	415.7
12/1/14 0:00	0.95		0.95	0.36	0.29	417.2
12/3/14 0:00	0.94		0.94	0.36	0.29	418.7
12/5/14 0:00	0.94		0.94	0.36	0.29	420.1
12/7/14 0:00	0.94		0.94	0.35	0.28	421.6
12/9/14 0:00	0.93		0.93	0.35	0.28	423.1
12/11/14 0:00	0.93		0.93	0.35	0.28	424.6
12/13/14 0:00	0.93		0.93	0.35	0.28	426.1
12/17/14 0:00	0.92		0.92	0.35	0.28	429.1
12/21/14 0:00	0.91		0.91	0.35	0.28	432.1
12/25/14 0:00	0.91		0.91	0.34	0.28	435.1
12/29/14 0:00	0.90		0.90	0.34	0.27	438.1
1/2/15 0:00	0.89		0.89	0.34	0.27	441.1
1/6/15 0:00	0.89		0.89	0.34	0.27	444.1
1/10/15 0:00	0.88		0.88	0.33	0.27	447.2
1/14/15 0:00	0.88		0.88	0.33	0.27	450.2
1/18/15 0:00	0.87		0.87	0.33	0.26	453.3
1/28/15 0:00	0.86		0.86	0.32	0.26	460.9
2/7/15 0:00	0.84		0.84	0.32	0.26	468.6
2/17/15 0:00	0.83		0.83	0.31	0.25	476.3
2/27/15 0:00	0.81		0.81	0.31	0.25	484.2

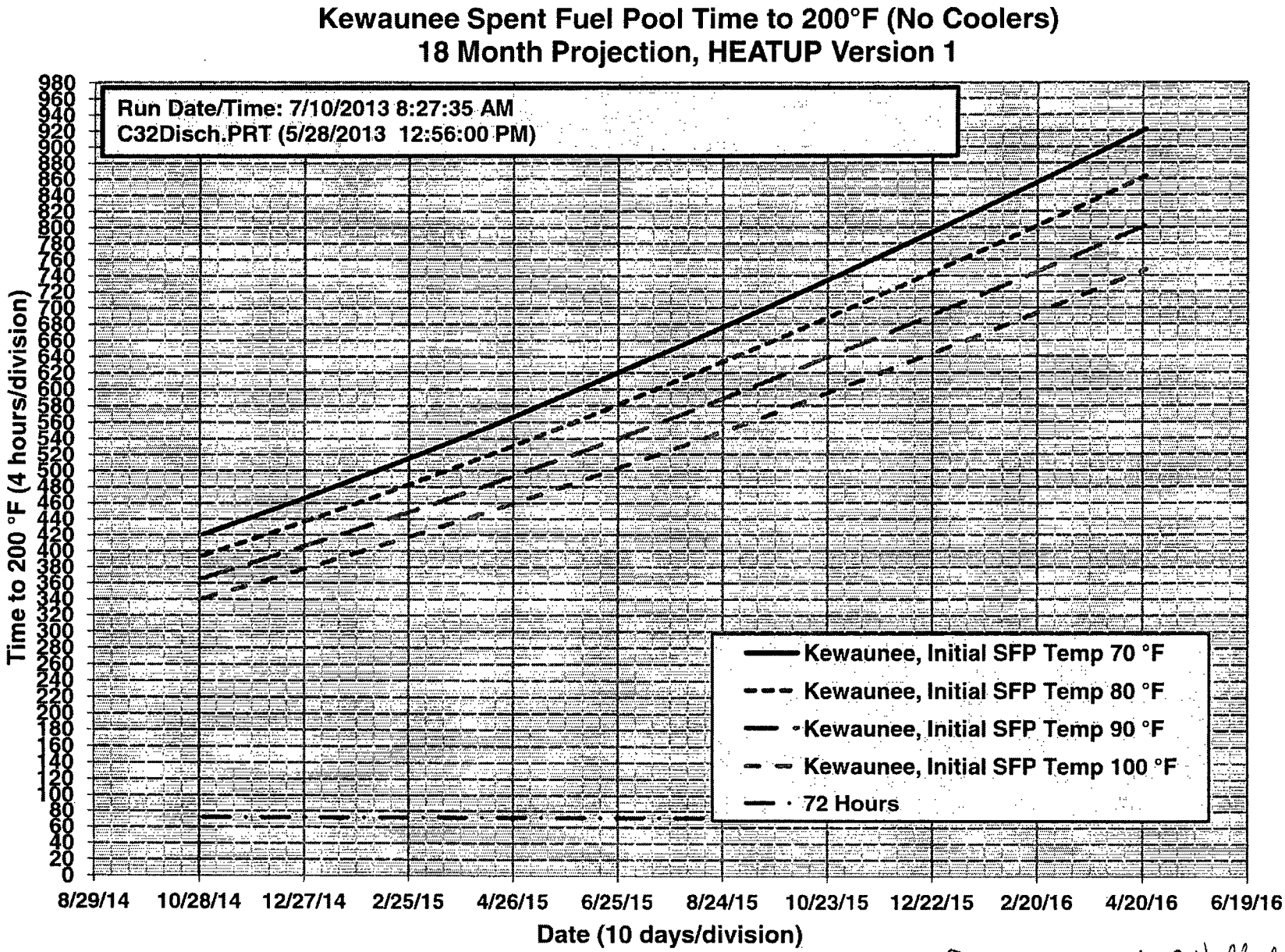
HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	05/28/13	12:56
Fig File:	CYCLE32.fig	
Print File:	C32Disch.PRT	
Burned Assemblies:	121	
Minimum cooling time:	541.0	Days
Maximum cooling time:	1.5	Years

Run date and time: 7/10/2013 8:27:35 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
3/9/15 0:00	0.80		0.80	0.30	0.24	492.0
3/19/15 0:00	0.79		0.79	0.30	0.24	500.0
3/29/15 0:00	0.78		0.78	0.29	0.24	508.0
4/8/15 0:00	0.76		0.76	0.29	0.23	516.1
4/18/15 0:00	0.75		0.75	0.29	0.23	524.2
4/28/15 0:00	0.74		0.74	0.28	0.23	532.4
5/18/15 0:00	0.72		0.72	0.27	0.22	549.0
6/7/15 0:00	0.70		0.70	0.26	0.21	565.8
6/27/15 0:00	0.68		0.68	0.26	0.21	582.8
7/17/15 0:00	0.66		0.66	0.25	0.20	600.0
8/6/15 0:00	0.64		0.64	0.24	0.19	617.5
8/26/15 0:00	0.62		0.62	0.24	0.19	635.1
9/15/15 0:00	0.60		0.60	0.23	0.18	653.0
10/5/15 0:00	0.59		0.59	0.22	0.18	671.1
10/25/15 0:00	0.57		0.57	0.22	0.17	689.4
11/14/15 0:00	0.56		0.56	0.21	0.17	707.9
12/4/15 0:00	0.54		0.54	0.21	0.17	726.6
12/24/15 0:00	0.53		0.53	0.20	0.16	745.5
1/13/16 0:00	0.52		0.52	0.20	0.16	764.7
2/2/16 0:00	0.50		0.50	0.19	0.15	784.0
2/22/16 0:00	0.49		0.49	0.19	0.15	803.6
3/13/16 0:00	0.48		0.48	0.18	0.15	823.4
4/2/16 0:00	0.47		0.47	0.18	0.14	843.3
4/22/16 0:00	0.46		0.46	0.17	0.14	863.5



Prepared by: Joel Helfenbein 7-10-13

Reviewed by: Dave Pearson 7-10-13
per email approval
Joel Helfenbein

(:ORIENTATION :PORTRAIT :CC T :TYPE :ASSEMBLY :TIME-STATE NIL :REPORT "Assembly Data for HEATUP Code")
KPS Pool - Assembly Data for HEATUP Code

Fig File: CYCLE32.fig
Print File: C32Disch.PRT
Date: 05/28/2013 Time: 12:56

Assy ID	Discharge	Burnup	Enrich
K63	05/07/2013	37.826	4.740
K64	05/07/2013	44.567	4.750
K65	05/07/2013	36.217	4.740
K66	05/07/2013	40.742	4.740
K67	05/07/2013	40.752	4.740
K68	05/07/2013	40.755	4.740
K69	05/07/2013	40.741	4.740
K70	05/07/2013	36.215	4.740
K71	05/07/2013	37.824	4.740
K72	05/07/2013	44.567	4.740
K73	05/07/2013	44.565	4.740
K74	05/07/2013	37.825	4.740
K75	05/07/2013	36.215	4.750
K76	05/07/2013	40.742	4.750
K77	05/07/2013	40.752	4.750
K78	05/07/2013	40.753	4.750
K79	05/07/2013	40.740	4.750
K80	05/07/2013	36.217	4.750
K81	05/07/2013	44.565	4.750
K82	05/07/2013	37.826	4.750
K83	05/07/2013	45.747	4.750
K84	05/07/2013	45.792	4.750
K85	05/07/2013	45.553	4.750
K86	05/07/2013	45.552	4.750
K87	05/07/2013	45.793	4.750
K88	05/07/2013	45.745	4.750
K89	05/07/2013	45.745	4.750
K90	05/07/2013	45.790	4.750
K91	05/07/2013	45.552	4.750
K92	05/07/2013	45.550	4.750
K93	05/07/2013	45.791	4.750
K94	05/07/2013	45.743	4.750
L51	05/07/2013	29.855	3.210
L52	05/07/2013	29.852	3.210
L53	05/07/2013	28.934	3.210
L54	05/07/2013	29.853	3.210
L55	05/07/2013	29.855	3.210
L56	05/07/2013	29.789	3.630
L57	05/07/2013	29.788	3.630
L58	05/07/2013	29.782	3.640
L59	05/07/2013	29.787	3.630
L60	05/07/2013	29.782	3.640
L61	05/07/2013	29.781	3.640
L62	05/07/2013	29.781	3.620
L63	05/07/2013	29.788	3.620
L64	05/07/2013	30.144	3.620
L65	05/07/2013	30.145	3.620
L66	05/07/2013	30.145	3.620
L67	05/07/2013	30.145	3.620
L68	05/07/2013	29.550	3.610
L69	05/07/2013	29.549	3.630
L70	05/07/2013	29.550	3.620

L71	05/07/2013	29.550	3.630
L72	05/07/2013	31.584	3.630
L73	05/07/2013	31.585	3.630
L74	05/07/2013	31.588	3.630
L75	05/07/2013	31.588	3.620
L76	05/07/2013	32.143	3.620
L77	05/07/2013	31.977	3.630
L78	05/07/2013	32.141	3.620
L79	05/07/2013	32.141	3.620
L80	05/07/2013	32.135	3.630
L81	05/07/2013	31.980	3.620
L82	05/07/2013	32.138	3.620
L83	05/07/2013	32.135	3.630
L84	05/07/2013	32.140	3.630
L85	05/07/2013	31.981	3.610
L86	05/07/2013	32.135	3.620
L87	05/07/2013	31.978	3.630
L88	05/07/2013	33.082	3.630
L89	05/07/2013	33.080	3.630
L90	05/07/2013	33.153	3.630
L91	05/07/2013	33.154	3.630
L92	05/07/2013	33.152	3.630
L93	05/07/2013	33.155	3.630
L94	05/07/2013	33.080	3.630
L95	05/07/2013	33.082	3.630
M51	05/07/2013	16.918	4.564
M52	05/07/2013	18.055	4.564
M53	05/07/2013	18.056	4.564
M54	05/07/2013	18.047	4.564
M55	05/07/2013	18.045	4.564
M56	05/07/2013	18.021	4.564
M57	05/07/2013	16.918	4.564
M58	05/07/2013	18.020	4.564
M59	05/07/2013	18.021	4.564
M60	05/07/2013	16.918	4.564
M61	05/07/2013	18.044	4.564
M62	05/07/2013	18.021	4.564
M63	05/07/2013	16.918	4.564
M64	05/07/2013	18.045	4.564
M65	05/07/2013	18.055	4.564
M66	05/07/2013	18.056	4.564
M67	05/07/2013	15.595	4.751
M68	05/07/2013	15.594	4.751
M69	05/07/2013	16.755	4.751
M70	05/07/2013	16.756	4.751
M71	05/07/2013	15.606	4.751
M72	05/07/2013	15.606	4.751
M73	05/07/2013	15.595	4.751
M74	05/07/2013	15.593	4.751
M75	05/07/2013	16.760	4.751
M76	05/07/2013	16.758	4.751
M77	05/07/2013	15.605	4.751
M78	05/07/2013	15.607	4.751
M79	05/07/2013	14.391	4.751
M80	05/07/2013	14.392	4.751
M81	05/07/2013	17.211	4.751
M82	05/07/2013	17.209	4.751
M83	05/07/2013	14.390	4.751
M84	05/07/2013	17.208	4.751
M85	05/07/2013	14.368	4.751
M86	05/07/2013	14.393	4.751

M87	05/07/2013	17.210	4.751
M88	05/07/2013	17.224	4.751
M89	05/07/2013	17.225	4.751
M90	05/07/2013	17.226	4.751
M91	05/07/2013	17.225	4.751
M92	05/07/2013	14.367	4.751
M93	05/07/2013	14.368	4.751
M94	05/07/2013	14.368	4.751

Same date and timesteps with only the Cycle 32 Discharged Core

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Heat Load from Cycle 32 Discharge Assemblies Only (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)	Hottest Fuel Assembly Estimate (Mbtu/hr) **	** Hottest fuel assembly approximation includes fraction of one assembly to core (1/121) x highest power fraction of last fluxmap, 1.449 (C-08, map K1C32M17)
5/8/13 0:00	32.25		32.25	12.22	9.81	12.2	0.386	
5/8/13 8:00	28.23		28.23	10.69	8.58	14.0	0.338	
5/8/13 16:00	26.62		26.62	10.08	8.10	14.8	0.319	
5/9/13 0:00	25.39		25.39	9.62	7.72	15.5	0.304	
5/9/13 8:00	24.36		24.36	9.23	7.41	16.2	0.292	
5/9/13 16:00	23.45		23.45	8.88	7.13	16.8	0.281	
5/10/13 0:00	22.62		22.62	8.57	6.88	17.4	0.271	
5/10/13 8:00	21.86		21.86	8.28	6.65	18.1	0.262	
5/10/13 16:00	21.15		21.15	8.01	6.43	18.7	0.253	
5/11/13 0:00	20.50		20.50	7.77	6.24	19.2	0.246	
5/11/13 8:00	19.90		19.90	7.54	6.05	19.8	0.238	
5/11/13 16:00	19.33		19.33	7.32	5.88	20.4	0.232	
5/12/13 0:00	18.81		18.81	7.12	5.72	21.0	0.225	
5/13/13 0:00	17.44		17.44	6.61	5.30	22.6	0.209	
5/14/13 0:00	16.30		16.30	6.17	4.96	24.2	0.195	
5/15/13 0:00	15.34		15.34	5.81	4.67	25.7	0.184	
5/16/13 0:00	14.52		14.52	5.50	4.42	27.2	0.174	
5/17/13 0:00	13.81		13.81	5.23	4.20	28.6	0.165	
5/18/13 0:00	13.19		13.19	5.00	4.01	29.9	0.158	
5/19/13 0:00	12.65		12.65	4.79	3.85	31.2	0.151	
5/20/13 0:00	12.16		12.16	4.61	3.70	32.4	0.146	
5/21/13 0:00	11.73		11.73	4.44	3.57	33.6	0.140	
5/22/13 0:00	11.34		11.34	4.30	3.45	34.8	0.136	
5/23/13 0:00	10.99		10.99	4.16	3.34	35.9	0.132	
5/24/13 0:00	10.67		10.67	4.04	3.25	37.0	0.128	
5/25/13 0:00	10.38		10.38	3.93	3.16	38.0	0.124	
5/26/13 0:00	10.11		10.11	3.83	3.08	39.0	0.121	
5/27/13 0:00	9.87		9.87	3.74	3.00	40.0	0.118	
5/28/13 0:00	9.64		9.64	3.65	2.93	40.9	0.115	
5/29/13 0:00	9.43		9.43	3.57	2.87	41.8	0.113	
5/30/13 0:00	9.24		9.24	3.50	2.81	42.7	0.111	

