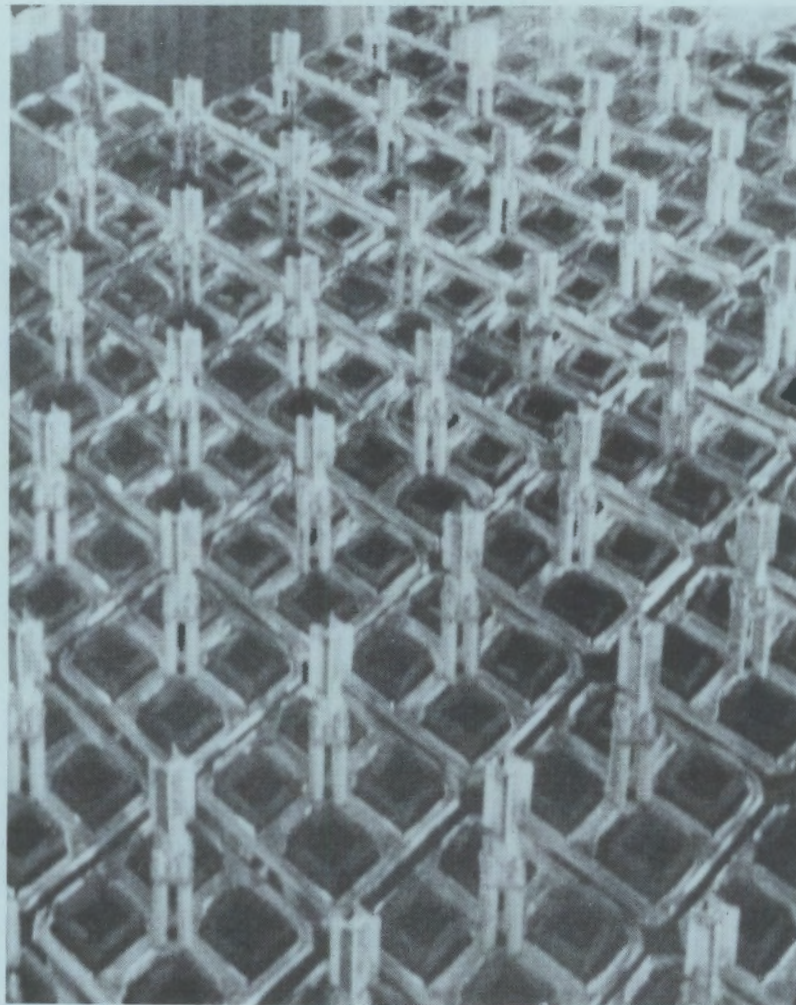


COBRA-SFS: A Thermal-Hydraulic Analysis Computer Code

Volume III: Validation Assessments



December 1986

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
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PACIFIC NORTHWEST LABORATORY
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BATTELLE
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UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

NTIS Price Codes
Microfiche A01

Printed Copy

Pages	Price Codes
001-025	A02
026-050	A03
051-075	A04
076-100	A05
101-125	A06
126-150	A07
151-175	A08
176-200	A09
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COBRA-SFS: A THERMAL-HYDRAULIC
ANALYSIS COMPUTER CODE

VOLUME III: VALIDATION ASSESSMENTS

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December 1986

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the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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ABSTRACT

This report presents the results of the COBRA-SFS (Spent Fuel Storage) computer code validation effort. COBRA-SFS, while refined and specialized for spent fuel storage system analyses, is a lumped-volume thermal-hydraulic analysis computer code that predicts temperature and velocity distributions in a wide variety of systems. Through comparisons of code predictions with spent fuel storage system test data, the code's mathematical, physical, and mechanistic models are assessed, and empirical relations defined. The six test cases used to validate the code and code models include single-assembly and multiassembly storage systems under a variety of fill media and system orientations, and include unconsolidated and consolidated spent fuel. In its entirety, the test matrix investigates the contributions of convection, conduction, and radiation heat transfer in spent fuel storage systems.

To demonstrate the code's performance for a wide variety of storage systems and conditions, comparisons of code predictions with data are made for 14 runs from the experimental data base. The cases selected exercise the important code models and code logic pathways and are representative of the types of simulations required for spent fuel storage system design and licensing safety analyses. For each test, a test description, a summary of the COBRA-SFS computational model, assumptions, and correlations employed are presented. For the cases selected, axial and radial temperature profile comparisons of code predictions with test data are provided, and conclusions drawn concerning the code models and the ability to predict the data and data trends. Comparisons of code predictions with test data demonstrate the ability of COBRA-SFS to successfully predict temperature distributions in unconsolidated or consolidated single and multiassembly spent fuel storage systems.

ACKNOWLEDGMENTS

The authors would like to thank the Department of Energy for sponsoring this work and validation tests performed in support of this effort. Thanks are also extended to Darell Newman, Dale Oden, and Gordon Beeman of the Pacific Northwest Laboratory Commercial Spent Fuel Management Program Office (CSFM-PO) and to Ron Hall of PNL's Monitored Retrievable Storage Program Office (MRS-PO) for their support of this work and associated validation tests. The authors would like to recognize Jim Creer of the CSFM/Dry Storage System Performance Evaluation Project and Dr. Dennis Kreid of the MRS-PO for their efforts toward the successful completion of this validation assessments effort. Finally, thanks to the editors, A. J. Currie and T. L. Gilbride, and to word processor E. C. Darby for their preparation of this document.

CONTENTS

ABSTRACT	iii
ACKNOWLEDGMENTS	v
1.0 INTRODUCTION	1.1
2.0 CONCLUSIONS AND RECOMMENDATIONS	2.1
2.1 CONCLUSIONS	2.1
2.2 RECOMMENDATIONS	2.3
3.0 COBRA-SFS DESCRIPTION	3.1
3.1 COBRA-SFS BACKGROUND	3.1
3.2 MODELING CAPABILITIES	3.2
3.3 COMPUTATIONAL PHILOSOPHY	3.4
4.0 SINGLE ASSEMBLY EVALUATION TESTS	4.1
4.1 PWR SINGLE ASSEMBLY SPENT FUEL TESTS	4.1
4.1.1 Test Description	4.2
4.1.2 Computational Model Description	4.8
4.1.3 Comparisons of Predictions to Data	4.13
4.2 ELECTRICALLY HEATED PWR SINGLE ASSEMBLY SPENT FUEL TEST	4.19
4.2.1 Test Description	4.20
4.2.2 COBRA-SFS Computational Model Description	4.25
4.2.3 Comparisons of Predictions to Data	4.34
4.3 SINGLE CANISTER CONSOLIDATED SPENT FUEL TEST	4.39
4.3.1 Test Description	4.40
4.3.2 Computational Model Description	4.44
4.3.3 Comparisons of Predictions to Data	4.50

5.0	MULTIASSEMBLY EVALUATION TESTS	5.1
5.1	CASTOR-1C SPENT FUEL STORAGE CASK PERFORMANCE TEST	5.1
5.1.1	CASTOR-1C Cask and Test Description	5.2
5.1.2	Computational Model Description	5.8
5.1.3	Comparisons of Predictions to Data.	5.18
5.2	REA-2023 BWR SPENT FUEL STORAGE CASK PERFORMANCE TEST	5.21
5.2.1	REA 2023 Cask and Test Description	5.21
5.2.2	COBRA-SFS Computational Model	5.26
5.2.3	Comparisons of Predictions to Data	5.38
5.3	TN-24P CASK PERFORMANCE TEST	5.43
5.3.1	TN-24P Cask and Test Description	5.43
5.3.2	Computational Model Description	5.52
5.3.3	Comparisons of Predictions to Data	5.65
	REFERENCES	R.1
	APPENDIX A - PWR SINGLE ASSEMBLY SPENT FUEL TEST SIMULATIONS INPUT, OUTPUT, AND CONVERGENCE LISTS	A.1
	APPENDIX B - ELECTRICALLY HEATED PWR SINGLE ASSEMBLY SPENT FUEL TEST SIMULATIONS INPUT, OUTPUT, AND CONVERGENCE LISTS	B.1
	APPENDIX C - REA SINGLE ASSEMBLY CONSOLIDATED ROD TEST SIMULATIONS INPUT, OUTPUT, AND CONVERGENCE LISTS	C.1
	APPENDIX D - CASTOR-1C BWR SPENT FUEL STORAGE CASK PERFORMANCE TEST SIMULATIONS INPUT, OUTPUT, AND CONVERGENCE LISTS	D.1
	APPENDIX E - REA 2023 BWR CASK PERFORMANCE TEST SIMULATIONS INPUT, OUTPUT, AND CONVERGENCE LISTS	E.1
	APPENDIX F - TN-24P PWR CASK PERFORMANCE TEST SIMULATIONS INPUT, OUTPUT, AND CONVERGENCE LISTS	F.1

FIGURES

3.1	Relation of Subchannel Control Volume to a Storage System . . .	3.4
4.1	PWR Single Assembly Spent Fuel Test Apparatus	4.3
4.2	Turkey Point Spent Fuel Assembly Axial Decay Heat Profile . . .	4.5
4.3	PWR Single Assembly Spent Fuel Test Apparatus Axial Cross Sections and Thermocouple Locations	4.6
4.4	Transverse Cross Sectional View of PWR Single Assembly Spent Fuel Test Apparatus	4.8
4.5	Transverse Cross Section of COBRA-SFS Computational Model for the PWR Single Assembly Test Apparatus	4.10
4.6	Predicted Axial Temperature Profile Compared to PWR Single Assembly Helium Test Data	4.14
4.7	Predicted Axial Temperature Profiles Compared to Rod No. 1, PWR Single Assembly Air Test Data	4.15
4.8	Predicted Axial Temperature Profile Compared to Rod No. 1, PWR Single Assembly Vacuum Test	4.16
4.9	Predicted Radial Temperature Profile Compared to PWR Single Assembly Helium Test Data at Elevation 185 cm	4.17
4.10	Predicted Radial Temperature Profile Compared to PWR Single Assembly Air Test Data at Elevation 185 cm	4.18
4.11	Predicted Radial Temperature Profile Compared to PWR Single Assembly Vacuum Test Data at Elevation 185 cm	4.19
4.12	Electrically Heated PWR Single Assembly Test Apparatus	4.21
4.13	Transverse Cross Sectional View of Electrically Heated Single Assembly Test Section	4.23
4.14	Fuel-Tube Transition Piece	4.25
4.15	Transverse Cross Section of COBRA-SFS Computational Model for the Electrically Heated PWR Single Assembly Test	4.27
4.16	Predicted Axial Temperature Profile Compared to Electrically Heated PWR Single Assembly Vertical, 1 kW, Air Test Data	4.35

4.17	Predicted Axial Temperature Profile Compared to Electrically Heated PWR Single Assembly Horizontal, 1 kW, Air Test Data . . .	4.36
4.18	Predicted Axial Temperature Profile Compared to Electrically Heated PWR Single Assembly Inclined, 1 kW, Air Test Data . . .	4.37
4.19	Cross Section of Consolidated Fuel Test Assembly	4.41
4.20	Consolidated Assembly Test Section	4.42
4.21	COBRA-SFS Subchannel Model of the Zero Gap Consolidated Test Section	4.45
4.22	Comparisons of Calculated and Measured Radial Temperature Profiles in a Consolidated Assembly with Zero Rod Gaps	4.51
4.23	Comparisons of Calculations to Measured Temperature Differences (A to E) in a Consolidated Assembly with Zero Rod Gaps	4.52
5.1	Elevation View of the CASTOR-1C Cask	5.3
5.2	Transverse Cross Section of the CASTOR-1C Cask	5.5
5.3	CASTOR-1C Cooling Fin Geometry	5.6
5.4	Typical General Electric 8x8 Fuel Assembly	5.9
5.5	Axial Decay Heat Profile Used for CASTOR-1C Analysis	5.11
5.6	COBRA-SFS One-Half Symmetry CASTOR-1C Cask Body Model	5.12
5.7	COBRA-SFS One-Half Symmetry CASTOR-1C Cask Cavity and Basket Model	5.13
5.8	Comparisons of COBRA-SFS Axial Temperature Profile Predictions with CASTOR-1C Test Data	5.19
5.9	Comparisons of COBRA-SFS Radial Temperature Profile Predictions with CASTOR-1C Test Data (266-cm Elevation)	5.20
5.10	REA 2023 BWR Spent Fuel Storage Cask	5.22
5.11	REA 2023 Cask Basket for 52 BWR Fuel Assemblies	5.24
5.12	Quarter Section Plan View of REA 2023 BWR Cask	5.24
5.13	Cooper BWR Spent Fuel Assembly	5.25
5.14	Axial Decay Heat Profile for Cooper BWR Assemblies	5.27