Same date and timesteps with only the Cycle 32 Discharged Core

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Heat Load from Cycle 32 Discharge Assemblies Only (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)	Hottest Fuel Assembly Estimate (Mbtu/hr) **	** Hottest fuel assembly approximation includes fraction of one assembly to core (1/121) x highest power fraction of last fluxmap, 1.449 (C-08, map K1C32M17)
5/31/13 0:00	9.06		9.06	3.43	2.75	43.6	0.108	
6/1/13 0:00	8.88		8.88	3.37	2.70	44.4	0.106	
6/3/13 0:00	8.57		8.57	3.25	2.61	46.0	0.103	
6/5/13 0:00	8.29		8.29	3.14	2.52	47.6	0.099	
6/7/13 0:00	8.04		8.04	3.04	2.44	49.1	0.096	
6/9/13 0:00	7.80		7.80	2.96	2.37	50.6	0.093	
6/11/13 0:00	7.59		7.59	2.87	2.31	52.0	0.091	
6/13/13 0:00	7.38		7.38	2.80	2.25	53.4	0.088	
6/15/13 0:00	7.19		7.19	2.72	2.19	54.9	0.086	
6/17/13 0:00	7.01		7.01	2.66	2.13	56.3	0.084	
6/19/13 0:00	6.84		6.84	2.59	2.08	57.7	0.082	
6/21/13 0:00	6.68		6.68	2.53	2.03	59.1	0.080	
6/25/13 0:00	6.38		6.38	2.42	1.94	61.9	0.076	
6/29/13 0:00	6.11		6.11	2.31	1.86	64.6	0.073	
7/3/13 0:00	5.86		5.86	2.22	1.78	67.3	0.070	
7/7/13 0:00	5.64		5.64	2.14	1.72	70.0	0.068	
7/11/13 0:00	5.43		5.43	2.06	1.65	72.6	0.065	
7/15/13 0:00	5.24		5.24	1.99	1.59	75.2	0.063	
7/19/13 0:00	5.07		5.07	1.92	1.54	77.8	0.061	
7/23/13 0:00	4.91		4.91	1.86	1.49	80.4	0.059	
7/27/13 0:00	4.76		4.76	1.80	1.45	83.0	0.057	
8/6/13 0:00	4.42		4.42	1.67	1.34	89.3	0.053	
8/16/13 0:00	4.13		4.13	1.56	1.26	95.5	0.049	
8/26/13 0:00	3.88		3.88	1.47	1.18	101.7	0.046	
9/5/13 0:00	3.66		3.66	1.38	1.11	107.9	0.044	
9/15/13 0:00	3.46		3.46	1.31	1.05	114.2	0.041	
9/25/13 0:00	3.27		3.27	1.24	1.00	120.5	0.039	
10/5/13 0:00	3.11		3.11	1.18	0.95	126.9	0.037	
10/15/13 0:00	2.96		2.96	1.12	0.90	133.4	0.035	
10/25/13 0:00	2.82		2.82	1.07	0.86	140.0	0.034	
11/4/13 0:00	2.69		2.69	1.02	0.82	146.6	0.032	

Same date and timesteps with only the Cycle 32 Discharged Core

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Heat Load from Cycle 32 Discharge Assemblies Only (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)	Hottest Fuel Assembly Estimate (Mbtu/hr) **	** Hottest fuel assembly approximation includes fraction of one assembly to core (1/121) x highest power fraction of last fluxmap, 1.449 (C-08, map K1C32M17)
11/24/13 0:00	2.46		2.46	0.93	0.75	160.1	0.030	
12/14/13 0:00	2.27		2.27	0.86	0.69	173.7	0.027	
1/3/14 0:00	2.10		2.10	0.80	0.64	187.5	0.025	
1/23/14 0:00	1.96		1.96	0.74	0.60	201.3	0.023	
2/12/14 0:00	1.84		1.84	0.70	0.56	215.0	0.022	
3/4/14 0:00	1.73		1.73	0.65	0.52	228.6	0.021	
3/24/14 0:00	1.63		1.63	0.62	0.50	242.2	0.020	
4/13/14 0:00	1.54		1.54	0.58	0.47	255.6	0.018	
5/3/14 0:00	1.47		1.47	0.56	0.45	269.1	0.018	
5/23/14 0:00	1.40		1.40	0.53	0.42	282.5	0.017	
6/12/14 0:00	1.33		1.33	0.51	0.41	295.9	0.016	
7/2/14 0:00	1.28		1.28	0.48	0.39	309.4	0.015	
7/22/14 0:00	1.22		1.22	0.46	0.37	323.0	0.015	
8/11/14 0:00	1.17		1.17	0.44	0.36	336.7	0.014	
8/31/14 0:00	1.13		1.13	0.43	0.34	350.6	0.013	
9/20/14 0:00	1.08		1.08	0.41	0.33	364.8	0.013	
10/10/14 0:00	1.04		1.04	0.39	0.32	379.2	0.012	
10/30/14 0:00	1.00		1.00	0.38	0.30	394.0	0.012	
11/19/14 0:00	0.97		0.97	0.37	0.29	408.5	0.012	
12/9/14 0:00	0.93		0.93	0.35	0.28	423.1	0.011	
12/29/14 0:00	0.90		0.90	0.34	0.27	438.1	0.011	
1/18/15 0:00	0.87		0.87	0.33	0.26	453.3	0.010	
2/7/15 0:00	0.84		0.84	0.32	0.26	468.6	0.010	
2/27/15 0:00	0.81		0.81	0.31	0.25	484.2	0.010	
3/19/15 0:00	0.79		0.79	0.30	0.24	500.0	0.009	
4/8/15 0:00	0.76		0.76	0.29	0.23	516.1	0.009	
4/28/15 0:00	0.74		0.74	0.28	0.23	532.4	0.009	
5/18/15 0:00	0.72		0.72	0.27	0.22	549.0	0.009	
6/7/15 0:00	0.70		0.70	0.26	0.21	565.8	0.008	
6/27/15 0:00	0.68		0.68	0.26	0.21	582.8	0.008	
7/17/15 0:00	0.66		0.66	0.25	0.20	600.0	0.008	

Same date and timesteps with only the Cycle 32 Discharged Core

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Heat Load from Cycle 32 Discharge Assemblies Only (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)	Hottest Fuel Assembly Estimate (Mbtu/hr) **	** Hottest fuel assembly approximation includes fraction of one assembly to core (1/121) x highest power fraction of last fluxmap, 1.449 (C-08, map K1C32M17)
8/6/15 0:00	0.64		0.64	0.24	0.19	617.5	0.008	
8/26/15 0:00	0.62		0.62	0.24	0.19	635.1	0.007	
9/15/15 0:00	0.60		0.60	0.23	0.18	653.0	0.007	
10/5/15 0:00	0.59		0.59	0.22	0.18	671.1	0.007	
10/25/15 0:00	0.57		0.57	0.22	0.17	689.4	0.007	
11/14/15 0:00	0.56		0.56	0.21	0.17	707.9	0.007	
12/4/15 0:00	0.54		0.54	0.21	0.17	726.6	0.007	
12/24/15 0:00	0.53		0.53	0.20	0.16	745.5	0.006	
1/13/16 0:00	0.52		0.52	0.20	0.16	764.7	0.006	
2/2/16 0:00	0.50		0.50	0.19	0.15	784.0	0.006	
2/22/16 0:00	0.49		0.49	0.19	0.15	803.6	0.006	
3/13/16 0:00	0.48		0.48	0.18	0.15	823.4	0.006	
4/2/16 0:00	0.47		0.47	0.18	0.14	843.3	0.006	
4/22/16 0:00	0.46		0.46	0.17	0.14	863.5	0.005	

Comparison of Decay Heat Values between HEATUP and ORIGEN

			A	[121 fuel assemblies]	B
Calendar Date:	Elapsed Time Since Shutdown (days)	*per assembly	per assembly	per offloaded core	^per single fuel assembly
5/8/2013 0:00	Shutdown	ORIGEN (Kwatts)	ORIGEN (Mbtu/Hr)	HEATUP code (Mbtu/hr)	(offloaded core/121) (Mbtu/hr)
5/18/2013 0:00	10	37.7	0.129	13.19	0.158
8/16/2013 0:00	100	12.2	0.042	4.13	0.049
5/8/2014 0:00	365	4.71	0.016	1.47	0.018
10/30/2014 0:00	540	2.48	0.008	1.00	0.012
5/7/2016 0:00	1095 days (3 years)	1.57	0.005	0.46	0.006

		Conservatisms in HEATUP code	[1079 fuel assemblies]	
Calendar Date:	Elapsed Time Since Shutdown (days)	difference in HEATUP vs. ORIGEN	HEATUP code best estimate heatup rate	Actual Heatup Rate
5/8/2013 0:00	Shutdown	[B - A]/[B] %	degrees F/hr	degrees F/hr
5/18/2013 0:00	10	18.56%	4.80	
8/16/2013 0:00	100	15.83%	1.99	
5/8/2014 0:00	365	8.71%	1.08	0.7**
10/30/2014 0:00	540	29.34%	0.89	
5/7/2016 0:00	1095 days (3 years)	2.75%	0.64	

For data column A:
* - reference values from procedure RE-20, Attachment A, for Region 27A
Region 27A is showing the highest decay heat loads for the time in question.

For data column B:
^- The values given in the HEATUP code for the entire discharged core (all 121 fuel assemblies) was divided by 121 to get an assembly average, and then multiplied by a factor of 1.449.
This factor comes from the last flux map which shows the highest power assembly having a power sharing factor of 1.449 when it was at full power conditions.
This value is provided for comparison to the ORIGEN runs. At 3 years timeframe, the ORIGEN values and the values in the above spreadsheet are approximately the same.

** - eSOMs data from 2/8/2012 "Control Room Log" shows the actual heatup rate when SFP cooling was removed from service for 14 hours, increased 10 degrees F
This data represents about one year of decay time for the most recently discharged fuel assemblies at that time. Although the data from HEATUP above is for the current discharged fuel
and represents current conditions going forward, the heatup rate we observed in the year 2012 at about the same decay time is representative of what we would expect to see in 2014 (following 1 year of decay time).

From: David Pearson [mailto:atomicrealestate@gmail.com]
Sent: Wednesday, July 10, 2013 10:16 AM
To: John F Helfenberger (Generation - 4)
Subject: Re: FW: for just the final core discharge assemblies

John, they look good. you can sign via email.

On Jul 10, 2013 9:33 AM, "John F Helfenberger" <john.f.helfenberger@dom.com> wrote:
Dave,
Here is email 2 of 2. This is the HEATUP runs for just the 121 offload assemblies.
Thanks for taking time out of your busy schedule to review this.
John

-----Original Message-----
From: Color 560 [mailto:PRT2947@dom.com]
Sent: Wednesday, July 10, 2013 9:22 AM
To: John F Helfenberger (Generation - 4)
Subject: Scan from a Xerox Color

Please open the attached document. It was scanned and sent to you using a Xerox Color.

Number of Images: 11
Attachment File Type: PDF

Device Name: Color 560
Device Location:

For more information on Xerox products and solutions, please visit http://www.xerox.com/

INDEX DOCUMENT INFORMATION FORM

"Information for Kewaunee Spent Fuel Pool Postulated Loss of Inventory Calculation," ETE-NAF-20130077, Rev. 0, Add. 0, by M. S. Lico, dated JUL 10 2013.

INDEX DOCUMENT INFORMATION
Index Document ID: 20130077-0-0
Index Entry Preparer(s): Michael S Lico
Index Entry Reviewers: Michael S Lico,Christopher Clemens,Jerry Kloecker,William J Eakin,John F Helfenberger

Document Title: Information for Kewaunee Spent Fuel Pool Postulated Loss of Inventory Calculation
Document Author: M. S. Lico
Document Date: 07/10/2013
Responsible Department: NAF
Responsible Group: NAF-FPE - Fuel Project Engineering Group
Applicable Sites: Kewaunee
Vendor Deliverable?: No
Owner Review Performed?: No
Owner Review Comments:

DOCUMENT HANDLING

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Plant Decommissioning Record: No
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ISFSI Record: No
Records Management Document Type: ETE
Records Management Document SubType: 000
Applicable Sites: Kewaunee
User Specified Instructions:
Additional Records Management Information: NOTE TO DOCUMENT PREPARER: Record generated under CM-AA-ETE-101. In accordance with CM-AA-ETE-101, this document should processed by Records Management under DocType=ETE, and SubType=000. The document identifier should be formatted in the Index of Record as ETE-ORG-YEAR-xxxx, where xxxx is a four-digit number (e.g., ETE-NAF-2010-1234).
Site Specific Records Management Instructions: NONENONENONENONE

RELATED REFERENCES

INDEX DOCUMENT INFORMATION FORM - Files

FILES USED TO CREATE FINAL DOCUMENT PACKAGE

1. KPS Zirc Fire ETE to S&L.docx (7/10/2013 4:01:12 PM)
2. Rx Eng SFP Heat Load Calc.pdf (7/9/2013 12:39:06 PM)

COMPUTER I/O FILES

None

INDEX DOCUMENT INFORMATION FORM - Correspondence

ASSOCIATED CORRESPONDENCE:

SENT DATE:

Recipients: Robert D Gerke,Christopher Clemens,Jerry Kloecker,William J Eakin,John Harrell,Tom Brookmire,Brian J Vitiello,John F Helfenberger

CC Recipients:

LETTER TEXT:

Attached please find the subject ETE (resent to correct the date in the INDEX entry).

INDEX DOCUMENT INFORMATION FORM - Approvals

"Information for Kewaunee Spent Fuel Pool Postulated Loss of Inventory Calculation," ETE-NAF-20130077, Rev. 0, Add. 0, by M. S. Lico, dated JUL 10 2013.

APPROVER	PURPOSE OF ELECTRONIC AUTHENTICATION	DATE APPROVED

ETE-NAF-2013-0119 Rev. 0

1. Stations:	2. Doc Type:	3. Sub Type:	4. Document Number:	5. Rev.:	6. Add:	7. Decomm?
☐MP ☐SU ☐NA ☒KW ☐CO Note: If both SU and NA, then check CO	ETE	000	ETE-NAF-2013-0119	0	0	☒Yes ☐No

8. Title:
Kewaunee Discharge Fuel Assembly Information for Spent Fuel Pool Postulated Loss of Inventory Calculation

9. ETE Level:	10. Unit(s):	11. Quality Classification:	12. FSRC Approval:
☒Level 1 ☐Level 2	☒Unit 1 ☐Unit 2 ☐Unit 3 ☐ISFSI	☐SR ☐NS ☒NSQ	☐Yes ☒No

13. Preparation, Review, and Approval Signatures (add or delete rows as needed)

Prepared by/Affiliation: (Print) M. S. Lico / NAF & J. F. Helfenberger /KPS Rx Eng	Signature: for J. Helfenberger per Fehrs	Date: 10/22/13
Reviewed by/Affiliation: (Print) S. F. Claffey / MPS Rx Eng (Spent Fuel Pool)	Signature: Stephen Claffey	Date: 10/22/13
Reviewed by/Affiliation: (Print) C. D. Clemens / NAF (Heat Loads)	Signature: C. D. Clemens	Date: 10/23/13
Program/Other Reviewer/Affiliation: (Print) N/A	Signature:	Date:
Supervisor Approval/Affiliation: (Print) W. J. Eakin / Supervisor NSAD	Signature: W J Eakin	Date: 10/24/13
Design Control Engineer (DCE) Approval/Site: (Print) N/A	Signature:	Date:
FSRC Approval/Site: (Print) N/A	Signature:	Date:

Standard Attachments	Attachment	# of pages	Reviewed/No Impact	Not Req.
14. Design Effects and Considerations (DNES-AA-GN-1003)			☐	☒
15. Document Impact Summary (DRUL) (DNES-AA-GN-1002)				☒

16. Considerations and Conditions for Document Updates (check ☒N/A if no document updates are noted on the DRUL)
☐ All Document updates noted on the DRUL can be initiated immediately
☐ Document updates noted on DRUL are delayed until the following documents/actions are completed (e.g., WO, CR, etc.)
(See DRUL Remarks section)

10CFR50.59 Attachments	Attachment	# of pages	Not Req.
17. 10CFR50.59/72.48 applicability review forms (CM AA-400)			☒
18. 10CFR50.59/72.48 screen form (CM-AA-400)			☒
19. 10CFR50.59/72.48 evaluation form (CM-AA-400)			☒

20. *Additional Attachments*

Attachment	# of pages	Description
1	6	Spent Fuel Pool Map
2	1	Limiting Cycle 29 Discharge Fuel Assembly Heat Load (Fuel Assembly G78)
3	1	Limiting Cycle 32 Discharge Fuel Assembly Heat Load (Fuel Assembly M52)
4	27	Spent Fuel Pool Heat Load Documentation for Cycle 29 (per KPS Reactor Engineering Procedure ER-AA-RXE-103)

21. *Distribution*

Primary Recipient(s): R. D. Gerke (Sargent & Lundy)
(Enter Name/Dept. or Location for EACH Primary Recipient in this block.)

Copy To?	Other Recipient/Department or Location	Copy To?	Other Recipient/Department Location
☒	Preparer – M. S. Lico	☒	J. R. Harrell / NAF
☒	Preparer – J. F. Helfenberger	☒	R. A. Borchert / MPS Rx Eng
☒	Reviewer – S. F. Claffey	☒	W. F. Zipp / KPS Nuc Eng
☒	Reviewer – C. D. Clemens	☐	
☒	Supervisor – W. J. Eakin	☐	
☒	T. R. Flowers / NAF	☐	

Table of Contents

N/A

Source Document

1. Task Release Traveler # 70157975 "Analysis for a Postulated Spent Fuel Pool Zirconium Fire at the Kewaunee Power Station," Revison 2, October 2013.

Record of Revision

Original Issue

Purpose

This Engineering Technical Evaluation (ETE) provides the present fuel assembly locations and updated fuel decay heat loads for the Kewaunee Power Station (KPS) spent fuel pool (SFP) to Sargent and Lundy (S & L) to support their analysis of the unlikely postulated event of a loss of inventory in the KPS SFP (Source Document 1). In particular, S & L requires a bounding fuel assembly decay heat load for the Cycle 29 and Cycle 32 discharge assemblies. S & L has also requested further documentation of the fuel assembly form loss coefficient. This information supports the diabatic calculation.

This ETE only provides information and inputs needed by S & L to perform their analysis per Source Document 1. In addition, the S & L analysis will be Nonsafety-related and will be performed to their quality program. Thus, this ETE is considered to be Level 1 per CM-AA-ETE-101 Step 2.3.i, and a Design Effects and Consideration review, DRUL, and 10 CFR 50.59 review are not required.

Design Inputs and Assumptions

The design inputs and assumptions will support S & L's analysis of the postulated loss of fuel pool inventory (diabatic case) in Source Document 1.

The SFP fuel assembly locations are taken from KPS SFP inventory documentation.

The design inputs and assumptions for computing bounding spent fuel assembly decay heat loads follow:

- The limiting case is a SFP grouping consisting of a Cycle 32 discharge assembly surrounded on 2 sides by a Cycle 30 and a Cycle 31 discharge assembly. The other 2 surrounding assemblies were discharged during a refueling outage before Cycle 30 (Cycle 29 or earlier). There are 13 such groupings in the South Pool (enclosed in borders on Page 3 of Attachment 1).
- The Cycle 32 discharge assembly with the highest end of cycle assembly power within these 13 groupings is fuel assembly M52. The peak assembly power factor for M52 was 1.386 per the last Cycle 32 flux map (Reference G). This peak assembly power is less than the peak assembly power of several other Cycle 32 discharge assemblies (References A and G). However, these other assemblies are surrounded by "cold" fuel assemblies (discharged before Cycle 29), and thus are not in a limiting configuration.
- S & L will use the conservatively estimated M52 heat load (Attachment 3) as the heat load for the adjacent Cycle 30 and Cycle 31 discharge fuel assemblies.
- The remaining assemblies adjacent to M52 were discharged during the Cycle 29 refueling outage:
    - The Cycle 29 discharge fuel assembly in the 13 groupings with the highest end of cycle assembly power is fuel assembly G78. Its peak assembly power factor was 0.641 per the last Cycle 29 flux map (Reference H). The other adjacent Cycle 29 discharge assembly had a slightly lower power. However, S & L will assume the conservatively estimated G78 heat load (Attachment 2) for both adjacent Cycle 29 assemblies.

S & L will use this information to compute assembly net radiative heat losses for the diabatic case.

Methodology

The method used to confirm SFP fuel assembly locations is SFP inventory inspections. The methodologies used for the SFP heat load estimate are described in Attachments 2, 3, and 4 herein, and Attachment 4 of Reference A.

First, the end of cycle heat loads for Cycle 32 (M52) and Cycle 29 (G78) are calculated based on Dominion's HEATUP code. Second, the end of cycle heat loads are divided by the number of fuel assemblies discharged at the end of the respective cycle (K1C32 = 121 assemblies and K1C29 = 44 fuel assemblies) to calculate an average heat load per discharge fuel assembly. Lastly, the maximum fuel assembly heat load values are conservatively estimated by multiplying the M52 (and G78 for K1C29) fuel assembly power by the respective average fuel assembly heat load. For example, the M52 assembly power (1.386) is multiplied by the K1C32 fuel assembly average discharge heat load.

Discussion

This ETE only provides data that S & L requested to perform their KPS SFP diabatic calculation per Source Document 1 (S & L will perform the work as Nonsafety-related to their quality program).

Attachment 1 provides present KPS SFP fuel assembly locations and identifies assemblies permanently discharged after the last three operating cycles. KPS performed SFP inventories to verify and document this information using approved site procedures (References B through F).

Attachments 2 and 3 respectively provide Cycle 29 and Cycle 32 maximum discharge fuel assembly heat load estimates. Attachment 2 summarizes relevant information presented in Attachment 4 herein, and Attachment 3 summarizes relevant information presented in Attachment 4 of Reference A (from HEATUP code). Only data for the last quarter of 2014 is listed because that is the time frame in which there appears to be enough decay time to prevent clad ignition per S & L preliminary reviews. Dominion can provide more data to S & L upon request.

S & L needs the heat load estimate for Cycle 29 and Cycle 32 discharge fuel to perform the KPS loss of spent fuel pool inventory diabatic analysis. The limiting SFP heat load scenario is the case of a Cycle 32 discharge fuel assembly adjacent to a Cycle 30 and a Cycle 31 discharge assembly. Due to its higher assembly power, the limiting case is assembly M52 in SFP location JJ-04. Its assembly power factor, which is 1.386 per the final Cycle 32 flux map, is the highest powered assembly in the 13 groupings described in the "Design Inputs and Assumptions" section above (Reference G).

Note that there are several other Cycle 32 discharge assemblies with higher assembly power factors than M52. However, all of these assemblies are surrounded on all four sides by "cold" fuel discharged before Cycle 30. The heat load for the M52 configuration bounds the heat loads associated with the higher powered assemblies because the assemblies surrounding the higher power assemblies produce much less decay heat.

The two other assemblies in the grouping were discharged during Cycle 29. One of these assemblies (G78 in SFP location JJ-03) has the highest assembly power factor (0.641) for a Cycle 29 discharge assembly located in the 13 groupings (Reference H). Both Cycle 29 adjacent assemblies are conservatively assumed to provide the heat load of assembly G78.

S & L plans to use this information for computing assembly net radiative assembly heat losses for the diabatic case using the conservative assumptions in the "Design Inputs and Assumptions" section above.

Finally, regarding the assembly form loss coefficient to support S & L's diabatic calculation, References A and I have previously documented an assembly loss coefficient of 30 for a Reynolds Number of 100 based on an assembly flow area of 32 square inches.

Cumulative Effects Review

This ETE only provides certain information to S & L for the analysis described in Source Document 1. S & L's analysis will be Nonsafety-related.

Thus, there are no cumulative effects associated with the information in this ETE.

Conclusions

This ETE provides certain data that S & L requested to support their analysis of the unlikely postulated event of a loss of SFP inventory (Source Document 1). The information provided in this ETE includes:

- present fuel assembly SFP locations, including which assemblies were discharged after Cycles 30, 31, and 32
- maximum fuel assembly heat load after final shutdown of KPS (Cycle 29 and Cycle 32 limiting discharge assembly).

S & L will use this information for their diabatic analysis, which is Nonsafety-related and will be performed to S & L's quality program.

Precautions and Limitations

NONE

Required Actions

NONE

Recommendations

NONE

References

A. Engineering Technical Evaluation ETE-NAF-2013-0077, Rev. 0, "Information for Kewaunee Spent Fuel Pool Postulated Loss of Inventory Calculation," M. S. Lico, July 10, 2013 (supplied to S & L under Dominion Correspondence CORRES-OUT-S&L-20130001, "Information for Kewaunee Spent Fuel Pool Postulated Loss of Inventory Calculation (TRT # 70157979)," from M. S. Lico [Dominion] to R. D. Gerke [S & L]), July 10, 2013.
B. KPS Work Order # KW100503534, "PM53-022: Inventory - No Grace," March 31, 2010.
C. KPS Work Order # KW100670870, "PM53-022: Inventory - (No Grace)," March 28, 2011.
D. KPS Work Order # KW100783326, "PM53-022: Inventory - (No Grace)," March 28, 2012.
E. KPS Work Order # KW100877023, "PM53-022: Inventory - (No Grace)," March 14, 2013.
F. KPS Work Order # KW100884091, "PM53-022: Inventory - (No Grace)," May 16, 2013.
G. KPS Flux Map KPS-Report-IFM-MAP 3217, April 2013.
H. KPS Flux Map KPS-Report-IFM-MAP 2920, August 2009.
I. Dominion Calculation SM-1669, Revision 0, "Kewaunee Fuel Assembly Form Loss Coefficients to Use in a Spent Fuel Pool Zirc Fire Analysis," B. J. Vitiello, July 8, 2013.

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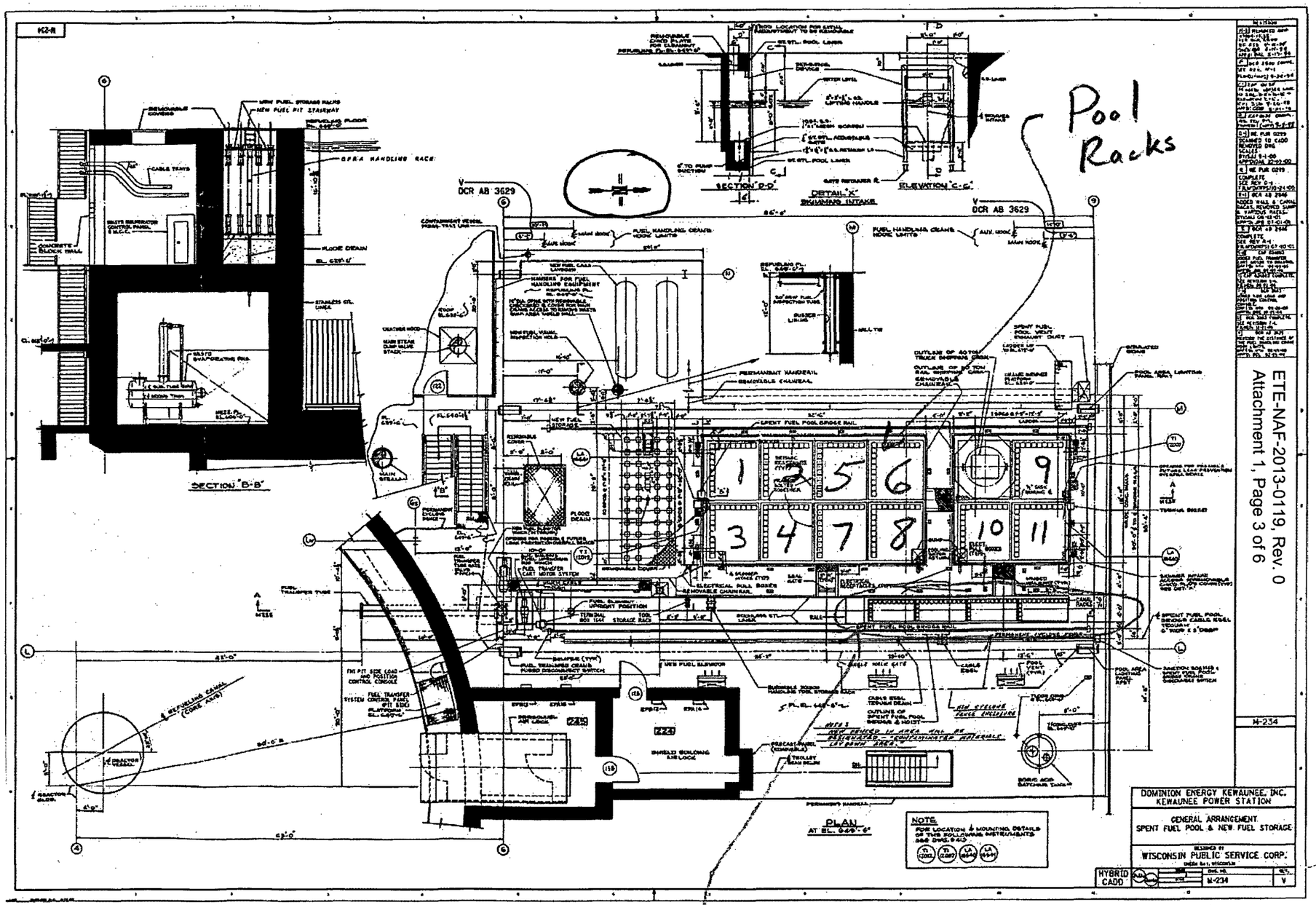
Spent Fuel Pool Map

The drawing on the next page arbitrarily hand numbers the spent fuel racks in the KPS spent fuel pool (not in the transfer canal). The racks each a have a 9 x 10 storage array, with 9 cells in the north-south direction and 10 cells in the east-west direction.

The pages after the drawing, which include a color-coded schematic marking the last 3 cycles' discharge fuel assembly locations, have a red border outlining each rack corresponding to the drawing. Also, each rack has a red text box marking the spent fuel rack number consistent with the hand markings on the drawing.

The "13 fuel assembly groupings" described in the "Design Inputs and Assumptions" section are highlighted in the cruciform shaped outlines.

NOTE: The first page of the color-coded schematic has one row of Rack 5 and Rack 7 cells on the extreme right, with these racks' remaining cells on the next page.