5.15	REA 2023 BWR Cask Partial and Full Load Patterns	5.28
5.16	COBRA-SFS One-Eighth Section Model of the REA 2023 BWR Cask . .	5.30
5.17	COBRA-SFS Axial Noding Scheme of the REA 2023 BWR Cask	5.31
5.18	COBRA-SFS Predictions of Axial Temperature Profiles Compared to Full Load, Vertical, Helium, REA 2023 Test Data	5.39
5.19	COBRA-SFS Predictions of Axial Temperature Profiles Compared to Full Load, Vertical, Nitrogen, REA 2023 Test Data	5.40
5.20	COBRA-SFS Predictions of Axial Temperature Profiles Compared to Full Load, Vertical, Vacuum, REA 2023 Test Data	5.41
5.21	COBRA-SFS Predictions of Radial Temperature Profiles Compared to Full Load, Vertical, Helium, Nitrogen, and Vacuum, REA 2023 Test Data at 3.33 m Elevation	5.42
5.22	TN-24P PWR Spent Fuel Storage Cask	5.45
5.23	TN-24P Cask Cross Section	5.46
5.24	TN-24P Basket Thermocouple Locations	5.47
5.25	TN-24P Thermocouple Lance Locations	5.49
5.26	Surry 15x15 PWR Spent Fuel Assembly	5.50
5.27	Surry 15x15 PWR Spent Fuel Assembly Cross Section	5.51
5.28	Spent Fuel Loading Pattern - TN-24P Cask Performance Test . . .	5.53
5.29	Predicted Axial Decay Heat Profile for Surry PWR Assemblies	5.54
5.30	COBRA-SFS Axial Noding Scheme for the One-Eighth and One-Half Section Models of the TN-24P PWR Cask	5.56
5.31	COBRA-SFS One-Eighth Section Model of the TN-24P PWR Cask Model for the TN-24P Cask Performance Test	5.57
5.32	Half Assembly Subchannel and Rod Noding Scheme for the One-Eighth Section Model of the TN-24P PWR	5.58

5.33	Lumped Rod and Channel Assembly Noding Scheme for the TN-24P PWR Cask	5.59
5.34	COBRA-SFS One-Half Section Model of the TN-24P PWR Cask	5.60
5.35	Comparisons of COBRA-SFS Axial Temperature Profile Predictions with Vertical, Helium TN-24P Test Data	5.66
5.36	Comparisons of COBRA-SFS Axial Temperature Profile Predictions with Horizontal, Helium TN-24P Test Data	5.67
5.37	Comparisons of COBRA-SFS Peak Axial Temperature Profile Predictions with Vertical and Horizontal, Helium, TN-24P Test Data	5.68

TABLES

4.1	Turkey Point No. 3 PWR Fuel Assembly Parameters	4.4
4.2	Electrically Heated PWR Single Assembly Test Matrix	4.26
5.1	CASTOR-1C Cask Dimensions and Design Specifications	5.4
5.2	Characteristics of Typical General Electric BWR Fuel Assemblies	5.8
5.3	Predicted Wurgassen BWR Assembly Decay Heat Rates	5.10
5.4	Assumed CASTOR-1C Cask Surface Emissivities	5.15
5.5	CASTOR-1C Cask Material Properties	5.17
5.6	Cooper BWR Spent Fuel Assembly Design Parameters	5.26
5.7	REA 2023 BWR Cask Performance Test Matrix	5.29
5.8	REA 2023 BWR Cask Test Material Emittance Values	5.33
5.9	Surry PWR Spent Fuel Characteristics	5.51
5.10	TN-24P Cask Performance Test Matrix	5.54
5.11	Material Properties for the TN-24P Cask Analysis	5.63

NOMENCLATURE

A	- aspect ratio
A_C	- contact heat transfer area
D_r	- fuel rod outer diameter
D_h	- hydraulic diameter
BWR	- boiling water reactor
f	- friction factor
Gr	- Grashof
GWD	- gigawatt days
h	- heat transfer coefficient
H_C	- thermal contact conductance
k	- thermal conductivity
K	- loss coefficient
MTU	- metric ton of uranium
Nu	- Nusselt number
P	- pitch-to-diameter ratio
Pr	- Prandtl number
PWR	- pressurized water reactor
Ra	- Rayleigh number
Re	- Reynolds number
T	- temperature
TC	- thermocouple
W	- watts
Δx	- distance between conducting surfaces
ϵ	- emissivity

COBRA-SFS: A THERMAL-HYDRAULIC ANALYSIS COMPUTER CODE
VOLUME III: VALIDATION ASSESSMENTS

1.0 INTRODUCTION

The COBRA-SFS (Spent Fuel Storage) code is a lumped, finite-volume, thermal-hydraulic computer code that predicts the temperature and velocity distributions in a wide variety of systems. COBRA-SFS was evaluated and documented for the U.S. Department of Energy's Commercial Spent Fuel Management Program and has been refined and specialized for spent fuel storage system analyses. One of the program's objectives was the evolution of a mechanistically-based computer code that could be used for accurate analyses of complex spent fuel dry storage systems.

Derived from the COBRA family of codes which have been extensively evaluated against in-pile and out-of-pile data, COBRA-SFS retains all the important features of the parent COBRA codes (Rowe 1973; Wheeler et al. 1976; Stewart et al. 1977; and George et al. 1980) and extends the range of application to analyses of spent fuel storage systems. Thus, COBRA-SFS benefits from the validation and assessment efforts of these precursor code versions. The COBRA codes are all based on the subchannel modeling philosophy, which allows complex three-dimensional geometries to be simulated relatively easily and accurately.

To demonstrate the credibility of COBRA-SFS as a computational thermal-hydraulic tool, a significant effort was extended to assess the code's performance and the validity of the computed results. Validation results using earlier versions of COBRA-SFS are provided in Lombardo et al. 1986; McKinnon et al. 1986a; Wiles et al. 1986; Rector et al. 1986a; Cuta and Creer 1986. Validation of the documented version of the code (Rector et al. 1986b, and Rector, Wheeler and Lombardo 1986) is presented in this report. The assessment is based on comparison of code predictions with spent fuel heat transfer test data. The assessment began with simulating simple phenomena in simple geometries and proceeded systematically to complex phenomena and geometries. Fourteen case comparisons were made with the results from six

unique spent fuel storage tests. The tests used in the comparisons include all of the combined heat transfer effects expected to occur within spent fuel storage systems.

Select cases were chosen from each test to exercise the important code models and logic pathways. For each test, a test description, and descriptions of the COBRA-SFS computational model and assumptions are given. Comparisons of predictions with data are then presented and the results evaluated. These comparisons, along with pre- and post-test data comparisons presented in other COBRA-SFS application reports, satisfy the objective of the code validation effort: to demonstrate that the coding logic is working correctly, that the physics are modeled properly, and that the code operates as advertised.

This validation assessment volume is the third of a series of three COBRA-SFS documentation volumes. The first volume, Volume 1: Mathematical Models and Solution Method is a description of the theory behind the code. Volume II: User's Manual provides input instructions and guidance in applying the code.

2.0 CONCLUSIONS AND RECOMMENDATIONS

The ability of the COBRA-SFS computer code to predict the thermal performance of spent fuel storage systems was investigated through comparisons of predictions with experimental test data. Fourteen case comparisons from six unique spent fuel storage system tests are presented in this report to assess the code's performance and the validity of the computed results. Comparisons of code predictions with data were made for single and multiassembly storage systems, and a single consolidated test canister. The cases selected for inclusion in this report exercise the important code models and logic pathways and are representative of the type of simulations required for design or licensing applications. The major conclusions and recommendations from this validation effort are presented below.

2.1 CONCLUSIONS

The following conclusions are based on comparisons offered in this report, as well as those documented in earlier applications reports (Lombardo et al. 1986; Wiles et al. 1986; Rector et al. 1986a; Cuta and Creer 1986; McKinnon et al. 1986a).

- Peak system temperatures predicted for the single and multiassembly tests presented in this report were within ± 19 and 23°C , respectively.
- The successful predictions of the thermal performance of single, multiassembly, and consolidated assembly storage systems under a variety of backfills (air, nitrogen, helium, and vacuum), heat loadings, and orientations (vertical, horizontal, and inclined) demonstrate that COBRA-SFS can be used for design and licensing safety analyses.
- For large, multiassembly dry storage casks located outdoors, existing standard correlations for cask surface-to-ambient natural and forced convection heat transfer consistently underpredict the actual heat transfer by 20% to 50%. Use of these standard correlations will result in conservatively high predictions of cask surface temperature (and, hence

internal temperatures) for mixed (natural and forced) convection atmospheric conditions.

- Although the majority of cases presented in this report reflect post-test simulations, the ability to make accurate predictions prior to the availability of test data depends heavily on the accuracy and reliability of the geometry, material, and heat generation data provided to the modelers. Generally speaking, the modifications made for the post-test predictions represent refinements in the above parameters, or their uncertainties, which are physically defensible, and do not constitute mere "tuning" or "force fitting" of the code to the data.
- Little effort was devoted to improving the data comparisons except for identifying and correcting obvious input and modeling deficiencies. In some cases the data comparisons might be improved by better noding, and by adjusting heat transfer and friction factor correlations, etc. Most of the comparisons were made in a way that an unfamiliar user might be expected to pursue and therefore are believed to be representative of the code's predictive capabilities.
- Additional refinements in the modeling of fluid-to-fluid heat transfer, and in the modeling of heat transfer and fluid flow in the plenum regions would be expected to further improve the code's predictive capabilities.
- Conduction is the primary mode of heat transfer in consolidated fuel assembly tests. To accurately (± 10 to 20°C) predict the temperature distribution in consolidated assemblies, accurate estimates of rod-to-rod and rod-to-wall contact conductances are required. The contact conductance values used in the simulation of the single assembly consolidated spent fuel test (electrically heated model fuel rods straightened to a tolerance of 0.083 mm/m (0.001 in./ft)) may not be representative of conductance values in actual consolidated fuel. However, when modeling consolidated rods, the assumption of uniform rod-to-rod and rod-to-wall gaps will not result in an excessively high ($\pm 20^\circ\text{C}$) overprediction of fuel rod temperatures.

- The 14-case comparison presented in this report, along with 54 other case comparisons documented in earlier applications reports, satisfies the objective of the code validation effort: to demonstrate that COBRA-SFS is capable of accurately predicting the thermal performance of spent fuel storage systems over a wide range of conditions, that the code logic is working correctly, and that the physics are modeled properly.
- To properly assess code predictions, comparisons of peak temperature, axial temperature profiles, and radial temperature profiles should be made.

2.2 RECOMMENDATIONS

Based on the case comparisons presented in this report and the other COBRA-SFS comparisons with data reported in the various applications reports, the following recommendations are offered.

- COBRA-SFS should continue to be used to predict temperature distributions in spent fuel storage systems and, when available, additional comparisons with measured data should be made.
- If accuracy better than approximately 20°C to 30°C is required, the following, in order of importance, should be pursued:
 - System geometries, especially as-built gap widths and characteristics of contacting surfaces (contact coefficients) should be known.
 - The surface conditions of the components (material emissivities) should be known.
 - The effects of atmospheric turbulence on the surface convective heat transfer for casks located outdoors should be modeled. Existing correlations do not adequately model these effects.
 - Detailed in-reactor radiation scans or spent fuel assembly gamma scans should be used to determine or calculate axial decay heat profiles.
 - COBRA-SFS models of heat transfer and fluid flow in the cask plenum regions should be refined to include radially varying inlet

conditions, a computed velocity field, and multidimensional heat transfer between solid structures.

- To enhance the prediction accuracy of convection heat transfer dominated systems, velocity fields should be measured in simulated casks or future cask tests for comparison with COBRA-SFS predictions.

3.0 COBRA-SFS DESCRIPTION

The COBRA-SFS code is a generalized, steady-state, finite-volume computer code that predicts flow and temperature distributions in spent fuel storage systems and fuel assemblies under mixed and/or natural convection conditions. Derived from the COBRA family of codes that have been extensively evaluated against in-pile and out-of-pile data (Stewart et al. 1977, Khan et al. 1981), COBRA-SFS retains all the important features of the parent COBRA codes and extends the range of application to problems with two-dimensional radiation and conduction heat transfer. This capability permits analyses of single- and multiassembly spent fuel storage systems with unconsolidated or consolidated fuel in both the vertical and horizontal orientations, using a variety of fill media.

In the following sections, COBRA-SFS background modeling capabilities and modeling philosophy are discussed. Detailed discussions of the code and its use are presented in Volumes I and II of this document (Rector, Wheeler and Lombardo, 1986, and Rector et al. 1986b).

3.1 COBRA-SFS BACKGROUND

COBRA-SFS was evolved on the strengths of the COBRA code series. COBRA-IIIC (Rowe 1973), COBRA-IV-I (Wheeler et al. 1976), COBRA-IV (Stewart et al. 1977), and COBRA-WC (George et al. 1980) were developed by the Pacific Northwest Laboratory under sponsorship of the Atomic Energy Commission, the Nuclear Regulatory Commission, and the Department of Energy as part of the reactor safety research effort. The basic computational philosophy of COBRA-SFS comes from COBRA-WC, which included the capability of predicting recirculating (natural convection) flows.