Canal Racks Cold cold fuel)

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Revision 0
Current Planning Simulation: Spent Fuel Pool Cycle IV
2013 SFP Post-Core Offload

RACK 5 (partial)

RACK 1

RACK 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
AA	N12 12N63	U02	E55	H65	D62	C88	F63	C62	O14 12N77	O21 12N84	N06 12N57	F91	L25 12N13	F75	N27 12N91	A81	J30 R15	J10	G85
BB	U23	U03 R17	O16 12N79	N26 12N90		H75	F61	F65	O15 12N78	M84 R64	J95		E88	M04 R24	M74	H68		J12 R44	I23 8P47
CC	U24	U05		H77	J90	C79 R57	N30 R06	L55	J67	J52	N07 12N58	N09 12N60	L78	J55	G88	K16 R37	J33 16P65	K74	J82
DD	U25 R21	H93	J88	A97	F67	L74 R65	H80	J53	O17 12N80	N29 12N85	L65	H70	J82	L21 R22	L01 8P11	L59	H88	J13 16P37	I25 8P50
EE	U26 R29	U06	G93		J60	J89	F89	G87	L71	J56	J94	G80	M06	L75 R67	J63	K18 8P15	J34 12N28	C61	M57 R76
FF	U27 R02	M78	H84	J61	S19 R09	C87 R41	L64	H69	O19 12N82	N31 12N86	N11 12N62	L52	H79	L23 12N10	F77	F80	M60 R86	J66	J08 12N5[illegible]
GG	T05	U08 R25	U07 R23	S20 R11	L61	J57	F53	G63	E72	L63	J70		E60	L24 12N12	L54	H78	G61	J16 16P67	F55
HH	W01	U09 R10	M51 R93	H74	G82	L22 12N08	G55		H91	O01 12N88	N13 12N64	M29 12N45	M63 R83	J65	F79	G69	G70	K63	K54
II	W02	H81	G91	G84	F54	L58	J69	E77	G51	D02 12N89	L85	J58	J68	E85	F90	L53 R81	J64	J18 4P23	C95
JJ	G53	U11 R14	G78	M52 R87	H66	J59	M09	N19 12N70	L82	H82	J54	E61	M11 12N34	M87 R73	H92	O03	A58	G62	K81
KK	W04	M68	H85	J87	F73	G59	L92	H90	J51	G94	N16 12N67	L76	H62	J93	E52	A65	L67	H87	G89
LL	W05	U13 R30	U12 R26	K04 R05	M64	H52	J91	P05 SS02	O25 12N96	M88 R77	H86	J92		L29 12N17	M73	H94	K05 12P24	G65	G73
MM	S05	U14	M59	H89	L27 12N15	A80	E57	L73 R88	H72	G79	N18 12N69	M34 12N49	M71	H73	L10 12P39	E80	J22 4P19	K83	K60
NN	W07	H83	U17	E58	M19 12N42	K92	H71	A85	G77	A83	K80	H76	M15 12N38	L31 12P56	L11 12P40	M82 R66	H67	J23 R33	G72
OO	F51	U15	T32	K72	K57	S08 R04	G83	E70	K67	J73	E62	M36 12N51	M16 12N39	M85 R91	H59	K28 R18	E82	J24 4P13	
PP	A60	K86	J85	A64	J06	N01 12N52	K75	J74	O29 12N00	Z30	N21 12N72	K94	J76	L33 12P58	L13 12P42	K29 8P53	K65		
QQ	T33	U18 R01	H60	T35	K73	J84	G66	G60	A59	K84	J75	G74	M18 12N41	L34 12P59	K66	J85	J04 12P20		
RR	F52	U19 R28	K70	K53	L09 12N22	A84	H54	K91	K56	H57	N23 12N74	N03 12N54	K79	K69	L15 12P44	K31 8P55	K09 12P29		
SS	H51	U20	Z33	M35 12N50	A79	M90 R79	Z31	A63	O32 16P95	A61	M91 R68	N04 12N55	E67	L36 12P61	L16 12P45	M77	N24 12N75		
TT	B51	U21	U01	G90	N22 12N73	M17 12N40	L35 12P60	P13 SS01	K30 8P54	A67	N25 12N61	N05 12N56	M21 12N44	M01 12P62	L17 12P46	K33 8P57	F86		

RACK 3

Cycle 32: K L M
(121) discharges

Cycle 31: J K L
(44) discharges

Cycle 30: H J K
(45) discharges

RACK 7 (partial)

RACK 4

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Keywords
Current (pulling simulation) Spent Fuel Pool Cycle 32
2013 SFP Post-Core Offload

N

	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
AA	M10 12N33	C80	N15 12N66	L28 12N16	F70	F18 16P92	E38 12P54	E18 16P17	D38 4P17	G54	C40 12P12	C20 12P18	G81	B20 12B35A	A41 12P52	U22 R12	C65
BB	M93 R72	D51	U28	D60	F39 16P86	F19 12N31	E39 12P53	E19 16P23	D39 4P25	D20 16P51	D01 4P27	C21 12P50	C01 16P09	B21 16P19	M30 12N46	E59	D76 RS01
CC	C69 R50	E81	E71	L81	F40 8P06	Z28	E40 16P06	E20 4P14	D40 12P38	D21 12P11	F83	C22 12P05	C02 16P47	B22 16P03	B02 16P32	A23 8P36	D59
DD	H64	K71	J83	F62	F71	G52	F01 16P90	E21 16P01	H63	Z14	D02 12P51	L94	C03 16P27	B23 16P35	G71	D75	D58
EE	I06 8P46	C75 R38	C84 R39	D55 R62	K68	J72	U04 R20	L07 12N19		D23 4P21	D03 4P31W	O36 R53	D82	6B4C 1981-1	M80 R78	C56	N28 12N92
FF		C85 R63	K88	J80	E76	L20 12N06	F03 4P22	E23 12N20	E03 16P56	D24 8P39	D04 12P34	D64	L91	J32 16P38	D84	I24 8P48	C78
GG	K82	J81	E69	H55	G56	M66 R71	F04 16P85	E24 4P28	E04 8P21	D25 4P04	L51	E83	G92	M26	E51	D74	D67
HH	C77	H58	D68 R52	K89	J71	C66	F05 16P88	E25 16P58	E05 16P02	G02 R54	D77	C93	D57	L80	C51	RACK PD12*	D63
II	F58	K78	K55	E79	C72 R46	E65	L89	E26 16P26	E06 8P17	E66	N32 12N87	M70	E84	D88	D52 R31	E78	C96
JJ	K58	C86	C92	H53	K77	K51	C52 R59	E27 12N26	E07 16P77	L69	D79 R58	A66	D65	D83	L84	C91	C94
KK	C81	F57	K87	K61	F60	N17 12N68	P02 R40	E28 12N09	E08 16P61	E86 R34	F67	N14 12N65	M56	F68	L26 12N14	K02 R49	F66
LL	K93	K52	C89 R55	G29 R08	C76	K64	J79	E29 16P41	E09 16P66	O24 12N95	L68	D86	D81	D72	M32 R27	D73	C53
MM	I14 R56	7B4C 1981-2	E64	K69	K62	L30 12P55	L08 R16	E30 16P43	E10 16P13	D87		E74		L62	E56	C58	D78
NN	G75	K90	J77	DC-1	L32 12P57	O06 PD18	K85	E31 16P63	E11 8P27		D71 R42	C33 16P42	D80	D89	D85	D70	D54
OO		D61 R45	D66 R60	E75	K76	J78	E68	E32 16P28	E12 16P24	D32 4P08	D13 4P07	C64 R36	E54	E90	L86	E63	U16 R03
PP				S28 PD80	D56 R48	P08 R51	N20 12N71	M54	E87	D33 12P35	D14 16P20	H61	L57	C74	O30 16P93	N02 12N53	C68
QQ				C90 R35	C60	L70	L14 12P43	C59 PD49	D90 R61	Z10	D15 12P33	C54	W12 R43	D69	T16	A37 16P81	N10 12N76
RR				L60	H56	Z29	Z26	Z25	E15 16P79	D35 8P34	D16 16P31	C37 12P14	C17 16P54	B37 16P08	B17 8P26	A38 16P80	C70 PD19
SS				M20 12N43	D53 PD11	F36	F16	E36 8P16	E16 16P83	D36	D17 16P78	C38 16P12	C18 16P44	B38 12P15	B18 12P32	A39 16P84	K32 8P56
TT				E53	F84	M12 12N35	F17 4P11	E37 8P18	E17 PD51	D37 12P02	D18 PD26	C39 4P26	F56	B39 16P34	B19 PD83	A40 PD74	L12 12P41

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Kewaunee
Current (planning simulation) Spent Fuel Pool - Cycle 32
2013 SFP Post-Core Offload

	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
AA																		X04
BB											F64	J21 12N30	M69	Z35	X13	G24 8P37	I18	Z16
CC											L87					L88	G31 PD04	Z15
DD														L83			X05	X02
EE												L90		1B4C 1988-1			M94 R89	X33
FF										L56		2B4C 1988-2			L66			X34
GG													L95					X35
HH											L77					L79		X36
II														M65 R82				X17
JJ											F78	G67	G57	G68	F72	F76	M79 R75	X14
KK	J01 PD61	F88	F59	G58	F81	J03 12P19	J14 16P70	B75	X21	L93	J19 8P30	X07	Z34	J20 16P29	M53 R90	F93	J36 16P39	W23
LL	A98	F69	M58	C67		B94	B85	B76	B66	B56	A88	A69	L72 R84	O18 12N81	G64	O20 12N83	O22 12N93	W24
MM	C71	C73 R47	X03	A62	Z07	X24	B86	IPLATE1 16P25	B67	B57	IMB7	A70	Z36	O26 12N97	O27 12N98	M89 R92	F92	X12
NN	X25	G86	Z11	F85	O28 12N99	X26	B87	B78	M55	B58	A90	O31 16P94	A51	M72	SAMPLE COUPON	G11 PD70	F74	W26
OO	C57	E73	Z32	Z08	X09	X27	X23	B79	G19 PD06	IPLATE3 12P04	A91	M81 R69	X06	3B4C 1979-3	G23 PD64	F82	M92 R80	W27
PP	G27 PD09	A68	G76	B77	A89	X28	B89	B80	B70	B60	A92	A72	A53	Z20	M62	M14 12N37	M24	W28
QQ	K26 R19	F94	M61	M33 12N48	B88	X29	B90	B81	X22	B61	A93	X08	M86 R85	Z21	E89	I29 8P12	J08	W29
RR	B59	A52	I13	B71	I12	X30	B91 R07	B82	B73	5B4C 1979-2	M75	A94	A54	4B4C 1979-1	I20 8P14	M67	I17 8P51	W30
SS	A74	K07 12P26	C55	Z01	I28	Z06	B92	B72	M83 R70	B68	X10	A55	A56	M76	X01	I15 16P71	W21	X20
TT	B83	A95	Z23		C63	DFA RS05	B93	B84	B74	B64	A96	A77	A57	J17 8P13	I27	X19	X18	X16

Limiting Cycle 29 Discharge Fuel Assembly Heat Load (Fuel Assembly G78)

Shutdown =	9/26/2009							
Months Since Shutdown	Date and Time	Total Heat Load (Mbtu/hr) - only the Cycle 29 Discharges	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)	Average Heat Load per Assembly (Mbtu/hr)	Highest Heat Load per Assembly - limiting combination of 13 (Mbtu/hr)	// - Highest Heat Load per Assembly - limiting combination of 13 includes fraction of one assembly to core (1/44) x highest power fraction of last fluxmap, 0.641 (Assembly G78 from Reference H)
59.1	8/28/14 0:00	0.16	0.06	0.05	1200.0	0.0037	0.0024	G78 resides in JJ-03 in the SFP (South Pool)
59.4	9/7/14 0:00	0.16	0.06	0.05	1200.0	0.0037	0.0024	
60.1	9/27/14 0:00	0.16	0.06	0.05	1200.0	0.0037	0.0023	
60.7	10/17/14 0:00	0.16	0.06	0.05	1200.0	0.0036	0.0023	
61.4	11/6/14 0:00	0.16	0.06	0.05	1200.0	0.0036	0.0023	
62.0	11/26/14 0:00	0.16	0.06	0.05	1200.0	0.0036	0.0023	
62.7	12/16/14 0:00	0.16	0.06	0.05	1200.0	0.0035	0.0023	
63.4	1/5/15 0:00	0.15	0.06	0.05	1200.0	0.0035	0.0022	

Limiting Cycle 32 Discharge Fuel Assembly Heat Load (Fuel Assembly M52)

Shutdown =	5/7/2013						
Months Since Shutdown	Date and Time	Cycle 32 Discharge Assemblies Only Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)	Hottest Fuel Assembly in South Pool Estimate (Mbtu/hr) //	// Hottest assembly approximation in South Pool includes fraction of one assembly to core (1/121) x highest power fraction of last fluxmap, 1.386 (Assembly M52 from Reference G)
15.4	8/17/14 0:00	1.16	0.44	0.35	341.2	0.013	M52 resides in JJ-04 in the SFP (South Pool)
16.0	9/6/14 0:00	1.11	0.42	0.34	355.1	0.013	
16.7	9/26/14 0:00	1.07	0.40	0.33	369.2	0.012	Although there are discharge assemblies with higher
17.3	10/15/14 0:00	1.03	0.39	0.31	383.6	0.012	peak assembly power factors per Reference G, they are
17.8	10/30/14 0:00	1.00	0.38	0.30	394.0	0.011	surrounded by "cool" assemblies and thus do not
18.0	11/5/14 0:00	0.99	0.38	0.30	398.4	0.011	represent a limiting configuration.
18.3	11/15/14 0:00	0.97	0.37	0.30	405.6	0.011	
18.8	11/29/14 0:00	0.95	0.36	0.29	415.7	0.011	
18.8	12/1/14 0:00	0.95	0.36	0.29	417.2	0.011	
19.3	12/15/14 0:00	0.92	0.35	0.28	427.5	0.011	
19.8	12/31/14 0:00	0.90	0.34	0.27	439.5	0.010	

NOTE: Some values above were interpolated from Attachment 4 of Reference A for simplicity of reviewing this table.

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Attachment 4

Spent Fuel Pool Heat Load Documentation for Cycle 29 (per KPS Reactor Engineering Procedure ER-AA-RXE-103)

(26 Pages attached)

10-17-2013

Nuclear Fleet

Dominion®

Administrative Procedure

Title: Spent Fuel Pool Heatup

Procedure Number	Revision Number	Effective Date and Approvals On File
ER-AA-RXE-103	1	

Revision Summary

Revised to add the following that did not transfer from NF-AA-RXE-103:

- 3.1 NOTE - "Performance of Step 3.1.4 is optional in the performance of Subsection 3.1."
- Added Step 3.1.3 - "Transfer of fuel from ISFSI to spent fuel pool - update should be performed prior to transferring fuel to spent fuel pool, raises decay heat load."
- Added Step 3.1.4 - "Transfer of fuel to ISFSI (or off-site) - update optional, lowers decay heat load."

Extra Runs to Support Zr fire calculations.

Only C29 and C32 offloads.

Prepared by: [signature] 10-17-13
Reviewed by: [signature] 10/22/13

Functional Area Manager: Manager Nuclear Systems Engineering

INFORMATION USE

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1.0 PURPOSE

The purpose of this document is to provide guidance to Reactor Engineers for the generation of the spent fuel pool (SFP) heatup plots as required for the response to INPO IER L1-11-2, Recommendation 3.

INPO IER L1-11-2, Recommendation 3, requires the following:

Establish, for all plant conditions, the time for the SFP to reach 200°F (bulk temperature) in the event that normal cooling is lost. Maintain this information in a format that is readily available in the control room and emergency response facilities. This time is intended for information purposes only in case a sustained loss of SFP cooling or inventory occurs.

2.0 SCOPE

This procedure is only applicable for the generation of spent fuel pool heatup plots as required for the response to INPO L1-IER 11-2, Recommendation 3.

3.0 INSTRUCTIONS

NOTE: Non-irradiated new fuel assemblies have NO decay heat. Therefore, it is NOT necessary to update the spent fuel pool heatup plot when new fuel assemblies are added to the pool.

NOTE: Removal of spent fuel assemblies from the pool results in a lower decay heat loading and a longer (more conservative) heatup time. Therefore, it is NOT required to update the spent fuel pool heatup plot when fuel is removed from the pool.