To extend the range of applicability of COBRA-WC to address the expected radiation and conduction heat transfer components in a spent fuel storage system, a wall conduction model and fuel rod and wall radiation heat transfer models were incorporated into COBRA-WC to form the earliest versions of COBRA-SFS. These somewhat crude versions of COBRA-SFS were used to make prelook

predictions for the pressurized water reactor (PWR) single assembly spent fuel test described in Section 4.1 of this report. The success of these predictions suggested that further comparisons of the code with data be performed to fully evaluate the models contained in COBRA-SFS. As new data were made available, COBRA-SFS was refined to provide additional heat transfer and fluid modeling capabilities to facilitate the modeling of different spent fuel storage systems.

Specifically, the documented version of the code (Rector et al. 1986b; Rector, Wheeler and Lombardo 1986) used to perform the simulations presented in this report contains:

- a numerical procedure to internally iterate to a zero-net flow solution
- upper and lower plenum heat transfer models
- a structural member axial conduction model
- a more flexible boundary heat transfer model
- a generalization of the input for the radiation exchange model.

3.2 MODELING CAPABILITIES

A wide range of spent fuel storage systems can be simulated by COBRA-SFS via input instructions. Applications have included analyses of single assembly storage systems (Lombardo et al. 1986; Cuta, Rector and Creer 1984), multiassembly spent fuel storage systems under various orientations and fill media (Wiles et al. 1986; Rector et al. 1986a; McKinnon et al. 1986a), and analyses of both single- and multiassembly consolidated storage systems (Cuta, Rector and Creer 1984; Cuta and Creer 1986; Rector and Wheeler, 1986). The code contains thermal-hydraulic models for pressure drop, turbulent mixing, subchannel diversion crossflow, buoyancy-induced flow recirculation, conduction and radiation heat transfer, and boundary and plenum heat losses. A summary of the code characteristics is presented in the list below.

- Modeling Capabilities
 - quasi three-dimensional
 - steady state
 - triangular, square, or consolidated rod arrays
 - multiple flow regions

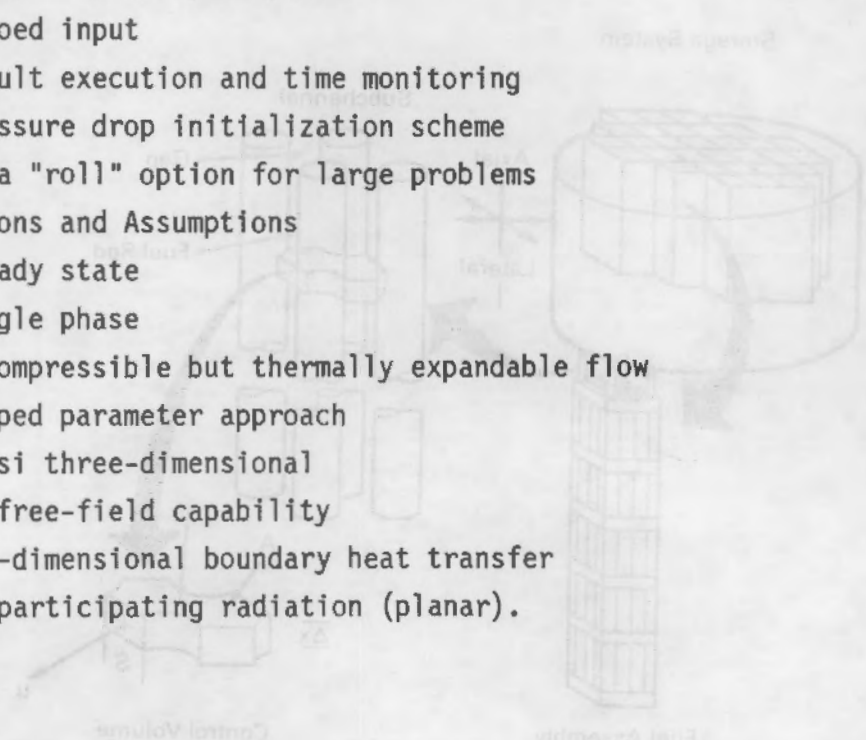
- recirculating flows
- interassembly and intra-assembly heat transfer
- mixed coordinate systems
- variable axial grid spacing
- fluid conduction and turbulent mixing
- pressure drop model (network and subchannel)
- variable rod property
- variable boundary heat transfer
- prescribed surface heat flux
- plenum heat transfer
- user-prescribed flow
- variable fluid properties

• Program and I/O Control

- constant prescribed flow
- zero-net flow solution
- restart and post-processing dump
- decoupled hydrodynamics (no buoyancy)
- fully coupled hydrodynamics
- echoed input
- result execution and time monitoring
- pressure drop initialization scheme
- data "roll" option for large problems

• Limitations and Assumptions

- steady state
- single phase
- incompressible but thermally expandable flow
- lumped parameter approach
- quasi three-dimensional
- no free-field capability
- one-dimensional boundary heat transfer
- nonparticipating radiation (planar).



3.3 COMPUTATIONAL PHILOSOPHY

The COBRA-SFS code is based on the subchannel modeling philosophy. This method has been used extensively in the nuclear industry in past years because it allows complex three-dimensional geometries to be simulated easily and accurately. In the subchannel approach, the storage system, fuel assembly, or waste form being simulated is divided into a number of quasi two-dimensional flow paths or channels. These channels are characterized mathematically by a flow area and wetted perimeter--the exact shape of the channel is unimportant. The relation of a subchannel control volume to a storage system is depicted in Figure 3.1.

Mass, momentum, and energy can be exchanged between neighboring channels by diversion crossflow and turbulent mixing. A lateral connection between channels is defined mathematically by a gap width and the distance between channel centroids. Since a crossflow exists only between adjacent channels that are connected and since there is no momentum coupling from one crossflow to another, discrete lateral coordinate directions or lateral boundary conditions are not needed.

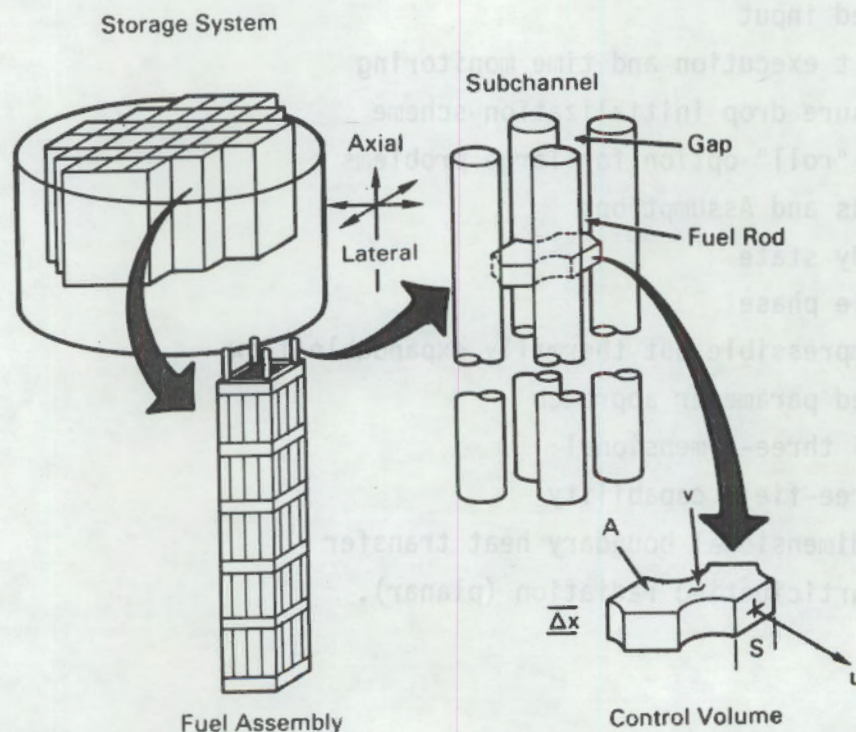


FIGURE 3.1. Relation of Subchannel Control Volume to a Storage System

Subchannels can be used in a variety of ways to describe fluid flow regions. The channel shapes may be quite regular, as in the square array of a fuel bundle, or quite irregular, where large areas of flow are lumped into a single flow channel. In either case, the channels may be connected to an arbitrary number of adjacent channels. Additionally, subchannels may be thermally connected to an arbitrary number of wall or slab nodes; wall nodes can then be thermally connected to any number of other walls by conduction or radiation heat transfer. The overall flexibility of the subchannel approach makes it a very powerful tool in effectively simulating complex geometries.

Subchannels can be used in a variety of ways to describe fluid flow regions. The channel shapes may be quite regular, as in the square array of a fuel bundle, or quite irregular, where large areas of flow are lumped into a single flow channel. In either case, the channels may be connected to an arbitrary number of adjacent channels. Additionally, subchannels may be thermally connected to an arbitrary number of wall or slab nodes; wall nodes can then be thermally connected to any number of other walls by conduction or radiation heat transfer. The overall flexibility of the subchannel approach makes it a very powerful tool in effectively simulating complex geometries.

4.0 SINGLE ASSEMBLY EVALUATION TESTS

The first step in the evaluation of COBRA-SFS was the analyses of single assembly storage systems. Conduction, convection, and radiation heat transfer mechanisms must be properly modeled to accurately predict the thermal performance of these systems. To demonstrate the effectiveness of the COBRA-SFS models for single assembly spent fuel heat transfer, COBRA-SFS predictions of three unique single assembly spent fuel tests, two with an unconsolidated assembly and one with a consolidated assembly, are compared against test data in the following sections. The first test performed and described below was the PWR Single Assembly Spent Fuel Heat Transfer Test, which examines the effect of fill media on thermal performance of an actual PWR spent fuel assembly. Next, the Electrically Heated PWR Single Assembly Test, which examines the thermal response of a model spent fuel assembly under various loadings, orientations, and backfills, is described. Finally, the Consolidated Spent Fuel Test, which examines the heat transfer of model consolidated fuel arrays, is described.

4.1 PWR SINGLE ASSEMBLY SPENT FUEL TESTS

In this test series, the temperature response of a single, instrumented, vertical PWR spent fuel assembly was investigated in atmospheres of air, helium, and a partial vacuum. Experimental axial temperature data were obtained at several radial positions for fixed boundary conditions, thereby quantifying the effect of fill media in the vertical orientation. To examine COBRA-SFS's predicted effect of fill media, simulations of all three test cases were made. In this section, descriptions of the test apparatus, computational model, and modeling uncertainties are provided, along with results of comparisons of predictions with data. Input, representative output, and convergence listings for the cases simulated are presented in Appendix A. Results of prelook simulations made prior to the availability of test data are documented in an earlier applications report (Lombardo et al. 1986).

4.1.1 Test Description

The PWR single assembly test apparatus is shown in Figure 4.1. The test section consisted of a single PWR spent fuel assembly sealed in an instrumented stainless steel canister, which was enclosed in a carbon steel cylindrical liner. The test assembly was maintained in a vertical position by a seismic restraint fixture. The test apparatus and procedures are fully described by Bates (1986), so only a summary of the components is given below.

The PWR spent fuel assembly used in these tests was discharged from the Florida Power and Light Turkey Point Unit Number 3 reactor with a burnup of approximately 28,000 MWD/MTU. The fuel assembly consisted of a 15x15 array with 204 fuel rods, 20 control rod guide tubes, and 1 instrumentation tube. The active fuel length after exposure was assumed to be 3658 mm (144 in.); the overall fuel assembly length was 4097 mm (161 in.). A total of seven spacer grids were located axially over the length of the fuel. A list of relevant fuel assembly parameters is presented in Table 4.1.

Decay heat measurements of the spent fuel assembly were obtained from boiling water calorimetry measurements (Creer et al. 1981; Schmittroth 1984). Decay heat levels of 1.17 kW for the air and vacuum runs and 1.16 kW for the helium run were reported subject to a $\pm 5\%$ accuracy. The axial decay heat profile was inferred from gamma flux measurements of a selected sample of individual fuel pins. It was assumed that the axial decay heat flux is directly proportional to the gamma flux; a plot of the axial decay heat distribution inferred from the measured gamma flux is displayed in Figure 4.2.