NOTE: Performance of Step 3.1.4 is optional in the performance of Subsection 3.1.

Reactor Engineer

3.1 **WHEN** any of the following events occur, **THEN UPDATE** the spent fuel pool heatup plot:

3.1.1 Refueling - update required prior to core offload or core shuffle, raises decay heat load.

* 3.1.2 Mid-cycle core offload - update should be performed prior to core offload, raises decay heat load. * Special runs for C29 offload and C32 fuel

3.1.3 Transfer of fuel from ISFSI to spent fuel pool - update should be performed prior to transferring fuel to spent fuel pool, raises decay heat load.

3.1.4 Transfer of fuel to ISFSI (or off-site) - update optional, lowers decay heat load.

3.2 **CREATE** the ShuffleWorks Input (.PRT) file using site specific guidance in Attachment 1 or 2 as appropriate.

> NOTE: The decay heat load from the Millstone 2 consolidated fuel storage boxes have been previously evaluated as insignificant (Ref. 5.4.2). It is NOT necessary to include the consolidated fuel storage boxes in the input (.PRT) file.

3.2.1 **REVIEW** the input (.PRT) file for the following attributes:

a. Configuration file (.FIG) is correct.

b. Date and Time are correct.

c. Irradiated fuel assembly discharge date, burnup or enrichment are NOT "NIL."

d. Compare a sample (e.g., 20 to 25) of different batch fuel assembly burnup values to a controlled document (i.e., a calculation or engineering technical evaluation) to ensure that measured burnup values are correct.

3.3 **SELECT** HEATUP_P01.xlsm and **CLICK** "Open".

3.4 **CLICK** the "Read Only" button when prompted for a password.

3.5 **CLICK** the "OK" button when the "Make sure EXCEL has macros enabled" message appears.

3.6 **ENSURE** that the "Version Check" says "Version OK."

> NOTE: A "CHECK VERSION" message will appear if the HEATUP last saved date and time does NOT agree within 12 hours of the date and time embedded in the code at the time of code release, or if the file name is NOT HEATUP_P01.xlsm. This may mean that the user saved a personal version of the HEATUP spreadsheet and reopened it later. The HEATUP code can NOT verify that the code version is valid unless the name and save date and times match.

3.7 IF a "CHECK VERSION" message appears, THEN **CLOSE** the EXCEL spreadsheet and **OBTAIN** a copy of the HEATUP_P01.xlsm spreadsheet from a controlled source (i.e., Nuclear Core Design).

3.8 **SELECT** the fuel pool to be updated in the "Select Fuel Pool" list.

3.9 ENTER "User Input Data" as follows:

NOTE: The start date and time is entered in cell F15 in the HEATUP_P01 spreadsheet in the format M/D/YY hh:mm.

NOTE: The default start time is the date and time when the HEATUP spreadsheet was opened.

NOTE: The start date and time is important if modeling the refueling outage core offload and onload.

3.9.1 **ENTER** the start date and time for the start of the 540 day look-ahead resident fuel decay heat calculation.

NOTE: Temperature values less than 60°F and greater than 150°F will cause a "CHECK VALUE" message to appear.

NOTE: The initial pool temperature and initial air temperature values affect the information in the "Heatup_Rate_Plot" and "Heatup_Plot_2" plots.

3.9.2 **IF** desired, **THEN ENTER** the initial pool temperature value (default value is 80°F).

3.9.3 **IF** desired, **THEN ENTER** the initial air temperature value (default value is 80°F).

3.10 **CLICK** on the "Read Fuel File and Calculate" button. A Windows Explorer pop-up menu will appear.

3.10.1 **SELECT** the directory containing the ShuffleWorks input (.PRT) file that was created using the appropriate attachment.

NOTE: If the input (.PRT) file is successfully read, a screen will appear that shows the progress of the heat load calculation.

CAUTION: HEATUP_P01 does **NOT** perform any checks to verify that the fuel file matches the spent fuel pool selected.

3.10.2 **SELECT** the ShuffleWorks input (.PRT) file that was created using the appropriate attachment.

3.10.3 IF the selected input file contains invalid data ("Error in Pool file data" error message will appear), THEN PERFORM the following:

a. **CLICK** on the "OK" button to clear the error message.

b. **REVIEW** the input (.PRT) file to determine and correct the invalid data.

NOTE: The default values for the core offload and onload parameters are estimates and are different for each plant.

NOTE: The core offload is modeled such that fuel movement starts at the date and time entered for the start of the pool decay heat calculation (Step 3.9.1). The decay time prior to offload starts before the start date and time. The shutdown date and time is the start date and time minus the decay time prior to offload and is shown in the blue header bar.

NOTE: Any changes to the start date and time values will require that the "Read Fuel File and Calculate" step be repeated (Step 3.10).

3.11 IF desired to model the core offload and onload, THEN PERFORM the following:

3.11.1 **REQUEST** Nuclear Core Design to provide the following information:

- Discharge batch enrichment (in w/o U-235)
- End-of-Cycle discharge batch burnup (in MWD/MTU)
- Core average enrichment (in w/o U-235)
- End-of-Cycle core average batch burnup (in MWD/MTU)

3.11.2 **ENTER** the expected decay time prior to core offload.

3.11.3 **ADJUST** the start date and time as required to make the core shutdown date and time agree with the actual core shutdown date and time.

3.11.4 **ENTER** the HIGHEST expected fuel pool temperature for the core offload in the "initial pool temperature" field.

3.11.5 **ENTER** the values for the remaining refueling outage parameters.

3.11.6 **CLICK** on the "Simulate Refueling Outage" button.

3.12 **REVIEW** the "Input File Data" for the following:

3.12.1 "Input File Date/Time" is consistent with the date and time of the ShuffleWorks Input (.PRT) file that was created using the appropriate attachment.

NOTE: The number of burned assemblies may NOT include all fuel items stored in the spent fuel pool (e.g., failed rod storage baskets, consolidated fuel storage boxes).

3.12.2 "Burned Assemblies" value agrees with the number of fuel assemblies currently stored in the spent fuel pool.

3.12.3 "Minimum cooling time" and "Maximum cooling time" values are reasonable considering the start date and time, and the discharge times of fuel assemblies stored in the fuel pool.

3.13 **REVIEW** the output data and plots for reasonable behavior by comparison against previously approved output data and plots.

3.14 **CHECK** that the labeling of the HEATUP plots are correct for the selected unit.

3.15 **PERFORM** ONE of the following:

3.15.1 IF modeling core offload and reload, THEN **PRINT** "Heatup_Plot_2".

3.15.2 IF performing non-core offload update, THEN **PRINT** "Heatup_Plot_1".

3.16 **SIGN** and **DATE** "Heatup_Plot_1" or "Heatup_Plot_2".

3.17 **REQUEST** that a second reactor engineer perform a Peer Review of the inputs and outputs of the HEATUP calculation in accordance with DNES-AA-GN-1001, Engineering Reviews.

Peer Reviewer 3.18 **SIGN** and **DATE** "Heatup_Plot_1" or "Heatup_Plot_2" as reviewer.

Reactor Engineer 3.19 **DISTRIBUTE** signed and dated copies of "Heatup_Plot_1" or "Heatup_Plot_2" to:

- Main Control Room
- Technical Support Center
- Emergency Operations Facility

4.0 RECORDS

4.1 The following record(s) completed as a result of this procedure are required to be transmitted to Nuclear Document Management (NDM). The records have been identified and retention requirements established for the Nuclear Records Retention Schedule (NRRS) per RM-AA-101, Record Creation, Transmittal, and Retrieval.

4.1.1 **Quality Assurance Records**

- "Heatup_Plot_1" or "Heatup_Plot_2"
- Site-Specific Heat-up Curves

4.1.2 **Non-Quality Assurance Records**

None

4.2 The following record(s) completed as a result of this procedure are NOT required to be transmitted to Nuclear Document Management (NDM), but are required to be retained as indicated below. The NRRS has been updated and Alternate Storage approved per RM-AA-101 for Quality Assurance Records.

4.2.1 **Quality Assurance Records**

None

4.2.2 **Non-Quality Assurance Records**

None

4.3 The following item(s) completed as a result of this procedure are NOT records and are NOT required to be transmitted to Nuclear Document Management (NDM).

None

5.0 ADMINISTRATIVE INFORMATION

5.1 Commitments

None

5.2 Responsibilities

5.2.1 **Reactor Engineers**

Reactor Engineers are responsible to apply the guidance in this procedure to generate the updated spent fuel pool heatup plots when specified by this procedure.

5.2.2 **Nuclear Analysis and Fuel**

Nuclear Analysis and Fuel is responsible to maintain and update the HEATUP computer code and to ensure that the ShuffleWorks neutronics data files accurately reflect the inventory, discharge dates, initial enrichments and measured burnup values of spent fuel assemblies stored in the spent fuel pool.

5.3 Definitions

None

5.4 References

5.4.1 INPO Event Report L1-11-2, dated 4/25/2011, Fukushima Daiichi Nuclear Station Spent Fuel Pool Loss of Cooling and Makeup

5.4.2 Calculation No. PM-1442, Rev. 1, HEATUP Version 1 Spent Fuel Pool Heatup Computer Code

5.4.3 ETE-NAF-2011-0104, HEATUPP01 Code Release

5.4.4 DNES-AA-GN-1001, Engineering Reviews

ATTACHMENT 1
(Page 1 of 1)
Millstone and Kewaunee Power Station PRT file Generation Guidance

NOTE: ShuffleWorks version 5.0.050106 (or later) is required to create the input (.PRT) file.

NOTE: Performance of this procedure requires a good working level of knowledge of the ShuffleWorks program.

NOTE: The "General Assembly Information" (.GAI) file and the 'Configuration' (.FIG) file are used by ShuffleWorks to create the input (.PRT) file at MPS.

NOTE: The "General Assembly Information" (.GAI) file may contain additional data, in addition to the required data specified below.

1. Ensure that a ShuffleWorks "General Assembly Information" (.GAI) file is available that contains at a minimum the following information for all irradiated fuel assemblies stored in the spent fuel pool for the desired plant:
   a. Fuel assembly identification serial number.
   b. Offload date when fuel assembly was discharged from core.
   c. Fuel assembly initial enrichment (weight percent U-235).

CAUTION: The measured fuel assembly burnup values used to generate the input (.PRT) file must NOT be reduced to account for measurement uncertainties.

   d. Measured fuel assembly Burnup.
2. Start ShuffleWorks.
3. Load the data file for the desired plant and current operating cycle.
4. Display the current spent fuel pool.

CAUTION: Failure to select all spent fuel assemblies stored in the spent fuel pool will result in a non-conservative decay heat load calculation.

5. Using the "Utility" function, highlight all fuel assemblies in the spent fuel pool.
6. Select the "Reports" function.
7. Select the "Save User Report" option.
8. Enter a descriptive file name in the pop-up box (e.g., SPS Pool Data July 2011 or KPSC30 July 2011).
9. Select the plant specific "Assembly data for HEATUP code" report option to create the input (.PRT) file.
10. Open the input (.PRT) file created in step 9 with a text editor (e.g., Wordpad or Notepad) or Excel. GO TO Step 3.2.1.

ATTACHMENT 2
(Page 1 of 2)
North Anna and Surry Power Stations PRT file Generation Guidance

NOTE: ShuffleWorks version 5.0.050106 (or later) is required to create the input (.PRT) file.

NOTE: Performance of this portion of the procedure requires a good working level of knowledge of the ShuffleWorks program.

NOTE: The "General Assembly Information" (.GAI) file, "Neutronics Information" (.NEU) File and the 'Configuration' (.FIG) file are used by ShuffleWorks to create the input (.PRT) file at the Virginia Units.

NOTE: The "General Assembly Information" (.GAI) file may contain additional data, in addition to the required data specified below.

1. Ensure that the status of the Configuration (.FIG) file is appropriate for determining the SFP fuel inventory.
2. Ensure that a ShuffleWorks "General Assembly Information" (.GAI) file is available that contains at a minimum the following information for all irradiated fuel assemblies stored in the spent fuel pool for the desired plant:
   a. Fuel assembly identification serial number.
   b. Shutdown date when fuel assembly was discharged from core.
3. Ensure that a ShuffleWorks "Neutronics Information" (.NEU) File is available that contains at a minimum the following information for all irradiated fuel assemblies stored in the spent fuel pool for the desired plant:
   a. Fuel assembly identification serial number.
   b. Fuel assembly initial enrichment (weight percent U-235).
   c. Measured (best estimate) fuel assembly Burnup.
4. Start ShuffleWorks.
5. Load the data and plant information files for the desired plant and current operating cycle.

CAUTION: Failure to select all spent fuel assemblies stored in the spent fuel pool will result in a non-conservative decay heat load calculation.

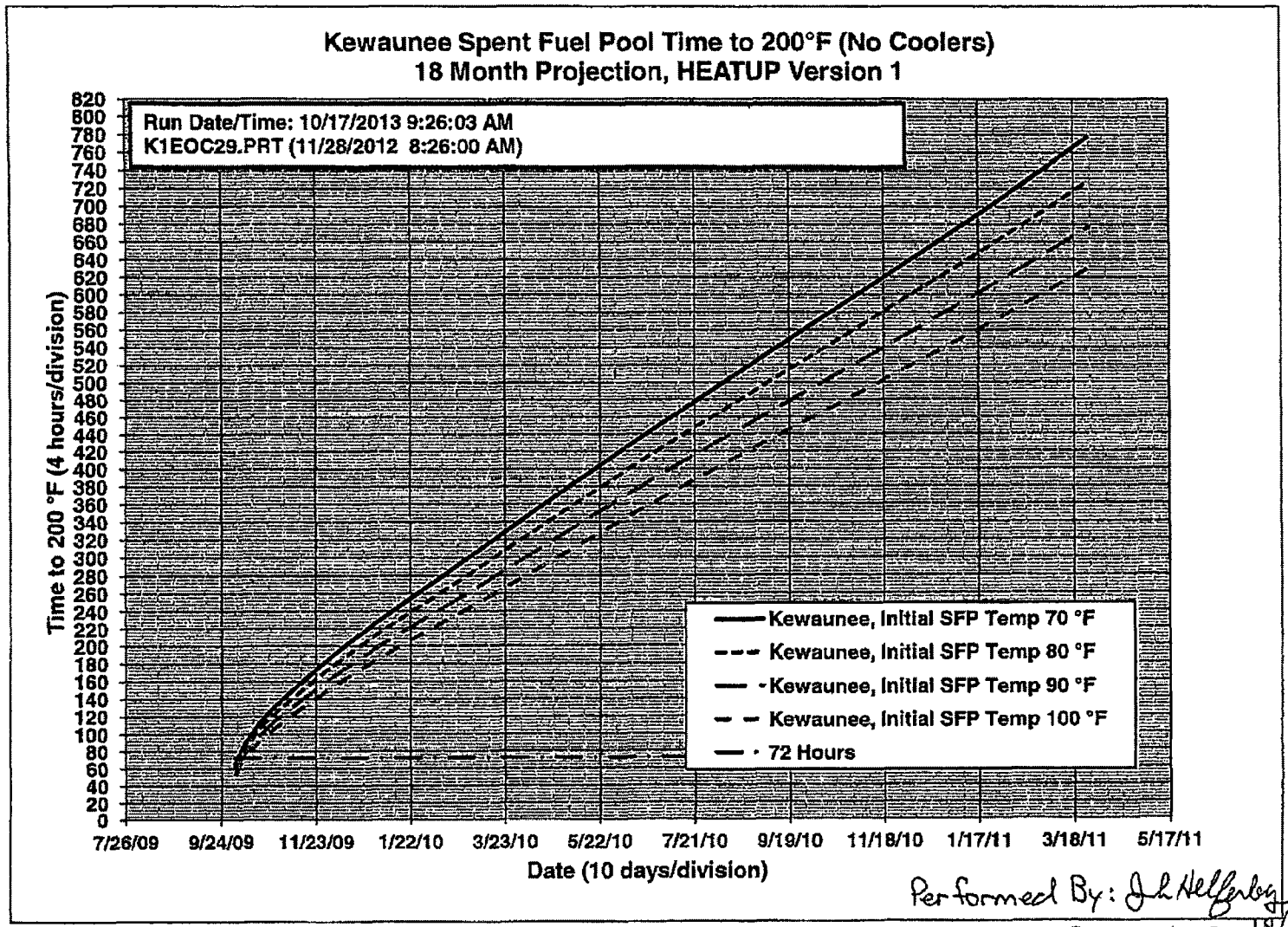
6. Select the "Reports" function.
7. Select the "Save User Report" option.
8. Enter a descriptive file name in the pop-up box (e.g., SPS Pool Data July 2011 or KPSC30 July 2011).
9. Select the plant specific "Assembly data for HEATUP code" report option to create the input (.PRT) file.