During testing, the spent fuel assembly was placed inside the cylindrical, stainless steel test canister. The canister was surrounded by an externally heated, carbon steel pipe which elevated the temperature of the canister wall to values typical of what might be expected in a multiassembly storage system. Welded to the inside of the canister was the fuel assembly vertical support cage, which provided lateral restraint and centered the assembly within the canister. The fuel assembly support cage was fabricated from four 50.8 mm

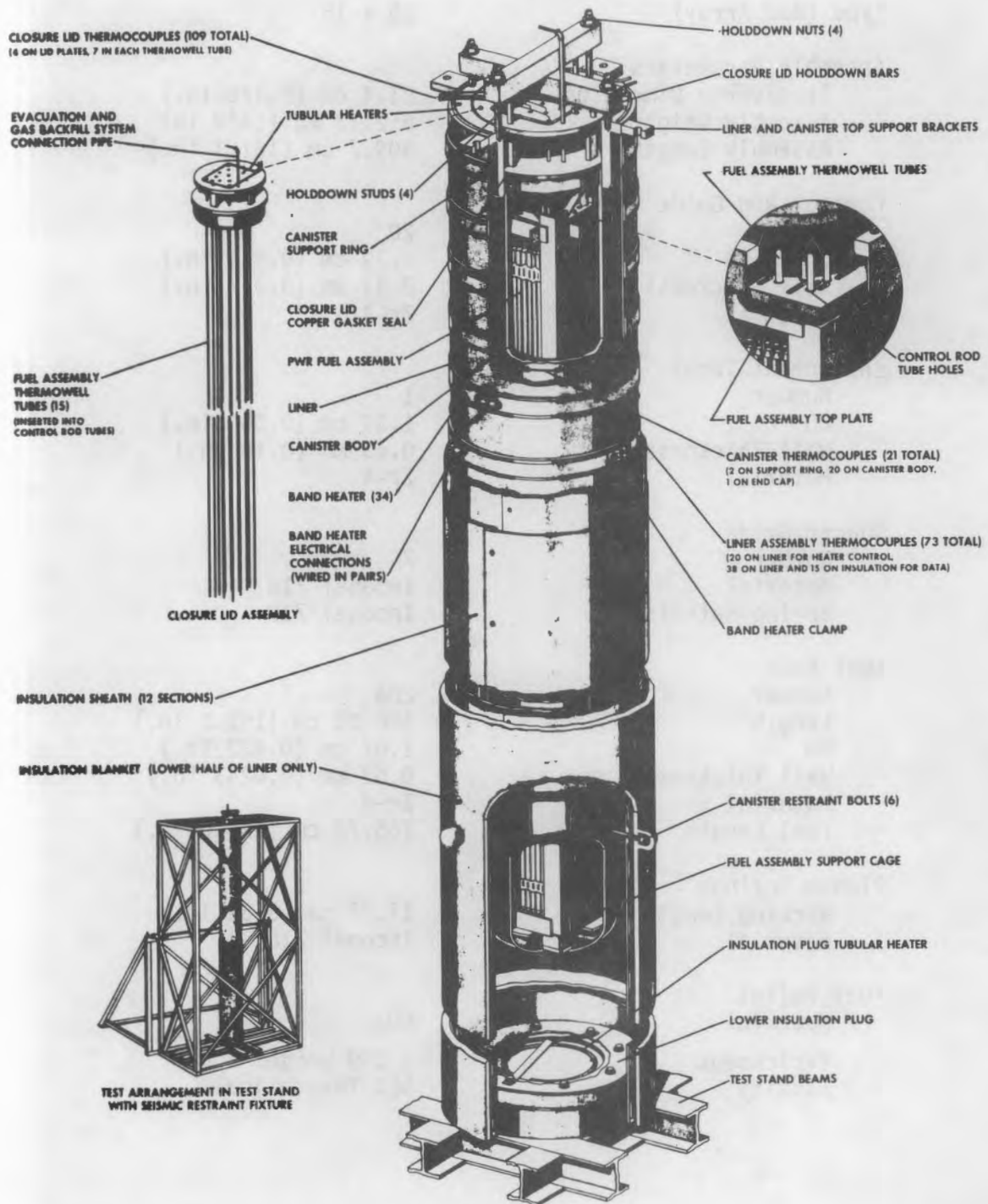


FIGURE 4.1. PWR Single Assembly Spent Fuel Test Apparatus

TABLE 4.1. Turkey Point No. 3 PWR Fuel Assembly Parameters

Vendor	Westinghouse Electric Corp
Type (Rod Array)	15 x 15
Assembly Parameters	
Transverse Dimension	21.4 cm (8.426 in.)
Assembly Weight	652.73 kg (1439 lb)
Assembly Length	409.7 cm (161.3 in.)
Control Rod Guide Thimble Tubes	
Number	20
Upper OD	1.39 cm (0.546 in.)
Wall Thickness	0.43 mm (0.017 in.)
Material	Zr-4
Instrument Tubes	
Number	1
OD	1.39 cm (0.546 in.)
Wall Thickness	0.43 mm (0.18 in.)
Material	Zr-4
Spacer Grids	
Number	7
Material	Inconel 718
Spring Material	Inconel 718
Fuel Rods	
Number	204
Length	386.08 cm (152.0 in.)
OD	1.07 cm (0.422 in.)
Wall Thickness	0.62 mm (0.0243 in.)
Material	Zr-4
Fuel Length	365.76 cm (144.0 in.)
Plenum Springs	
Working Length	17.27 cm (6.80 in.)
Material	Inconel 718
Fuel Pellet	
Material	UO ₂
Enrichment	2.559 Weight % U ²³⁵
Density	92% Theoretical

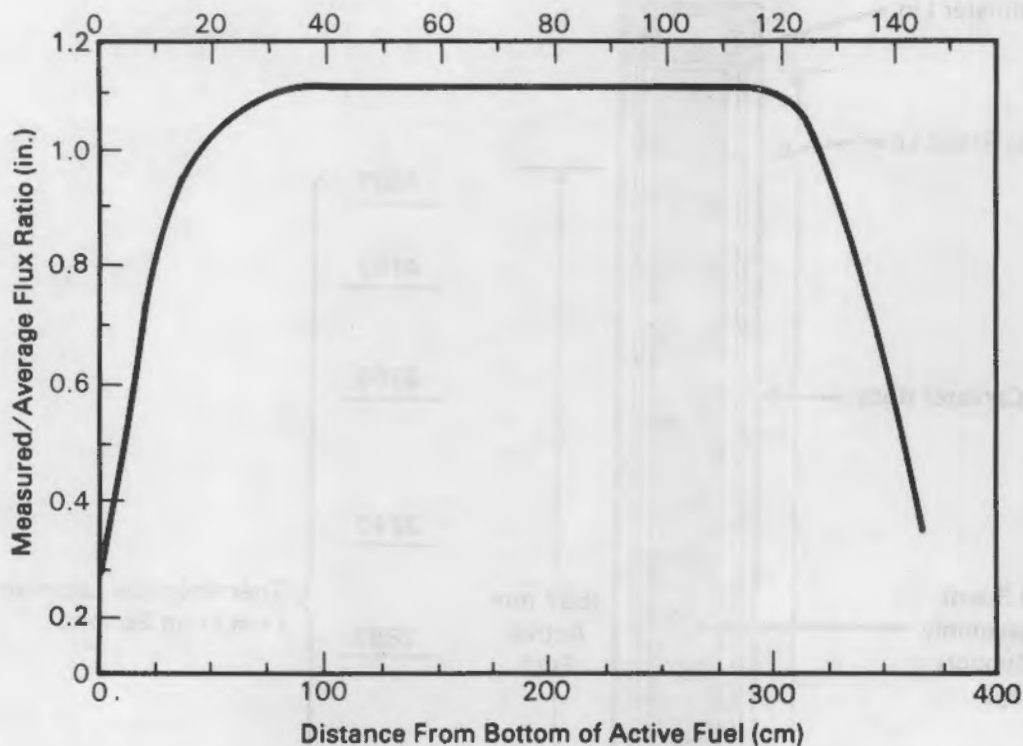


FIGURE 4.2. Turkey Point Spent Fuel Assembly Axial Decay Heat Profile

(2 in.) angle-iron pieces, with each member set upright and positioned adjacent to the assembly corners. Rectangular metal plates were used to join the vertical members of the support cage at six axial levels.

Instrumentation of the canister consisted of 20 thermocouples placed at 5 different axial locations on the outer wall to provide boundary temperature data and heater control. Attached to the canister upper end cap was a tubular heater, also used to maintain elevated boundary temperatures. An axial cross section of the test assembly and canister thermocouple locations is shown in Figure 4.3. Note that the canister was suspended from the liner to minimize the axial heat transfer.

The test assembly was sealed by the canister closure lid assembly. The closure lid assembly was penetrated by 15 instrumentation tubes. The tubes were positioned so that they could be inserted into the existing, hollow

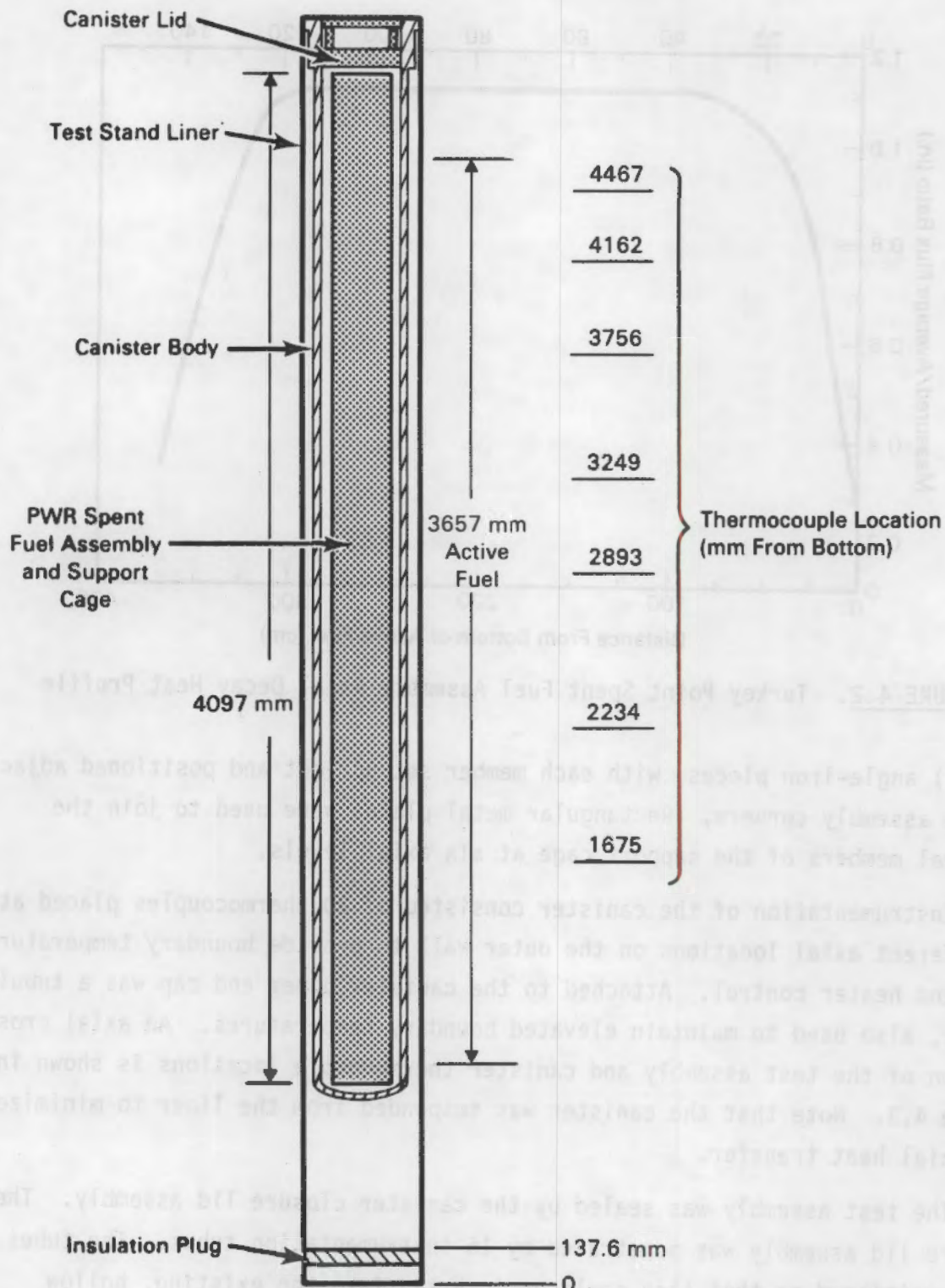


FIGURE 4.3. PWR Single Assembly Spent Fuel Test Apparatus Axial Cross Sections and Thermocouple Locations

PWR fuel assembly control rod guide tubes and center instrumentation tube. Each instrumentation tube contained seven thermocouples and provided fuel assembly temperature data over the length of the bundle. A cross sectional view of the fuel assembly and canister presented in Figure 4.4 illustrates the thermocouple position within the canister. In addition to the instrument tubes, a penetration for gas evacuation and backfill was provided to allow the canister to be filled with various gaseous media for fuel temperature response testing.

Surrounding the canister assembly was a 457.2-mm-(18 in.) diameter carbon steel pipe referred to as the liner. Thirty-four electric-band trace heaters were placed along the liner outside surface to impose an elevated axial temperature distribution along the canister surface. The liner and band heaters were surrounded by a stainless steel insulation sheath; wrapped around the sheath was an insulation blanket to further reduce the test assembly radial heat loss. Additional trace heating was applied in the liner bottom and top plates.