ATTACHMENT 2
(Page 2 of 2)
North Anna and Surry Power Stations PRT file Generation Guidance

10. When Prompted to select assemblies for this report, select yes.
11. Choose to select items interactively.
12. Select the Spent Fuel Pool ICA.
13. Right click in the Spent Fuel Pool Display.
14. Choose 'Select Region'.
15. Left click and hold in the Spent Fuel Pool Display to drag a box around all items in the Spent Fuel Pool.
16. When all items are selected, select done.
17. When Prompted to save the items to a file, click no.
18. Open the input (.PRT) file created by the performance of this attachment with a text editor (e.g., Wordpad or Notepad) or Excel. GO TO Step 3.2.1.

Cycle 29 Discharged Fuel

HEATUP_P01 Runs



Performed By: J L Helferby 10/17/13

Reviewed By: DJAR 10/22/13

Select Fuel Pool	Select Fuel Pool File	Simulate Refueling Outage	Version Check
Surry North Anna Millstone 2 Millstone 3 Kewaunee			7/6/2011 11:09 HEATUP_P01.xlsm Version OK

This is a HEATUP Version 1 Kewaunee calculation

User Input Data

Fuel in Pool Heat Load Input		
Date and Time for Start of Pool Decay Heat Calculation	10/3/09 0:00	
Initial Pool Temperature for Time to 200 °F Calculation	80	°F
Initial Air Temperature for Time to 200 °F Calculation	80	°F
Refueling Outage Simulation Input	Core shutdown date & time =	9/26/09 0:00
Decay time prior to offload	168	Hours
Time to offload	48	Hours
Outage length at onload	13	Days
Time to onload	60	Hours
Batch size to discharge	44	Fuel Assemblies
Discharge batch enrichment	4.70	w/o U-235
Discharge batch burnup	52000	MWD/MTU
Core average enrichment	4.80	w/o U-235
Core average burnup	39000	MWD/MTU

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLE32.fig	
Print File:	K1EOC29.PRT	
Burned Assemblies:	44	
Minimum cooling time:	7.0	Days
Maximum cooling time:	0.0	Years

Run date and time: 10/17/2013 9:26:03 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
10/3/09 0:00	6.37		6.37	2.41	1.94	61.9
10/3/09 8:00	6.16		6.16	2.33	1.87	64.0
10/3/09 16:00	6.06		6.06	2.29	1.84	65.2
10/4/09 0:00	5.96		5.96	2.26	1.81	66.2
10/4/09 8:00	5.87		5.87	2.22	1.78	67.3
10/4/09 16:00	5.77		5.77	2.19	1.76	68.3
10/5/09 0:00	5.68		5.68	2.15	1.73	69.4
10/5/09 8:00	5.59		5.59	2.12	1.70	70.6
10/5/09 16:00	5.50		5.50	2.08	1.67	71.7
10/6/09 0:00	5.41		5.41	2.05	1.65	72.9

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12 8:26	
Fig File:	CYCLE32.fig	
Print File:	K1EOC29.PRT	
Burned Assemblies:	44	
Minimum cooling time:	7.0	Days
Maximum cooling time:	0.0	Years

Run date and time: 10/17/2013 9:26:03 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
10/6/09 8:00	5.33		5.33	2.02	1.62	74.0
10/6/09 16:00	5.25		5.25	1.99	1.60	75.2
10/7/09 0:00	5.17		5.17	1.96	1.57	76.3
10/8/09 0:00	4.96		4.96	1.88	1.51	79.5
10/9/09 0:00	4.78		4.78	1.81	1.45	82.6
10/10/09 0:00	4.62		4.62	1.75	1.40	85.5
10/11/09 0:00	4.47		4.47	1.69	1.36	88.2
10/12/09 0:00	4.34		4.34	1.64	1.32	90.9
10/13/09 0:00	4.22		4.22	1.60	1.28	93.4
10/14/09 0:00	4.12		4.12	1.56	1.25	95.9
10/15/09 0:00	4.02		4.02	1.52	1.22	98.2
10/16/09 0:00	3.93		3.93	1.49	1.19	100.5
10/17/09 0:00	3.84		3.84	1.46	1.17	102.7
10/18/09 0:00	3.76		3.76	1.43	1.14	104.9
10/19/09 0:00	3.69		3.69	1.40	1.12	106.9
10/20/09 0:00	3.62		3.62	1.37	1.10	108.9
10/21/09 0:00	3.56		3.56	1.35	1.08	110.9
10/22/09 0:00	3.50		3.50	1.33	1.06	112.8
10/23/09 0:00	3.44		3.44	1.30	1.05	114.6
10/24/09 0:00	3.39		3.39	1.28	1.03	116.4
10/25/09 0:00	3.34		3.34	1.26	1.02	118.2
10/26/09 0:00	3.29		3.29	1.25	1.00	119.9
10/27/09 0:00	3.24		3.24	1.23	0.99	121.6
10/29/09 0:00	3.16		3.16	1.20	0.96	124.9
10/31/09 0:00	3.08		3.08	1.17	0.94	128.1
11/2/09 0:00	3.01		3.01	1.14	0.91	131.2
11/4/09 0:00	2.94		2.94	1.11	0.89	134.3
11/6/09 0:00	2.87		2.87	1.09	0.87	137.4
11/8/09 0:00	2.81		2.81	1.06	0.85	140.4
11/10/09 0:00	2.75		2.75	1.04	0.84	143.4
11/12/09 0:00	2.70		2.70	1.02	0.82	146.4
11/14/09 0:00	2.64		2.64	1.00	0.80	149.3
11/16/09 0:00	2.59		2.59	0.98	0.79	152.2
11/20/09 0:00	2.50		2.50	0.95	0.76	158.0
11/24/09 0:00	2.41		2.41	0.91	0.73	163.8
11/28/09 0:00	2.33		2.33	0.88	0.71	169.4
12/2/09 0:00	2.26		2.26	0.85	0.69	174.9
12/6/09 0:00	2.19		2.19	0.83	0.67	180.4
12/10/09 0:00	2.12		2.12	0.80	0.65	185.8
12/14/09 0:00	2.07		2.07	0.78	0.63	191.0
12/18/09 0:00	2.01		2.01	0.76	0.61	196.2
12/22/09 0:00	1.96		1.96	0.74	0.60	201.2
1/1/10 0:00	1.85		1.85	0.70	0.56	213.6
1/11/10 0:00	1.75		1.75	0.66	0.53	225.6
1/21/10 0:00	1.66		1.66	0.63	0.51	237.4
1/31/10 0:00	1.58		1.58	0.60	0.48	249.0

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLE32.fig	
Print File:	K1EOC29.PRT	
Burned Assemblies:	44	
Minimum cooling time:	7.0	Days
Maximum cooling time:	0.0	Years

Run date and time: 10/17/2013 9:26:03 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
2/10/10 0:00	1.51		1.51	0.57	0.48	260.5
2/20/10 0:00	1.45		1.45	0.55	0.44	272.0
3/2/10 0:00	1.39		1.39	0.53	0.42	283.6
3/12/10 0:00	1.34		1.34	0.51	0.41	295.2
3/22/10 0:00	1.29		1.29	0.49	0.39	306.8
4/1/10 0:00	1.24		1.24	0.47	0.38	318.5
4/21/10 0:00	1.15		1.15	0.44	0.35	341.8
5/11/10 0:00	1.08		1.08	0.41	0.33	365.2
5/31/10 0:00	1.02		1.02	0.38	0.31	388.5
6/20/10 0:00	0.96		0.96	0.36	0.29	411.7
7/10/10 0:00	0.91		0.91	0.34	0.28	434.7
7/30/10 0:00	0.86		0.86	0.33	0.26	457.3
8/19/10 0:00	0.82		0.82	0.31	0.25	479.8
9/8/10 0:00	0.79		0.79	0.30	0.24	502.1
9/28/10 0:00	0.75		0.75	0.29	0.23	524.2
10/18/10 0:00	0.72		0.72	0.27	0.22	546.3
11/7/10 0:00	0.69		0.69	0.26	0.21	568.4
11/27/10 0:00	0.67		0.67	0.25	0.20	590.6
12/17/10 0:00	0.64		0.64	0.24	0.20	612.9
1/6/11 0:00	0.62		0.62	0.24	0.19	635.3
1/26/11 0:00	0.60		0.60	0.23	0.18	658.0
2/15/11 0:00	0.58		0.58	0.22	0.18	681.0
3/7/11 0:00	0.56		0.56	0.21	0.17	704.3
3/27/11 0:00	0.54		0.54	0.21	0.16	728.1

Select Fuel Pool	Select Fuel Pool File	Simulate Refueling Outage	Version Check
Surry North Anna Millstone 2 Millstone 3 Kewaunee			7/6/2011 11:09 HEATUP_P01.xlsm Version OK

This is a HEATUP Version 1 Kewaunee calculation

User Input Data

Fuel in Pool Heat Load Input		
Date and Time for Start of Pool Decay Heat Calculation	3/27/11 0:00	
Initial Pool Temperature for Time to 200 °F Calculation	80	°F
Initial Air Temperature for Time to 200 °F Calculation	80	°F
Refueling Outage Simulation Input — Core shutdown date & time =	3/20/11 0:00	
Decay time prior to offload	168	Hours
Time to offload	48	Hours
Outage length at onload	13	Days
Time to onload	60	Hours
Batch size to discharge	44	Fuel Assemblies
Discharge batch enrichment	4.70	w/o U-235
Discharge batch burnup	52000	MWD/MTU
Core average enrichment	4.80	w/o U-235
Core average burnup	39000	MWD/MTU

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12 8:26	
Fig File:	CYCLE32.fig	
Print File:	K1EOC29.PRT	
Burned Assemblies:	44	
Minimum cooling time:	547.0	Days
Maximum cooling time:	1.5	Years

Run date and time: 10/17/2013 9:30:53 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
3/27/11 0:00	0.54		0.54	0.21	0.16	728.1
3/27/11 8:00	0.54		0.54	0.21	0.16	728.7
3/27/11 16:00	0.54		0.54	0.20	0.16	729.1
3/28/11 0:00	0.54		0.54	0.20	0.16	729.4
3/28/11 8:00	0.54		0.54	0.20	0.16	729.8
3/28/11 16:00	0.54		0.54	0.20	0.16	730.1
3/29/11 0:00	0.54		0.54	0.20	0.16	730.5
3/29/11 8:00	0.54		0.54	0.20	0.16	730.9
3/29/11 16:00	0.54		0.54	0.20	0.16	731.3
3/30/11 0:00	0.54		0.54	0.20	0.16	731.7

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLE32.fig	
Print File:	K1EOC29.PRT	
Burned Assemblies:	44	
Minimum cooling time:	547.0	Days
Maximum cooling time:	1.5	Years

Run date and time: 10/17/2013 9:30:53 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
3/30/11 8:00	0.54		0.54	0.20	0.16	732.1
3/30/11 16:00	0.54		0.54	0.20	0.16	732.5
3/31/11 0:00	0.64		0.54	0.20	0.16	732.9
4/1/11 0:00	0.54		0.54	0.20	0.16	734.1
4/2/11 0:00	0.54		0.54	0.20	0.16	735.2
4/3/11 0:00	0.54		0.54	0.20	0.16	736.4
4/4/11 0:00	0.53		0.53	0.20	0.16	737.6
4/5/11 0:00	0.53		0.53	0.20	0.16	738.7
4/6/11 0:00	0.53		0.53	0.20	0.16	739.9
4/7/11 0:00	0.53		0.53	0.20	0.16	741.1
4/8/11 0:00	0.53		0.53	0.20	0.16	742.2
4/9/11 0:00	0.53		0.53	0.20	0.16	743.4
4/10/11 0:00	0.53		0.53	0.20	0.16	744.6
4/11/11 0:00	0.53		0.53	0.20	0.16	745.8
4/12/11 0:00	0.53		0.53	0.20	0.16	746.9
4/13/11 0:00	0.53		0.53	0.20	0.16	748.1
4/14/11 0:00	0.53		0.53	0.20	0.16	749.3
4/15/11 0:00	0.53		0.53	0.20	0.16	750.5
4/16/11 0:00	0.52		0.52	0.20	0.16	751.7
4/17/11 0:00	0.52		0.52	0.20	0.16	752.8
4/18/11 0:00	0.52		0.52	0.20	0.16	754.0
4/19/11 0:00	0.52		0.52	0.20	0.16	755.2
4/20/11 0:00	0.52		0.52	0.20	0.16	756.4
4/22/11 0:00	0.52		0.52	0.20	0.16	758.8
4/24/11 0:00	0.52		0.52	0.20	0.16	761.1
4/26/11 0:00	0.52		0.52	0.20	0.16	763.5
4/28/11 0:00	0.52		0.52	0.20	0.16	765.9
4/30/11 0:00	0.51		0.51	0.19	0.16	768.3
5/2/11 0:00	0.51		0.51	0.19	0.16	770.7
5/4/11 0:00	0.51		0.51	0.19	0.16	773.1
5/6/11 0:00	0.51		0.51	0.19	0.15	775.5
5/8/11 0:00	0.51		0.51	0.19	0.15	777.9
5/10/11 0:00	0.51		0.51	0.19	0.15	780.4
5/14/11 0:00	0.50		0.50	0.19	0.15	785.2
5/18/11 0:00	0.50		0.50	0.19	0.15	790.0
5/22/11 0:00	0.50		0.50	0.19	0.15	794.9
5/26/11 0:00	0.49		0.49	0.19	0.15	799.8
5/30/11 0:00	0.49		0.49	0.19	0.15	804.6
6/3/11 0:00	0.49		0.49	0.18	0.15	809.5
6/7/11 0:00	0.48		0.48	0.18	0.15	814.4
6/11/11 0:00	0.48		0.48	0.18	0.15	819.3
6/15/11 0:00	0.48		0.48	0.18	0.15	824.2
6/25/11 0:00	0.47		0.47	0.18	0.14	836.5
7/5/11 0:00	0.46		0.46	0.18	0.14	848.9
7/15/11 0:00	0.46		0.46	0.17	0.14	861.3
7/25/11 0:00	0.45		0.45	0.17	0.14	873.8

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLE32.fig	
Print File:	K1EOC29.PRT	
Burned Assemblies:	44	
Minimum cooling time:	547.0	Days
Maximum cooling time:	1.5	Years

Run date and time: 10/17/2013 9:30:53 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
8/4/11 0:00	0.45		0.45	0.17	0.14	888.4
8/14/11 0:00	0.44		0.44	0.17	0.13	899.1
8/24/11 0:00	0.43		0.43	0.16	0.13	911.8
9/3/11 0:00	0.43		0.43	0.16	0.13	924.6
9/13/11 0:00	0.42		0.42	0.16	0.13	937.5
9/23/11 0:00	0.42		0.42	0.16	0.13	950.4
10/13/11 0:00	0.40		0.40	0.15	0.12	976.5
11/2/11 0:00	0.39		0.39	0.15	0.12	1002.8
11/22/11 0:00	0.38		0.38	0.15	0.12	1029.3
12/12/11 0:00	0.37		0.37	0.14	0.11	1056.0
1/1/12 0:00	0.36		0.36	0.14	0.11	1083.0
1/21/12 0:00	0.36		0.36	0.13	0.11	1110.1
2/10/12 0:00	0.35		0.35	0.13	0.11	1137.4
3/1/12 0:00	0.34		0.34	0.13	0.10	1164.9
3/21/12 0:00	0.33		0.33	0.13	0.10	1192.6
4/10/12 0:00	0.32		0.32	0.12	0.10	1200.0
4/30/12 0:00	0.32		0.32	0.12	0.10	1200.0
5/20/12 0:00	0.31		0.31	0.12	0.09	1200.0
6/9/12 0:00	0.30		0.30	0.11	0.09	1200.0
6/29/12 0:00	0.30		0.30	0.11	0.09	1200.0
7/19/12 0:00	0.29		0.29	0.11	0.09	1200.0
8/8/12 0:00	0.28		0.28	0.11	0.09	1200.0
8/28/12 0:00	0.28		0.28	0.11	0.08	1200.0
9/17/12 0:00	0.27		0.27	0.10	0.08	1200.0

Select Fuel Pool	Select Fuel Pool File	Simulate Refueling Outage	Version Check
Surry North Anna Millstone 2 Millstone 3 Kewaunee			7/6/2011 11:09 HEATUP_P01.xlsm Version OK

This is a HEATUP Version 1 Kewaunee calculation

User Input Data

Fuel in Pool Heat Load Input		
Date and Time for Start of Pool Decay Heat Calculation	9/17/12 0:00	
Initial Pool Temperature for Time to 200 °F Calculation	80	°F
Initial Air Temperature for Time to 200 °F Calculation	80	°F
Refueling Outage Simulation Input — Core shutdown date & time =	9/10/12 0:00	
Decay time prior to offload	168	Hours
Time to offload	48	Hours
Outage length at onload	13	Days
Time to onload	60	Hours
Batch size to discharge	44	Fuel Assemblies
Discharge batch enrichment	4.70	w/o U-235
Discharge batch burnup	52000	MWD/MTU
Core average enrichment	4.80	w/o U-235
Core average burnup	39000	MWD/MTU

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLES2.fig	
Print File:	K1EOC29.PRT	
Burned Assemblies:	44	
Minimum cooling time:	1087.0	Days
Maximum cooling time:	3.0	Years

Run date and time: 10/17/2013 9:31:40 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
9/17/12 0:00	0.27		0.27	0.10	0.08	1200.0
9/17/12 8:00	0.27		0.27	0.10	0.08	1200.0
9/17/12 16:00	0.27		0.27	0.10	0.08	1200.0
9/18/12 0:00	0.27		0.27	0.10	0.08	1200.0
9/18/12 8:00	0.27		0.27	0.10	0.08	1200.0
9/18/12 16:00	0.27		0.27	0.10	0.08	1200.0
9/19/12 0:00	0.27		0.27	0.10	0.08	1200.0
9/19/12 8:00	0.27		0.27	0.10	0.08	1200.0
9/19/12 16:00	0.27		0.27	0.10	0.08	1200.0
9/20/12 0:00	0.27		0.27	0.10	0.08	1200.0

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLE32.fig	
Print File:	K1EOC29.PRT	
Burned Assemblies:	44	
Minimum cooling time:	1087.0	Days
Maximum cooling time:	3.0	Years

Run date and time: 10/17/2013 9:31:40 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
9/20/12 8:00	0.27		0.27	0.10	0.08	1200.0
9/20/12 16:00	0.27		0.27	0.10	0.08	1200.0
9/21/12 0:00	0.27		0.27	0.10	0.08	1200.0
9/22/12 0:00	0.27		0.27	0.10	0.08	1200.0
9/23/12 0:00	0.27		0.27	0.10	0.08	1200.0
9/24/12 0:00	0.27		0.27	0.10	0.08	1200.0
9/25/12 0:00	0.27		0.27	0.10	0.08	1200.0
9/26/12 0:00	0.27		0.27	0.10	0.08	1200.0
9/27/12 0:00	0.27		0.27	0.10	0.08	1200.0
9/28/12 0:00	0.27		0.27	0.10	0.08	1200.0
9/29/12 0:00	0.27		0.27	0.10	0.08	1200.0
9/30/12 0:00	0.27		0.27	0.10	0.08	1200.0
10/1/12 0:00	0.27		0.27	0.10	0.08	1200.0
10/2/12 0:00	0.27		0.27	0.10	0.08	1200.0
10/3/12 0:00	0.27		0.27	0.10	0.08	1200.0
10/4/12 0:00	0.27		0.27	0.10	0.08	1200.0
10/5/12 0:00	0.27		0.27	0.10	0.08	1200.0
10/6/12 0:00	0.27		0.27	0.10	0.08	1200.0
10/7/12 0:00	0.27		0.27	0.10	0.08	1200.0
10/8/12 0:00	0.27		0.27	0.10	0.08	1200.0
10/9/12 0:00	0.27		0.27	0.10	0.08	1200.0
10/10/12 0:00	0.27		0.27	0.10	0.08	1200.0
10/11/12 0:00	0.27		0.27	0.10	0.08	1200.0
10/13/12 0:00	0.27		0.27	0.10	0.08	1200.0
10/15/12 0:00	0.26		0.26	0.10	0.08	1200.0
10/17/12 0:00	0.26		0.26	0.10	0.08	1200.0
10/19/12 0:00	0.26		0.26	0.10	0.08	1200.0
10/21/12 0:00	0.26		0.26	0.10	0.08	1200.0
10/23/12 0:00	0.26		0.26	0.10	0.08	1200.0
10/25/12 0:00	0.26		0.26	0.10	0.08	1200.0
10/27/12 0:00	0.26		0.26	0.10	0.08	1200.0
10/29/12 0:00	0.26		0.26	0.10	0.08	1200.0
10/31/12 0:00	0.26		0.26	0.10	0.08	1200.0
11/4/12 0:00	0.26		0.26	0.10	0.08	1200.0
11/8/12 0:00	0.26		0.26	0.10	0.08	1200.0
11/12/12 0:00	0.26		0.26	0.10	0.08	1200.0
11/16/12 0:00	0.26		0.26	0.10	0.08	1200.0
11/20/12 0:00	0.26		0.26	0.10	0.08	1200.0
11/24/12 0:00	0.25		0.25	0.10	0.08	1200.0
11/28/12 0:00	0.25		0.25	0.10	0.08	1200.0
12/2/12 0:00	0.25		0.25	0.10	0.08	1200.0
12/6/12 0:00	0.25		0.25	0.10	0.08	1200.0
12/16/12 0:00	0.25		0.25	0.09	0.08	1200.0
12/26/12 0:00	0.25		0.25	0.09	0.08	1200.0
1/5/13 0:00	0.25		0.25	0.09	0.07	1200.0
1/15/13 0:00	0.24		0.24	0.09	0.07	1200.0

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLE32.fig	
Print File:	K1EOC29.PRT	
Burned Assemblies:	44	
Minimum cooling time:	1087.0	Days
Maximum cooling time:	3.0	Years

Run date and time: 10/17/2013 9:31:40 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
1/25/13 0:00	0.24		0.24	0.09	0.07	1200.0
2/4/13 0:00	0.24		0.24	0.09	0.07	1200.0
2/14/13 0:00	0.24		0.24	0.09	0.07	1200.0
2/24/13 0:00	0.23		0.23	0.09	0.07	1200.0
3/6/13 0:00	0.23		0.23	0.09	0.07	1200.0
3/16/13 0:00	0.23		0.23	0.09	0.07	1200.0
4/5/13 0:00	0.23		0.23	0.09	0.07	1200.0
4/25/13 0:00	0.22		0.22	0.08	0.07	1200.0
5/15/13 0:00	0.22		0.22	0.08	0.07	1200.0
6/4/13 0:00	0.22		0.22	0.08	0.07	1200.0
6/24/13 0:00	0.21		0.21	0.08	0.06	1200.0
7/14/13 0:00	0.21		0.21	0.08	0.06	1200.0
8/3/13 0:00	0.21		0.21	0.08	0.06	1200.0
8/23/13 0:00	0.20		0.20	0.08	0.06	1200.0
9/12/13 0:00	0.20		0.20	0.08	0.06	1200.0
10/2/13 0:00	0.20		0.20	0.08	0.06	1200.0
10/22/13 0:00	0.20		0.20	0.07	0.06	1200.0
11/11/13 0:00	0.19		0.19	0.07	0.06	1200.0
12/1/13 0:00	0.19		0.19	0.07	0.06	1200.0
12/21/13 0:00	0.19		0.19	0.07	0.06	1200.0
1/10/14 0:00	0.19		0.19	0.07	0.06	1200.0
1/30/14 0:00	0.18		0.18	0.07	0.06	1200.0
2/19/14 0:00	0.18		0.18	0.07	0.06	1200.0
3/11/14 0:00	0.18		0.18	0.07	0.05	1200.0

Select Fuel Pool	Select Fuel Pool File	Simulate Refueling Outage	Version Check
Surry North Anna Millstone 2 Millstone 3 Kewaunee			7/6/2011 11:09 HEATUP_P01.xlsm Version OK

This is a HEATUP Version 1 Kewaunee calculation

User Input Data

Fuel in Pool Heat Load Input		
Date and Time for Start of Pool Decay Heat Calculation	3/11/14 0:00	
Initial Pool Temperature for Time to 200 °F Calculation	80	°F
Initial Air Temperature for Time to 200 °F Calculation	80	°F
Refueling Outage Simulation Input — Core shutdown date & time =	3/4/14 0:00	
Decay time prior to offload	168	Hours
Time to offload	48	Hours
Outage length at onload	13	Days
Time to onload	60	Hours
Batch size to discharge	44	Fuel Assemblies
Discharge batch enrichment	4.70	w/o U-235
Discharge batch burnup	52000	MWD/MTU
Core average enrichment	4.80	w/o U-235
Core average burnup	39000	MWD/MTU

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:28
Fig File:	CYCLE32.fig	
Print File:	K1EOC29.PRT	
Burned Assemblies:	44	
Minimum cooling time:	1627.0	Days
Maximum cooling time:	4.5	Years

Run date and time: 10/17/2013 9:32:24 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
3/11/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/11/14 8:00	0.18		0.18	0.07	0.05	1200.0
3/11/14 16:00	0.18		0.18	0.07	0.05	1200.0
3/12/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/12/14 8:00	0.18		0.18	0.07	0.05	1200.0
3/12/14 16:00	0.18		0.18	0.07	0.05	1200.0
3/13/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/13/14 8:00	0.18		0.18	0.07	0.05	1200.0
3/13/14 16:00	0.18		0.18	0.07	0.05	1200.0
3/14/14 0:00	0.18		0.18	0.07	0.05	1200.0

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLE32.fig	
Print File:	K1EOC29.PRT	
Burned Assemblies:	44	
Minimum cooling time:	1627.0	Days
Maximum cooling time:	4.5	Years

Run date and time: 10/17/2013 9:32:24 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
3/14/14 8:00	0.18		0.18	0.07	0.05	1200.0
3/14/14 16:00	0.18		0.18	0.07	0.05	1200.0
3/15/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/16/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/17/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/18/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/19/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/20/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/21/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/22/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/23/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/24/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/25/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/26/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/27/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/28/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/29/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/30/14 0:00	0.18		0.18	0.07	0.05	1200.0
3/31/14 0:00	0.18		0.18	0.07	0.05	1200.0
4/1/14 0:00	0.18		0.18	0.07	0.05	1200.0
4/2/14 0:00	0.18		0.18	0.07	0.05	1200.0
4/3/14 0:00	0.18		0.18	0.07	0.05	1200.0
4/4/14 0:00	0.18		0.18	0.07	0.05	1200.0
4/6/14 0:00	0.18		0.18	0.07	0.05	1200.0
4/8/14 0:00	0.18		0.18	0.07	0.05	1200.0
4/10/14 0:00	0.18		0.18	0.07	0.05	1200.0
4/12/14 0:00	0.18		0.18	0.07	0.05	1200.0
4/14/14 0:00	0.18		0.18	0.07	0.05	1200.0
4/16/14 0:00	0.18		0.18	0.07	0.05	1200.0
4/18/14 0:00	0.18		0.18	0.07	0.05	1200.0
4/20/14 0:00	0.18		0.18	0.07	0.05	1200.0
4/22/14 0:00	0.17		0.17	0.07	0.05	1200.0
4/24/14 0:00	0.17		0.17	0.07	0.05	1200.0
4/28/14 0:00	0.17		0.17	0.07	0.05	1200.0
5/2/14 0:00	0.17		0.17	0.07	0.05	1200.0
5/6/14 0:00	0.17		0.17	0.07	0.05	1200.0
5/10/14 0:00	0.17		0.17	0.07	0.05	1200.0
5/14/14 0:00	0.17		0.17	0.07	0.05	1200.0
5/18/14 0:00	0.17		0.17	0.07	0.05	1200.0
5/22/14 0:00	0.17		0.17	0.07	0.05	1200.0
5/26/14 0:00	0.17		0.17	0.07	0.05	1200.0
5/30/14 0:00	0.17		0.17	0.06	0.05	1200.0
6/9/14 0:00	0.17		0.17	0.06	0.05	1200.0
6/19/14 0:00	0.17		0.17	0.06	0.05	1200.0
6/29/14 0:00	0.17		0.17	0.06	0.05	1200.0
7/9/14 0:00	0.17		0.17	0.06	0.05	1200.0

HEATUP Version 1 Output Data

Input File Data		
File Date/Time:	11/28/12	8:26
Fig File:	CYCLE32.fig	
Print File:	K1EOC29.PRT	
Burned Assemblies:	44	
Minimum cooling time:	1627.0	Days
Maximum cooling time:	4.5	Years

Run date and time: 10/17/2013 9:32:24 AM

SFP Initial Water Temp = 80°F
SFP Initial Air Temp = 80°F

Date and Time	Pool File Heat Load (Mbtu/hr)	Core Offload Heat Load (Mbtu/hr)	Total Heat Load (Mbtu/hr)	Adiabatic Heatup Rate (F/Hr)	Best Estimate Heatup Rate (F/Hr)	Best Estimate Time to 200 °F (Hours)
7/19/14 0:00	0.17		0.17	0.06	0.05	1200.0
7/29/14 0:00	0.17		0.17	0.06	0.05	1200.0
8/8/14 0:00	0.16		0.16	0.06	0.05	1200.0
8/18/14 0:00	0.16		0.16	0.06	0.05	1200.0
8/28/14 0:00	0.16		0.16	0.06	0.05	1200.0
9/7/14 0:00	0.16		0.16	0.06	0.05	1200.0
9/27/14 0:00	0.16		0.16	0.06	0.05	1200.0
10/17/14 0:00	0.16		0.16	0.06	0.05	1200.0
11/6/14 0:00	0.16		0.16	0.06	0.05	1200.0
11/26/14 0:00	0.16		0.16	0.06	0.05	1200.0
12/16/14 0:00	0.16		0.16	0.06	0.05	1200.0
1/5/15 0:00	0.15		0.15	0.06	0.05	1200.0
1/25/15 0:00	0.15		0.15	0.06	0.05	1200.0
2/14/15 0:00	0.16		0.15	0.06	0.05	1200.0
3/6/15 0:00	0.15		0.15	0.06	0.05	1200.0
3/26/15 0:00	0.15		0.15	0.06	0.05	1200.0
4/15/15 0:00	0.15		0.16	0.06	0.05	1200.0
5/5/15 0:00	0.15		0.15	0.06	0.04	1200.0
5/25/15 0:00	0.15		0.15	0.06	0.04	1200.0
6/14/15 0:00	0.14		0.14	0.05	0.04	1200.0
7/4/15 0:00	0.14		0.14	0.05	0.04	1200.0
7/24/15 0:00	0.14		0.14	0.05	0.04	1200.0
8/13/15 0:00	0.14		0.14	0.05	0.04	1200.0
9/2/15 0:00	0.14		0.14	0.05	0.04	1200.0