A total of 71 thermocouples were secured to the liner. Of these, 55 provided temperature data; the remaining 18 provided temperature feedback information to the heater controllers. The liner data thermocouples were located midway between the band heaters.

Operation of the test assembly was conducted in atmospheres of air, helium, and a vacuum. For each of the test runs, the liner heater controllers were set to provide a predetermined temperature profile along the canister. Fuel temperature data were taken when thermal stabilization was reached. For the air runs, the vent valve was left open to the atmosphere; in the helium runs the canister was backfilled and pressurized to 1.07 ± 0.03 atmospheres. All vacuum runs were conducted with the vacuum pump running and the cask internal pressure maintained at approximately 0.2 atmospheres. The degree of vacuum imposed in this test represents a low pressure condition, sufficient to eliminate convection, but not low enough for free molecular flow. Thus, the gas thermal conductivity was assumed to be unaffected at these low pressures.

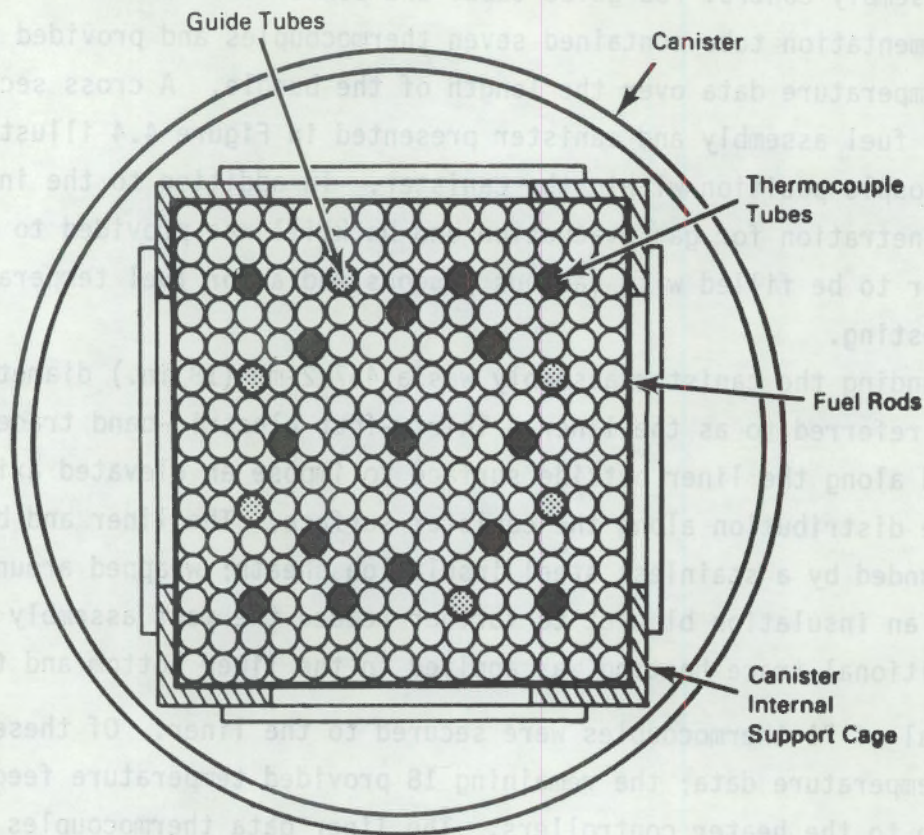


FIGURE 4.4. Transverse Cross Sectional View of PWR Single Assembly Spent Fuel Test Apparatus

4.1.2 Computational Model Description

The computational model used to simulate the PWR Single Assembly Heat Transfer Test is described in this section, along with the modeling parameters and correlations employed. A brief discussion of the modeling uncertainties is also provided. A comparison of code predictions with data is then presented and discussed.

4.1.2.1 Nodal Representation

A three-dimensional model of the PWR Single Assembly Spent Fuel Test Apparatus was used for this analysis. A transverse cross sectional view of the computational cell arrangement illustrating the subchannel and wall noding

employed is displayed in Figure 4.5. A total of 34 axial levels were used in the model.

The test apparatus was modeled using a single assembly, segregated into two distinct regions. The inner, or fuel assembly region, consisted of 31 fuel rods, 4 control rod guide tubes, a center instrumentation guide tube, and 28 fluid subchannels. The second, or downcomer region, consisted of the large flow area defined between the outer row of rods and the canister wall and was modeled as a single channel. Boundary temperatures were specified at the canister wall via input instructions.

Each rod in the interior assembly was individually modeled and divided into five, uniform radial nodes: four for the fuel, and a single node for the cladding. No circumferential rod effects or rod axial heat transfer were modeled. Only the fuel rods were assumed to produce any heat; the measured axial heat profile presented in Figure 4.2 was applied uniformly at each radial position. No flow through the hollow guide or instrumentation tubes was allowed. Appropriate fuel and guide tube diameters were used for the rod and subchannel models.

Two-dimensional rod-to-rod and rod-to-wall radiation heat transfer in a plane was modeled from graybody exchange factors that were provided as input to the code. The exchange factors were developed using the following assumptions:

- isothermal, gray surfaces
- non-participating media
- diffusely reflecting and emitting surfaces
- uniform radiosity over an exchanging surface.

For the fuel rods, the minimum area used to calculate black body view factors was a one-quarter rod surface segment. The evaluation of black body viewfactors based on one-quarter pin surface segments has been shown previously to provide accurate modeling of radiation heat transfer in a fuel rod bundle (Lombardo et al. 1986; Cox 1977). The assembly support cage was ignored when calculating the graybody exchange factors, and it was further assumed that the fuel rods,

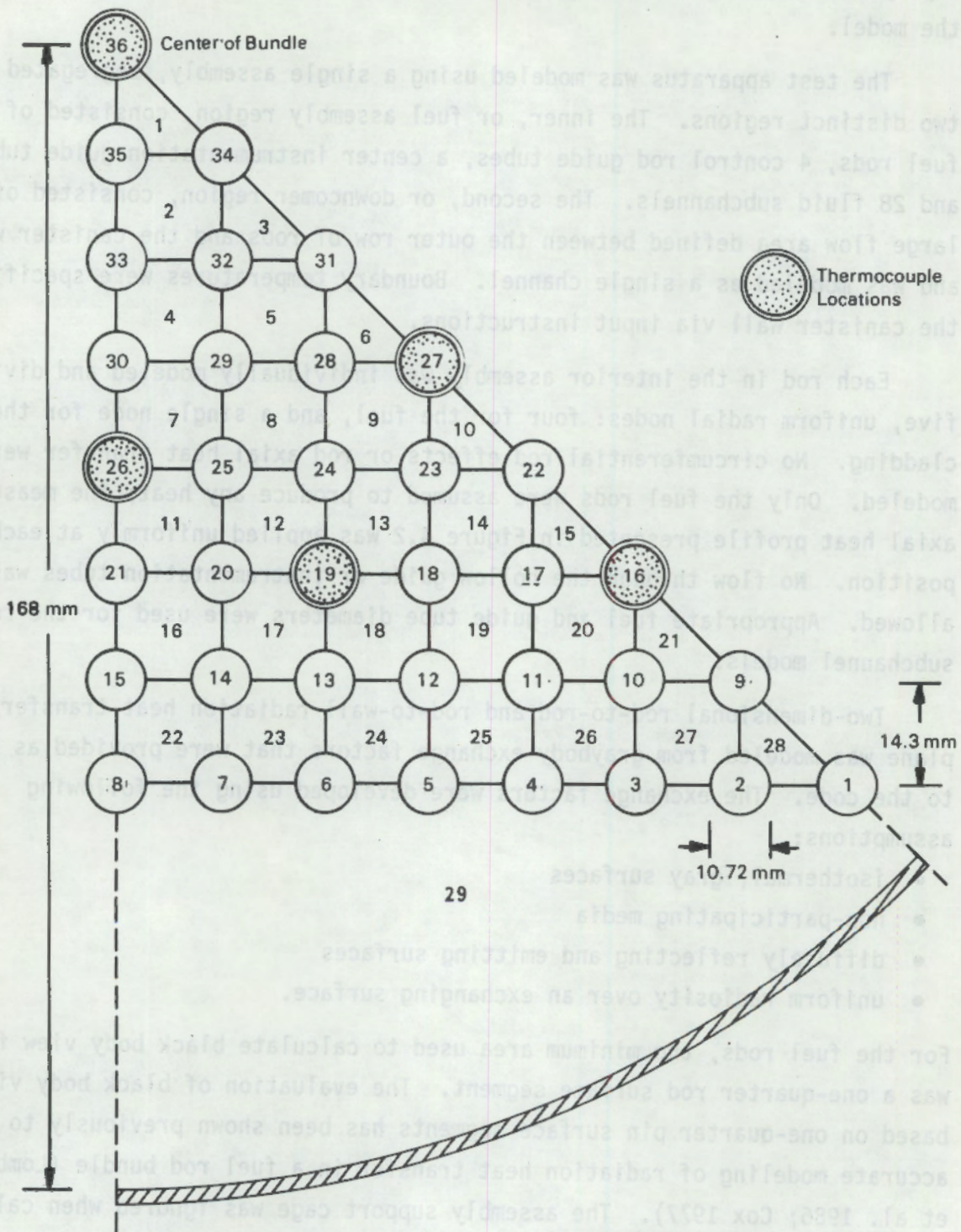


FIGURE 4.5. Transverse Cross Section of COBRA-SFS Computational Model for the PWR Single Assembly Test Apparatus

guide tubes, and instrumentation tube all had the same diameter and emissivities.

4.1.2.2 Modeling Parameters and Correlations

The material properties used in the computational model, with the exception of emittances, were well defined. Solid properties were assumed to be independent of temperature, while fluid properties were input as functions of temperature and were continuously updated during the simulation. The emissivity values used for the highly oxidized zircaloy clad fuel rods and stainless steel canister inner wall were best-estimate values, selected at 0.8 and 0.3, respectively (Peterson 1975, Siegel and Howell 1972).

Fluid conduction was included for all fill media, but was most important for helium. Conduction lengths similar to the fuel rod pitch were used within the fuel rod array.^(a) Fluid conduction between the subchannels adjacent to the outer row of rods and the large downcomer subchannel was also accounted for.

The flow resistance of the test section is important in defining the overall contribution of convection heat transfer within the cask. Rod and wall friction losses were modeled using an analytical solution for fully developed laminar flow along cylinders arranged in a square array; $f = 100/Re$ (Sparrow and Loeffler 1959). Loss coefficients for grid spacers, entrance, and exit losses were assumed to be negligible.

Heat transfer from the rods and walls to the coolant was prescribed using the film coefficient $Nu = 3.66$ (Kays and Crawford 1980). This formulation is an exact solution of the energy equation for a circular tube with a constant surface-temperature and fully developed velocity and temperature profiles. The film coefficient was evaluated as a function of temperature at each location and was applied to both the fuel assembly and downcomer assemblies. For the vacuum case (low pressure air), no enhancement of the heat transfer by convection was assumed; thus, $Nu = 1.0$.

(a) Conduction length is the distance used to define the temperature gradient when calculating the heat transfer between adjacent subchannels.

4.1.2.3 Modeling Uncertainties

The computational model used in the analysis was based on information provided by Westinghouse, Advanced Energy Systems Division (Unterzuber 1981) and summarized by Bates (1986). In developing the model, significant uncertainties were associated with the following important heat transfer and fluid flow parameters:

- material emissivities
- radiation heat transfer shielding effects
- contact heat transfer
- flow resistances
- axial decay heat generation profiles.

The rod and canister wall emissivities are key parameters in the radiation model. A wide range of emissivity values was observed in the literature for these components and was found to be dependent upon oxidation buildup, fabrication technique, and temperature. The values used for the fuel rods and canister wall, 0.8 and 0.3, respectively, are best estimates. Confidence in these values is not absolute, and variations in emissivity from rod to rod may exist. Axial variations in rod emissivity may exist as well.

The heat transfer shielding effect of the fuel assembly support cage is another uncertainty in the radiation model. The angle-iron structures and horizontal support plates of the support cage act as an intermediate radiation shield; however, that effect was ignored for simplicity of model setup. The consequences of ignoring the shielding effects of the support cage are expected to be most severe for the vacuum run.

The unmodeled contact between the fuel assembly and the support cage is another uncertainty. The effect of contact would be to slightly lower and/or skew the fuel rod temperature distribution within the bundle. Since the existence and type of contact were not well defined, the fuel assembly was assumed centered vertically within the canister. Some contact between the spent fuel assembly bottom inlet nozzle and the canister bottom was also expected. Again, specific details of this contact are not known and were not modeled.

Thus, an additional source of uncertainty exists in the unmodeled axial heat transfer from the lower regions of the fuel assembly to the canister bottom.

A good deal of uncertainty exists in the modeling test section flow resistances. Unmodeled flow resistances include those of the grid spacers, and the fuel assembly inlet and outlet nozzles. The unmodeled losses from these components should enhance the natural convection predicted within the cask. The form drag correlation used for the fuel rods was assumed to apply in the open downcomer region; application of this correlation to the geometry of the downcomer region thus represents another uncertainty.

The assumption of symmetry in fuel loading and geometry allowed simulation of the test apparatus using a one-eighth sector model. Some uncertainty may be attributed to this assumption, since the radial heat distribution within a spent fuel assembly can be significantly asymmetric depending on its exposure history. A small uncertainty exists in the measured axial decay heat profile as well.

4.1.3 Comparisons of Predictions to Data

Representative predicted axial temperature profiles for the peak temperature instrumentation tube are plotted with the experimental test data for the three fill media cases in Figures 4.6 through 4.8. The data are presented for rod number 36 (center tube) as a function of elevation from the cask bottom for each fill media. Radial profiles are also plotted with the data at an elevation of 185 cm (72.8 in.) above the cask bottom in Figure 4.9 through 4.11. Both the axial and radial plots are presented in order of increasing system temperature, i.e., helium, air, and vacuum backfills.

Rod temperature data were obtained from thermocouples located inside an instrument tube inserted into the hollow instrumentation tube of the spent fuel assembly. The two cylinders surrounding the thermocouples act as thermal radiation shields so the recorded temperature is slightly lower ($< 5^\circ$) than the surface temperature (Unterzuber 1982). Code predictions represent surface or cladding temperatures, which should be slightly higher than the internally measured data.

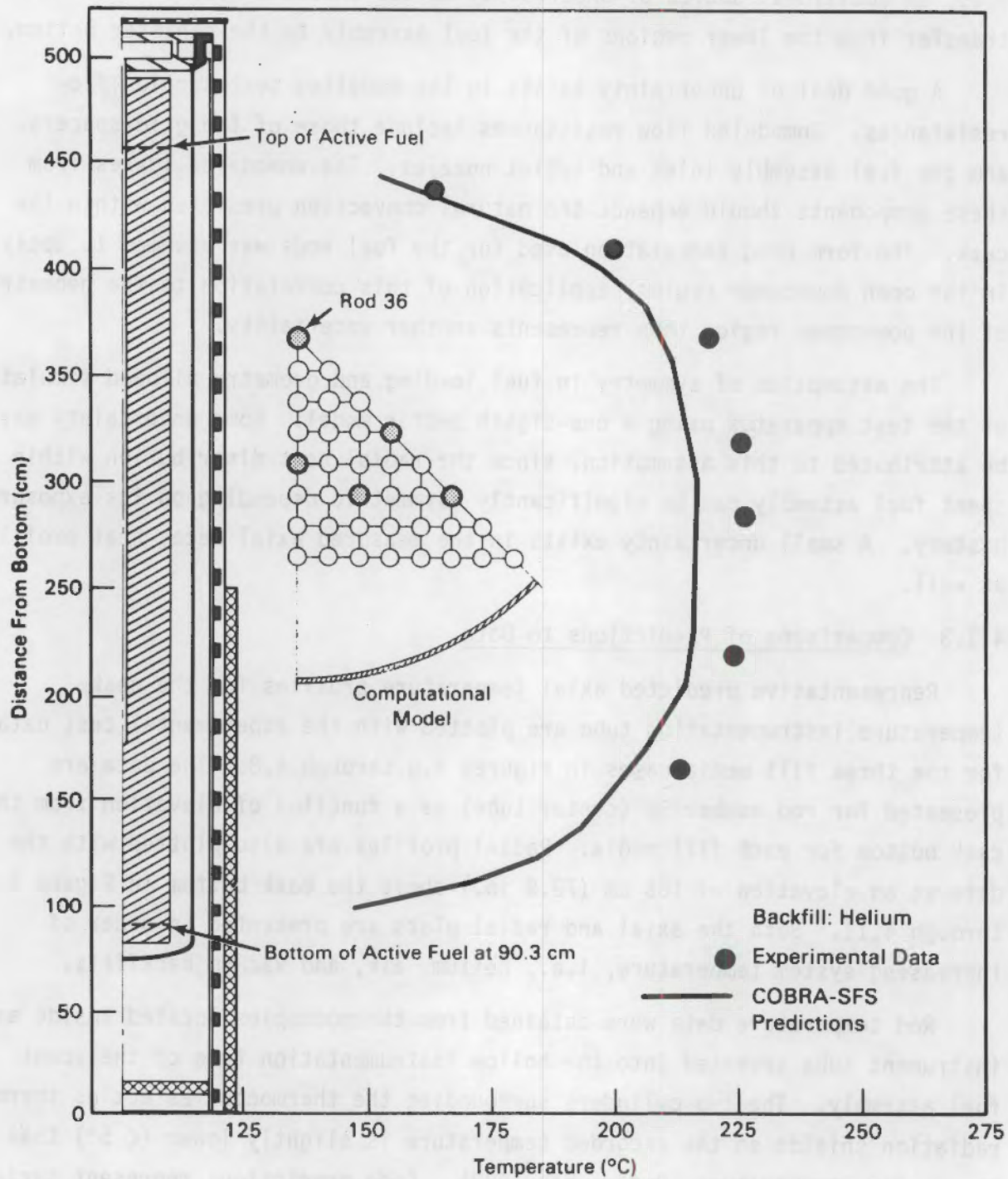


FIGURE 4.6. Predicted Axial Temperature Profile Compared to Rod No. 36, PWR Single Assembly Helium Test Data

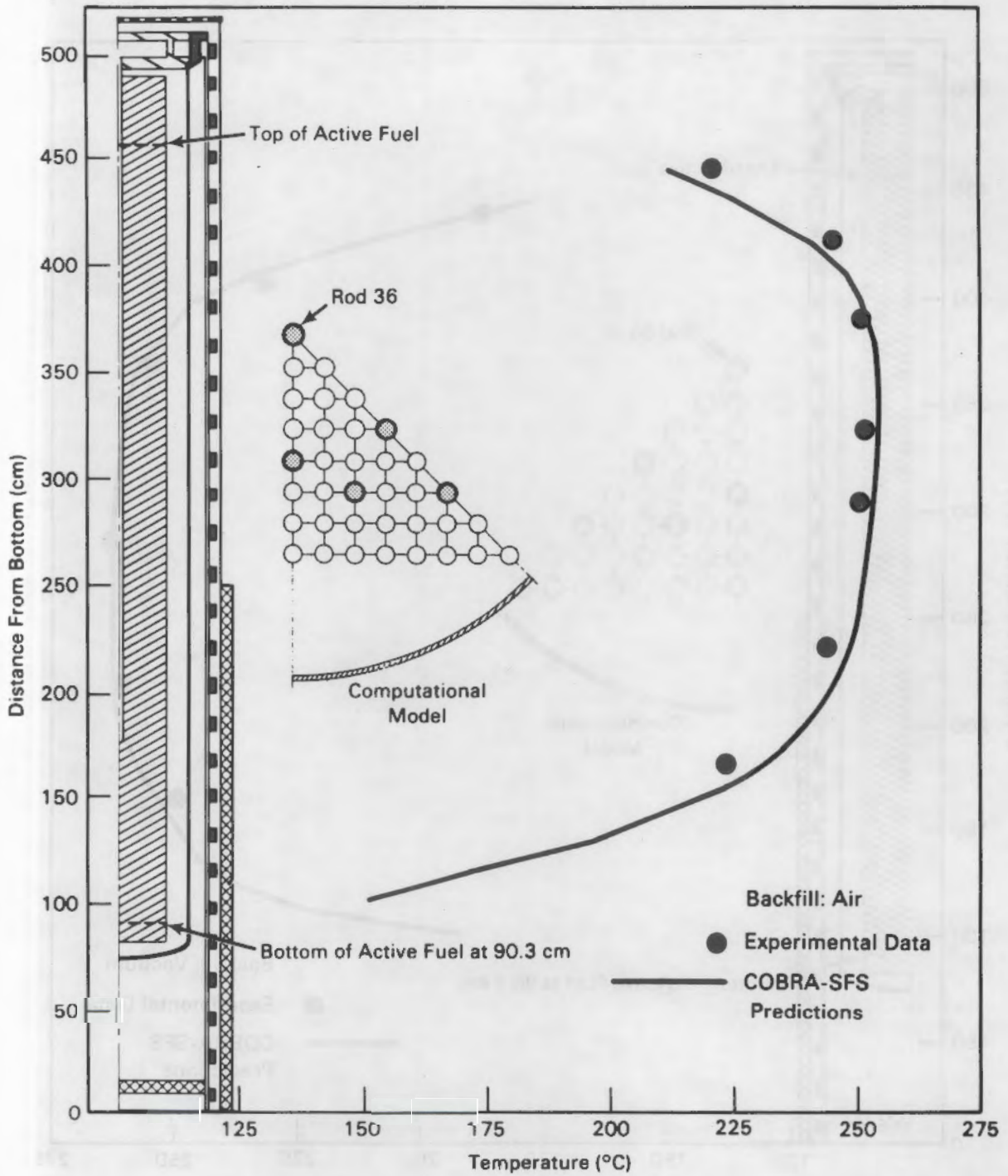


FIGURE 4.7. Predicted Axial Temperature Profiles Compared to Rod No. 36, PWR Single Assembly Air Test Data

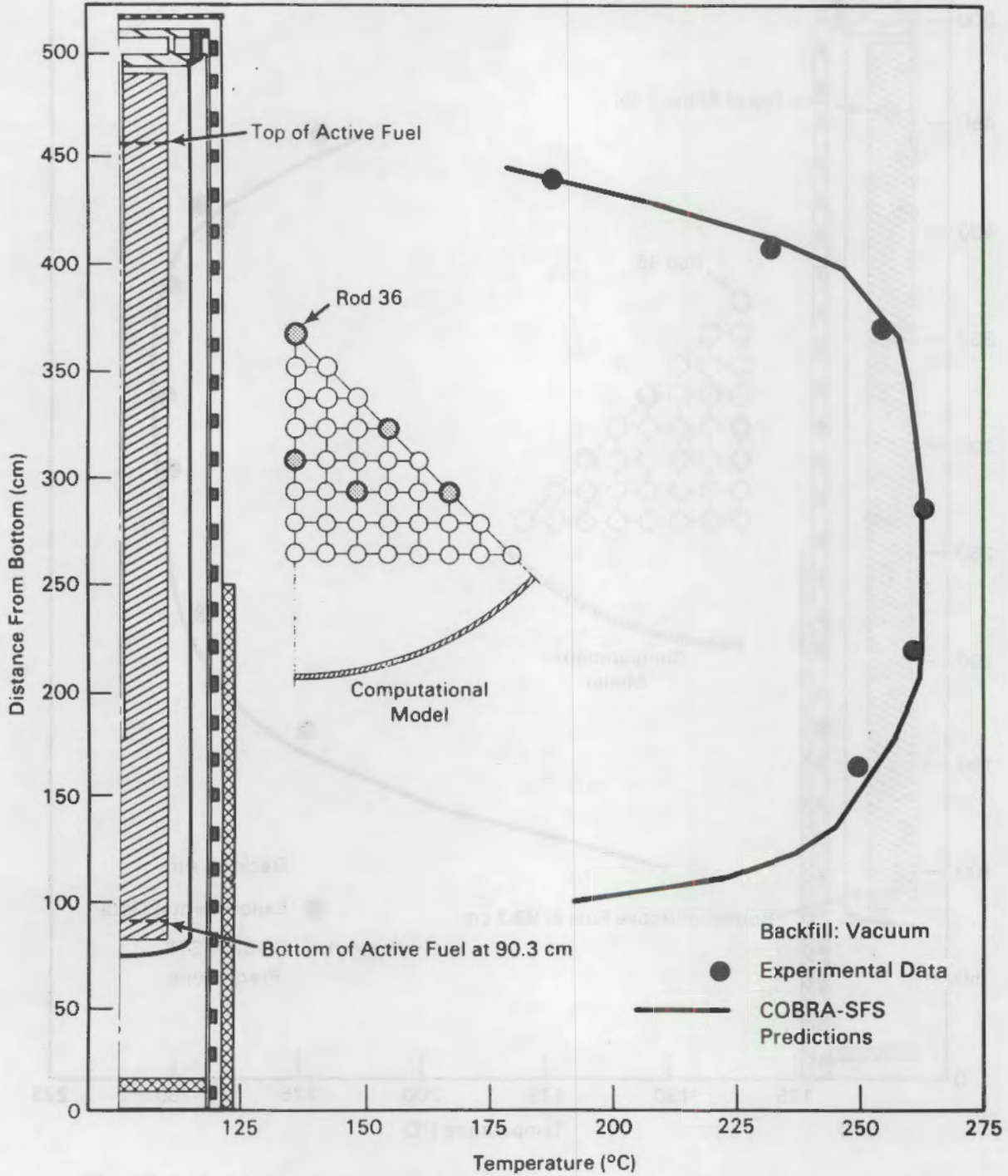


FIGURE 4.8. Predicted Axial Temperature Profile Compared to Rod No. 36, PWR Single Assembly Vacuum Test Data