(:ORIENTATION :PORTRAIT :CC T :TYPE :ASSEMBLY :TIME-STATE NIL :REPORT "Assembly Data for HEATUP Code")
KPS Pool - Assembly Data for HEATUP Code

Fig File: CYCLE32.fig
Print File: K1EOC29.PRT
Date: 11/28/2012 Time: 08:26

Assy ID	Discharge	Burnup	Enrich
G51	09/26/2009	49.820	4.300
G52	09/26/2009	49.565	4.290
G53	09/26/2009	49.539	4.290
G54	09/26/2009	49.567	4.300
G56	09/26/2009	49.370	4.300
G59	09/26/2009	48.982	4.290
G60	09/26/2009	49.372	4.290
G61	09/26/2009	49.383	4.290
G62	09/26/2009	49.433	4.280
G63	09/26/2009	49.343	4.280
G65	09/26/2009	49.386	4.290
G66	09/26/2009	48.903	4.290
G72	09/26/2009	51.132	4.470
G73	09/26/2009	48.455	4.470
G74	09/26/2009	48.755	4.470
G75	09/26/2009	51.031	4.470
G77	09/26/2009	51.215	4.480
G78	09/26/2009	51.074	4.480
G79	09/26/2009	51.457	4.470
G80	09/26/2009	51.399	4.480
G81	09/26/2009	48.068	4.480
G83	09/26/2009	48.787	4.470
G84	09/26/2009	50.929	4.470
G85	09/26/2009	50.627	4.480
G87	09/26/2009	48.979	4.680
G88	09/26/2009	48.740	4.680
G89	09/26/2009	49.173	4.670
G90	09/26/2009	48.325	4.680
G91	09/26/2009	48.516	4.680
G92	09/26/2009	49.202	4.680
G93	09/26/2009	48.571	4.670
G94	09/26/2009	49.264	4.670
H51	09/26/2009	45.132	4.610
H53	09/26/2009	44.776	4.610
H54	09/26/2009	45.347	4.610
H55	09/26/2009	44.181	4.610
H56	09/26/2009	44.574	4.610
H57	09/26/2009	44.284	4.600
H58	09/26/2009	44.000	4.610
H60	09/26/2009	45.330	4.610
H61	09/26/2009	44.749	4.610
H63	09/26/2009	46.040	4.610
H64	09/26/2009	44.432	4.610
H65	09/26/2009	45.044	4.600

INDEX DOCUMENT INFORMATION FORM

**"Transmittal of Dominion Engineering Technical Evaluation ETE-NAF-2013-0119, Rev. 0 "Kewaunee Discharge Fuel Assembly Information for Spent Fuel Pool Postulated Loss of Inventory Calculation"
," CORRES-OUT-S&L-20130003, Rev. 0, Add. 0, by M. S. Lico, dated OCT 24 2013.**

INDEX DOCUMENT INFORMATION
Index Document ID: 20130003-0-0
Index Entry Preparer(s): Michael S Lico
Index Entry Reviewers: None

Document Title: Transmittal of Dominion Engineering Technical Evaluation ETE-NAF-2013-0119, Rev. 0 "Kewaunee Discharge Fuel Assembly Information for Spent Fuel Pool Postulated Loss of Inventory Calculation"
Document Author: M. S. Lico
Document Date: 10/24/2013
Responsible Department: NAF
Responsible Group: NAF-FPE - Fuel Project Engineering Group
Applicable Sites: Kewaunee
Vendor Deliverable?: No
Owner Review Performed?: No
Owner Review Comments:

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ISFSI Decommissioning Record: No
ISFSI Record: No
Records Management Document Type: CORRES
Records Management Document SubType: ENG
Applicable Sites: Kewaunee
User Specified Instructions:
Additional Records Management Information:
Site Specific Records Management Instructions:

RELATED REFERENCES
1.ETE-NAF-20130119-Rev0-Add-0,Kewaunee Spent Fuel Pool Fuel Assembly Locations for Spent Fuel Pool Postulated Loss of Inventory Calculation by M. S. Lico, dated 24-OCT-13
2.ETE-NAF-20130077-Rev0-Add-0,Information for Kewaunee Spent Fuel Pool Postulated Loss of Inventory Calculation by M. S. Lico, dated 10-JUL-13

INDEX DOCUMENT INFORMATION FORM - Files

FILES USED TO CREATE FINAL DOCUMENT PACKAGE

1. OA 95F Design Basis.pdf (8/19/2013 5:29:25 PM)
2. KPS C30-C31-C32 Fuel Discharge Locations (Racks Numbered).pdf (7/26/2013 3:51:18 PM)
3. KW-CORR-SER-12011978 for High Density Racks.pdf (6/4/2013 1:03:53 PM)
4. KPS Physical Inventory KW100877023-RE-24.pdf (8/28/2013 4:13:10 PM)

COMPUTER I/O FILES

None

INDEX DOCUMENT INFORMATION FORM - Correspondence

ASSOCIATED CORRESPONDENCE

SENT DATE:

Recipients: Robert D Gerke,William F Zipp,Alexander M. Pechette(Sargent & Lundy),Matthew M. Ross(Sargent & Lundy),Robert J. Peterson(Sargent & Lundy),Todd Flowers,Stephen F Claffey,William J Eakin,John Harrell,John F Helfenberger,Christopher Clemens,Robert A Borchert

CC Recipients:

LETTER TEXT

October 24, 2013
CORRES-OUT-S&L-20130003

Robert D. Gerke
Sargent & Lundy
5000 Dominion Blvd.
Glen Allen, VA 23060

Subject: Transmittal of Dominion Engineering Technical Evaluation ETE-NAF-2013-0119, Rev. 0 "Kewaunee Discharge Fuel Assembly Information for Spent Fuel Pool Postulated Loss of Inventory Calculation"

Reference 1: Task Release Traveler (TRT) # 70157979 "Analysis for a Postulated Spent Fuel Pool Zirconium Fire at the Kewaunee Power Station," Revision 2, October 2013

Mr. Gerke:

Attached please find the subject Engineering Technical Evaluation which provides information for the subject diabatic analysis requested in the Reference 1 TRT.

Please contact me at 804-273-2226 with any questions. Thanks for your help with this project.

Sincerely,

Michael S. Lico
Fuel Project Engineer

E-copy:
A. M. Pechette
R. J. Peterson
M. M. Ross

INDEX DOCUMENT INFORMATION FORM - Approvals

**"Transmittal of Dominion Engineering Technical Evaluation ETE-NAF-2013-0119, Rev. 0 "Kewaunee Discharge Fuel Assembly Information for Spent Fuel Pool Postulated Loss of Inventory Calculation"
," CORRES-OUT-S&L-20130003, Rev. 0, Add. 0, by M. S. Lico, dated OCT 24 2013.**

APPROVER	PURPOSE OF ELECTRONIC AUTHENTICATION	DATE APPROVED

S&L Calc. No. 2013-11284, Rev. 0
Project No. 11862-198
Attachment 19, Page 1 of 1

A Flame of Innovation...

Boron Carbide

Boron Carbide is one of the hardest man-made materials available. Boron Carbide also has a low thermal conductivity (29-67 W/mK) and an electrical resistivity ranging from .1-10 ohm-cm. This material is ideal for a wide range of applications because of an excellent strength to weight ratio, low thermal conductivity (29-67 W/mK), and an electrical reistivity ranging from .1-10 ohm-cm. Through research and development, APS Materials, Inc. has engineered a unique and highly successful process yielding a high purity coating utilizing inert or vacuum plasma spray techniques. This material yields an extremely hard surface resistant to wear, abrasion and erosion.

For example:

- Blasting Nozzles
- Aerospace
- Nuclear technology
- Ceramic composites/seals
- Metal matrix composites
- Honing stones
- Refractory shapes, cements
- Armor Plate
- Wear Plates

Physical Properties

Hardness: Vickers 2300
Hardness: Mohs 9.6
Oxidation Temperature: 932°F (500°C)
Melting point: 4262°F (2350°C)
Specific Gravity: 2.52 g/cc
Particle shape: Blocky/angular
Color: Black

Typical Chemical Analysis

Total Boron: 77.8%
Total Carbon: 21.7%
Total Iron: .05% Max
Total B+C: 98%

Dielectrics

Through cooperative research and development between APS Materials, Inc. and a semiconductor manufacturer, APS has perfected the previously difficult process of applying aluminum oxide to an aluminum substrate. Aluminum oxide is currently in production for the semiconductor industry and features enhanced characteristics as a result of the unique APS process, including a superior tensile strength of 7505 psi or better, increased quality of dielectric properties, and increased density that allows the surface to be ground to a superior finish of 10 microinches or better. The process is executed under complete automation and process control to help eliminate risk of contamination and inconsistency.

Preparing the robotics unit to spray alumina.

Back to Corporate Main

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1. Stations:	2. Doc Type:	3. Sub Type:	4. Document Number:	5. Rev.:	6. Add:	7. Decomm?
☐MP ☐SU ☐NA ☒KW ☐CO Note: If both SU and NA, then check CO	ETE	000	ETE-NAF-2013-0130	0	0	☒Yes ☐No

8. Title:
Fuel Assembly Peak Pin Factor for Kewaunee Spent Fuel Pool Loss of Inventory Calculation

9. ETE Level:	10. Unit(s):	11. Quality Classification:	12. FSRC Approval:
☒Level 1 ☐Level 2	☒Unit 1 ☐Unit 2 ☐Unit 3 ☐ISFSI	☐SR ☐NS ☒NSQ	☐Yes ☒No

13. Preparation, Review, and Approval Signatures (add or delete rows as needed)

Prepared by/Affiliation: (Print) M. S. Lico / NAF	Signature:	Date: 11/6/13
Reviewed by/Affiliation: (Print) R. W. Twitchell / NAF	Signature:	Date: 11/6/13
Program/Other Reviewer/Affiliation: (Print) N/A	Signature:	Date:
Supervisor Approval/Affiliation: (Print) W. J. Eakin / NSAD	Signature:	Date: 11/6/13
Design Control Engineer (DCE) Approval/Site: (Print) N/A	Signature:	Date:
FSRC Approval/Site: (Print) N/A	Signature:	Date:

Standard Attachments	Attachment	# of pages	Reviewed/No Impact	Not Req.
14. Design Effects and Considerations (DNES-AA-GN-1003)			☐	☒
15. Document Impact Summary (DRUL) (DNES-AA-GN-1002)				☒

16. Considerations and Conditions for Document Updates (check ☒N/A if no document updates are noted on the DRUL)
☐ All Document updates noted on the DRUL can be initiated immediately
☐ Document updates noted on DRUL are delayed until the following documents/actions are completed (e.g., WO, CR, etc.) (See DRUL Remarks section)

10CFR50.59 Attachments	Attachment	# of pages	Not Req.
17. 10CFR50.59/72.48 applicability review forms (CM AA-400)			☒
18. 10CFR50.59/72.48 screen form (CM-AA-400)			☒
19. 10CFR50.59/72.48 evaluation form (CM-AA-400)			☒

20. *Additional Attachments*		
Attachment	**# of pages**	**Description**
N/A		

21. *Distribution*			
Primary Recipient(s): R. D. Gerke (Sargent & Lundy) (Enter Name/Dept. or Location for EACH Primary Recipient in this block.)			
Copy To?	Other Recipient/Department or Location	Copy To?	Other Recipient/Department Location
☒	Preparer – M. S. Lico	☒	M. A. Powers / NAF
☒	Reviewer – R. W. Twitchell	☒	J. F. Helfenberger / KPS Rx Engineering
☒	Supervisor – W. J. Eakin	☐	Nuclear Document Management
☒	T. R. Flowers / NAF	☐	
☒	J. R. Harrell / NAF	☐	
☒	C. D. Clemens / NAF	☐	

Table of Contents

N/A

Source Document

1. Task Release Traveler # 70157975, "Analysis for a Postulated Spent Fuel Pool Zirconium Fire at the Kewaunee Power Station," Revision 2, October 2013.

Record of Revision

Original Issue

Purpose

This Engineering Technical Evaluation (ETE) provides the following information to Sargent and Lundy (S & L) to support their analysis of the unlikely postulated event of a loss of spent fuel pool (SFP) inventory at the Kewaunee Power Station (KPS) (Source Document 1):

- Peak pin factor (ratio of the single fuel rod with highest burnup to the average assembly burnup) for the fuel assembly of interest with the highest decay heat load (M52) as described in Reference A.

This ETE only provides information and inputs needed by S & L to perform their analysis per Source Document 1. In addition, the S & L analysis will be Nonsafety-related and will be performed to their quality program. Thus, this ETE is considered to be Level 1 per CM-AA-ETE-101 Step 2.3.i, and a Design Effects and Consideration review, DRUL, and 10 CFR 50.59 review are not required.

Design Inputs and Assumptions

The design inputs and assumptions are:

- The assembly peak pin and average burnup for the assembly with the highest decay heat load calculated in Reference A.

Methodology

This ETE simply takes the peak pin and average assembly burnups for M52 at the appropriate cycle burnup, and calculates the peak pin factor by ratioing the peak pin to the average assembly burnup.

Discussion

This ETE only provides data needed by S & L to support their KPS SFP calculation per Source Document 1. (Per Source Document 1 S & L will perform the work as Nonsafety-related to their quality program).

Reference A estimated the decay heat load of assembly M52 (SFP location JJ-04) as the bounding heat load for the limiting configuration in the SFP. The limiting configuration is a SFP grouping consisting of a Cycle 32 discharge assembly surrounded on 2 sides by a Cycle 30 and a Cycle 31 discharge assembly (there are 13 such groupings in the south SFP).

S & L has also asked for the peak pin factor in this assembly. The peak pin factor for a single fuel pin in assembly M52 is **1.07** (best estimate without uncertainties).

This M52 burnup data follows. The burnup based on the Cycle 32 SIMULATE depletion runs (Reference B). The data is taken for 13 GWD/MTU. (Cycle 32 burned slightly higher than this, but 13 GWD/MTU provides an adequate approximation):

- M52 peak pin burnup – 19.309 GWD/MTU
- M52 assembly average burnup – 18.055 GWD/MTU
- Thus, the ratio of peak pin burnup to assembly average burnup is:

  19.309 GWD/MTU ÷ 18.055 GWD/MTU = 1.07.

Cumulative Effects Review

This ETE provides certain data to S & L for the analysis described in Source Document 1. S & L's analysis will be Nonsafety-related and the results will be used for information, and not for design related purposes.

Thus, there are no cumulative effects associated with the information in this ETE.

Conclusions

This ETE provides certain data that S & L requested to support their analysis of the unlikely postulated event of a loss of SFP inventory at KPS (Source Document 1). This ETE transmits the M52 peak pin factor of 1.07. S & L will use it for their analysis, which is Nonsafety-related and will be performed to S & L's quality program.

Precautions and Limitations

NONE

Required Actions

NONE

Recommendations

NONE

References

A. Dominion Engineering Technical Evaluation ETE-NAF-2013-0119, Revision 0, "Kewaunee Discharge Fuel Assembly Information for Spent Fuel Pool Postulated Loss of Inventory Calculation," M. S. Lico, October 2013.
B. Dominion Calculation CALC-KPS-C12002, Revision 0, "Kewaunee Cycle 32 Simulator Data," R. W. Twitchell, March 2012 (specifically from file k1c32_dep_ndr.out).