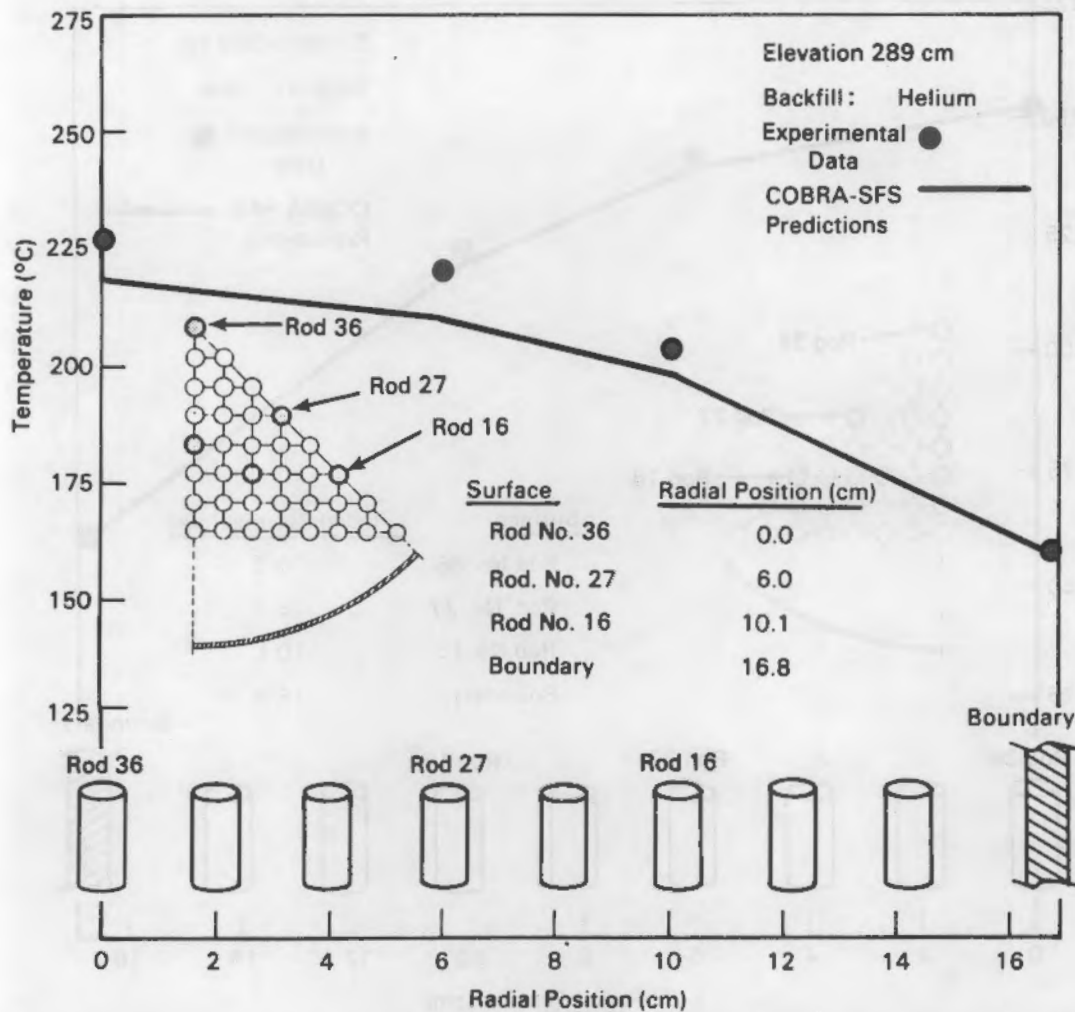


FIGURE 4.9. Predicted Radial Temperature Profile Compared to PWR Single Assembly Helium Test Data at Elevation 185 cm

As indicated in the hot rod axial profile displayed in Figures 4.6 through 4.8, excellent agreement ($\pm 3^\circ\text{C}$) in peak rod temperature for the helium, air, and vacuum runs was obtained. The agreement between predictions and data is approximately equal to the data scatter, estimated at $\pm 3^\circ\text{C}$ (Bates 1986). The exception to this is the helium run, which underpredicted the data by 9°C . The overall agreement with the axial profiles is also seen to closely match the data.

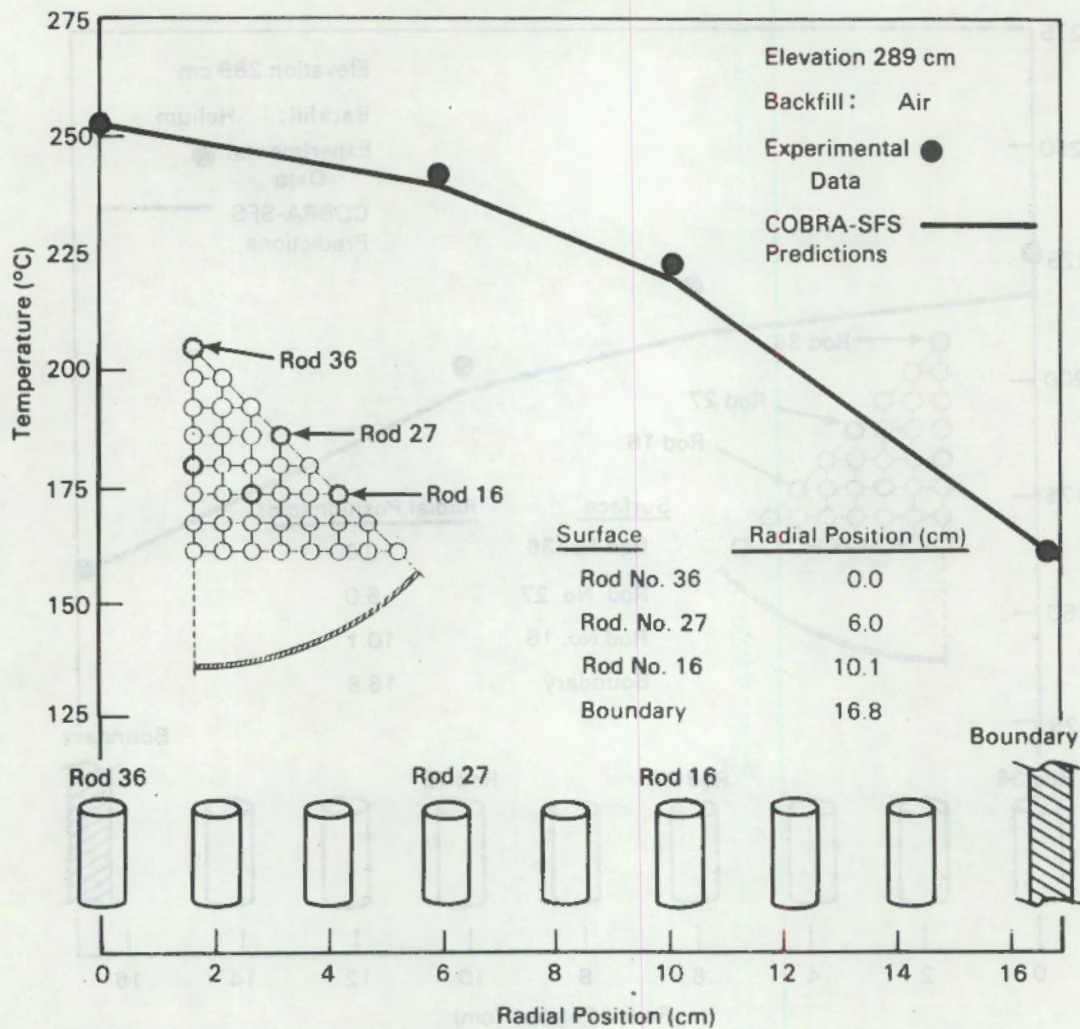


FIGURE 4.10. Predicted Radial Temperature Profile Compared to PWR Single Assembly Air Test Data at Elevation 185 cm

The excellent agreement with data is further supported by the radial temperature profiles shown in Figures 4.8 through 4.11. The air predictions are shown to be within the data scatter at this elevation, although somewhat less agreement is seen in the vacuum predictions, especially towards the outer regions of the fuel assembly. Again, the slight overprediction in this case may be due to the unmodeled radiation heat transfer shielding effects of the fuel assembly support cage. The results for the helium backfill indicate that the assembly thermal resistance is slightly underpredicted, although the predictions are still within 10°C of the data at this elevation. The good

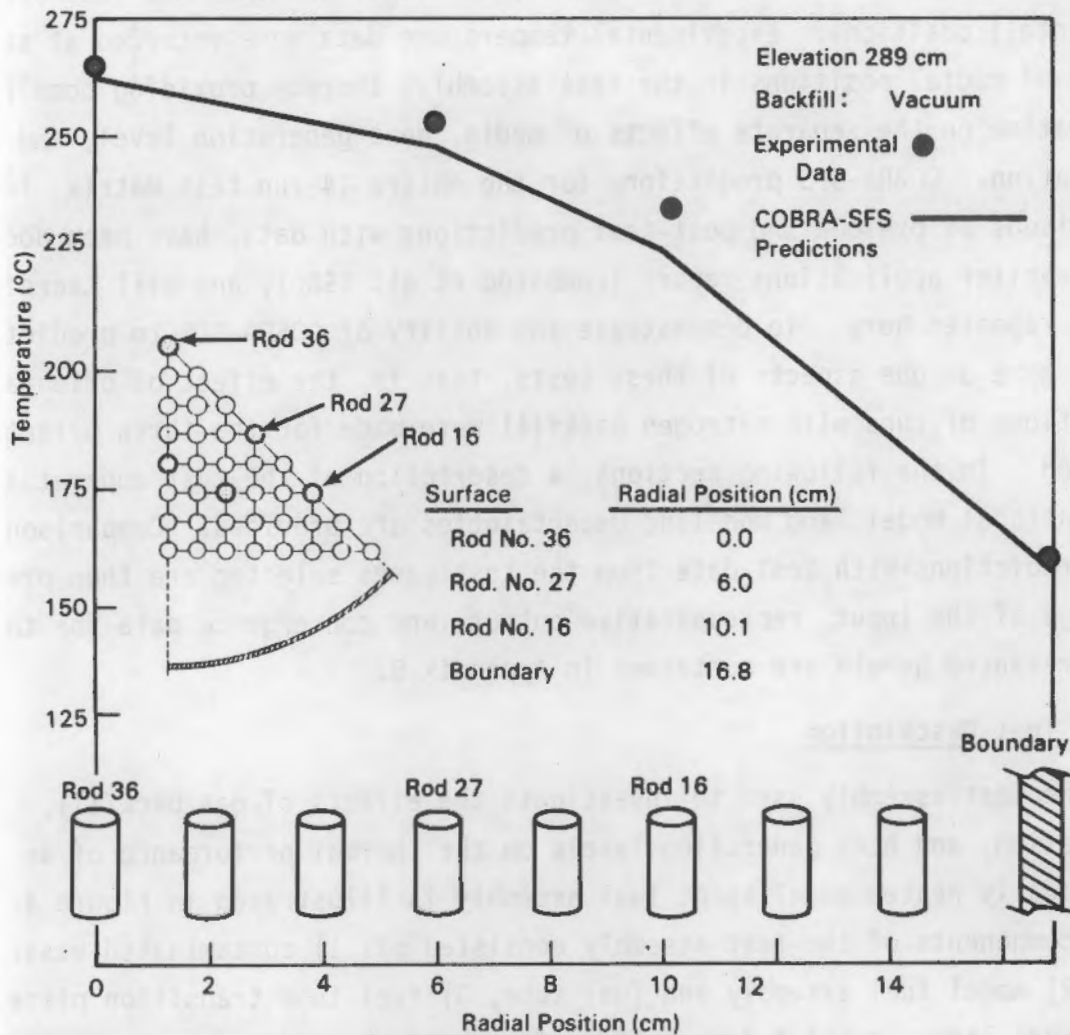


FIGURE 4.11. Predicted Radial Temperature Profile Compared to PWR Single Assembly Vacuum Test Data at Elevation 185 cm

agreement with the data for the three different fill media supports the conclusion that the conduction, convection, and radiation models implicitly contained within COBRA-SFS are performing adequately.

4.2 ELECTRICALLY HEATED PWR SINGLE ASSEMBLY SPENT FUEL TEST

The temperature response of an electrically heated model PWR assembly was investigated at two heat generation levels in atmospheres of air, helium,

and vacuum, while oriented in horizontal, vertical, and inclined (25° from horizontal) positions. Experimental temperature data were recorded at several axial and radial positions in the test assembly, thereby providing complete information on the separate effects of media, heat generation level, and orientation. COBRA-SFS predictions for the entire 14 run test matrix, including comparisons of prelook and post-test predictions with data, have been documented in an earlier applications report (Lombardo et al. 1986), and will therefore not be repeated here. To demonstrate the ability of COBRA-SFS to predict one of the more unique aspects of these tests, that is, the effect of orientation, simulations of runs with nitrogen backfill were made for the three orientations examined. In the following sections, a description of the test apparatus, computational model, and modeling uncertainties are provided. Comparisons of code predictions with test data from the test cases selected are then presented. Listings of the input, representative output, and convergence data for the runs presented herein are contained in Appendix B.

4.2.1 Test Description

The test assembly used to investigate the effects of gas backfill, orientation, and heat generation levels on the thermal performance of an electrically heated model spent fuel assembly is illustrated in Figure 4.12. Major components of the test assembly consisted of: 1) contaminated vessel body, 2) model fuel assembly and fuel tube, 3) fuel-tube transition piece, and 4) closure lids. A brief description of each of the major components is given below; detailed descriptions are given by Bates (1986).

The containment was a cylindrical vessel formed from two concentric steel pipes. Mating flanges were welded to each end of the vessel for the closure lids. The resulting interior cavity of the vessel was 444.5 mm (17.5 in.) in diameter and 4826 mm (190 in.) long. In this test series the vessel annulus contained air at one atmosphere. Natural convection within this annulus was observed as expected.

Encircling the vessel exterior wall were three electrical resistance strip heaters that were spirally wound in parallel along the length of the containment

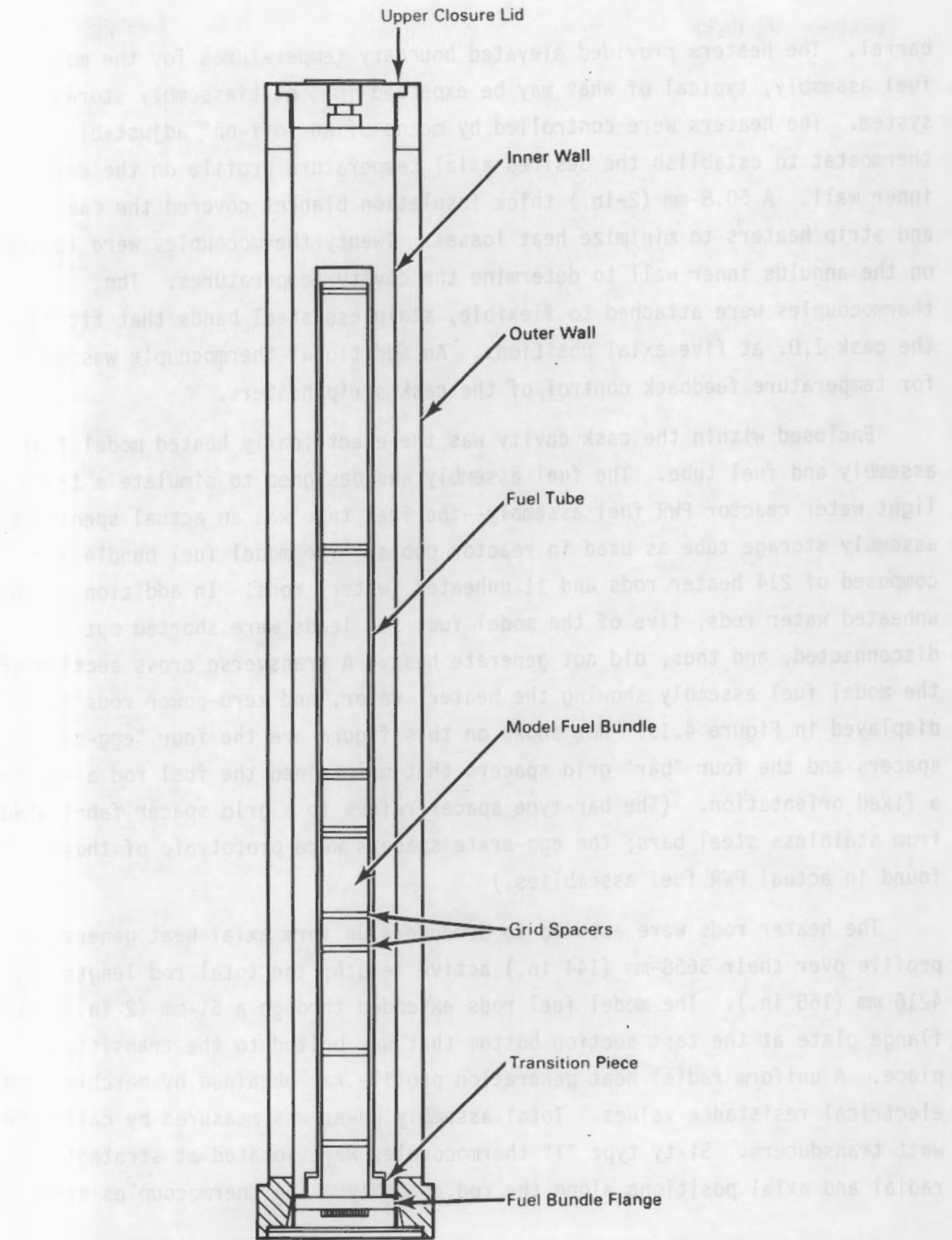


FIGURE 4.12. Electrically Heated PWR Single Assembly Test Apparatus

barrel. The heaters provided elevated boundary temperatures for the model fuel assembly, typical of what may be expected in a multiassembly storage system. The heaters were controlled by means of an "off-on" adjustable setpoint thermostat to establish the desired axial temperature profile on the cask inner wall. A 50.8-mm (2-in.) thick insulation blanket covered the cask barrel and strip heaters to minimize heat losses. Twenty thermocouples were located on the annulus inner wall to determine the cavity temperatures. The thermocouples were attached to flexible, stainless steel bands that fit into the cask I.D. at five axial positions. An additional thermocouple was used for temperature feedback control of the cask strip heaters.

Enclosed within the cask cavity was the electrically heated model fuel assembly and fuel tube. The fuel assembly was designed to simulate a 15x15 light water reactor PWR fuel assembly--the fuel tube was an actual spent fuel assembly storage tube as used in reactor pools. The model fuel bundle was composed of 214 heater rods and 11 unheated (water) rods. In addition to the unheated water rods, five of the model fuel rod leads were shorted out or disconnected, and thus, did not generate heat. A transverse cross section of the model fuel assembly showing the heater, water, and zero-power rods is displayed in Figure 4.13. Not shown on this figure are the four "egg-crate" spacers and the four "bar" grid spacers that maintained the fuel rod array in a fixed orientation. (The bar-type spacer refers to a grid spacer fabricated from stainless steel bars; the egg-crate spacers were prototypic of those found in actual PWR fuel assemblies.)

The heater rods were assumed to produce a uniform axial heat generation profile over their 3658-mm (144 in.) active length; the total rod length was 4216 mm (166 in.). The model fuel rods extended through a 51-mm (2 in.) thick flange plate at the test section bottom that was bolted to the transition piece. A uniform radial heat generation profile was obtained by matching rod electrical resistance values. Total assembly power was measured by calibrated watt transducers. Sixty type "T" thermocouples were located at strategic radial and axial positions along the rod assembly. The thermocouples were

FIGURE 4.13. Electrically Heated PWR Single Assembly Test Apparatus

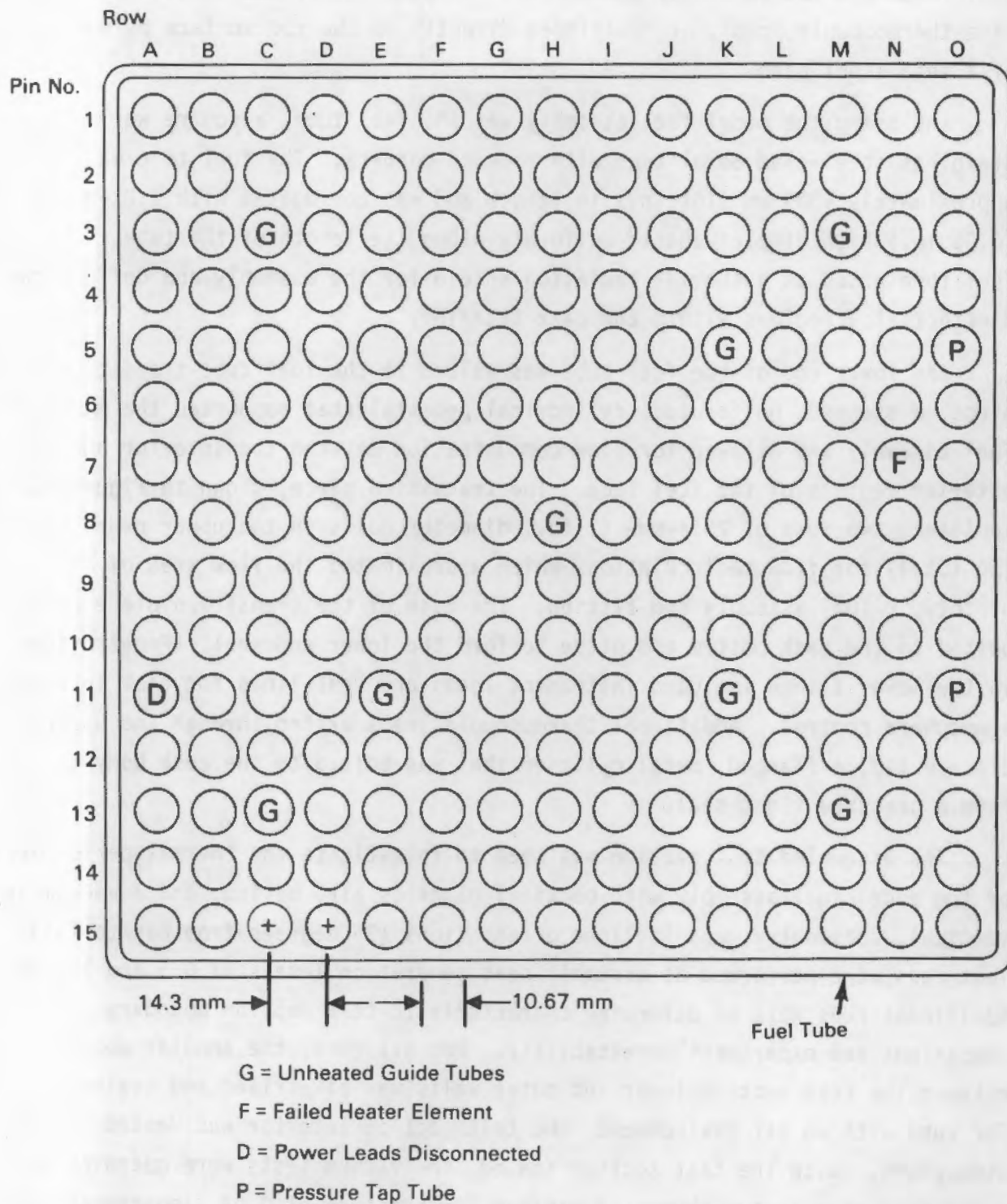


FIGURE 4.13. Transverse Cross Sectional View of Electrically Heated Single Assembly Test Section

positioned and locked midway between two adjacent heater rod sheaths by means of a thermocouple "pad", or positioned directly on the rod surface by means of a thin steel band.

Enclosing the model fuel assembly was the fuel tube, a square walled, stainless steel-clad Boral tube with rounded corners. The fuel tube was approximately 4089 mm (161 in.) in length and was corrugated with 1.27-mm- (0.05 in.) high dimples spaced uniformly along the length of the tube. The fuel tube acted as a thermal radiation shield for the assembly and defined two distinct flow regions within the cask interior.

The lower end of the fuel tube was welded to the fuel tube-transition piece, a stepped, perforated, cylindrical pedestal that supported the model fuel assembly and allowed for flow communication between the interior and exterior regions of the fuel tube. The transition piece, shown in Figure 4.14, contained two rows of 25.4-mm- (1 in.) diameter holes in the upper pedestal (50 total) for flow recirculation, which approximated the flow area of a prototypic fuel assembly end fitting. The base of the transition piece was bolted to the cask bottom end piece to form the lower end seal. Penetrations in the lower flange included instrument leads and vent lines for cask internal atmosphere control. Additional thermocouple leads exited through the upper closure lid, a flanged, metal cylinder that was bolted to the cask body to form a pressure tight seal.

The assembled test section was used to investigate the thermal performance of the model fuel assembly with backfill gases of air, helium, and a vacuum in vertical, horizontal, and inclined orientations (25 degrees from horizontal). Test runs were performed at assembly heat generation levels of 0.5 and 1.0 kW. Additional runs were to determine characteristic test section boundary conditions and experiment repeatability. For all runs, the annular space between the test section inner and outer walls was air-filled and sealed. For runs with an air environment, the test section interior was vented to the atmosphere. With the test section sealed, the vacuum tests were operated at a pressure of 0.1 atmospheres; a minimum low pressure of 0.04 atmospheres was reached to investigate the effect of the vacuum level on the assembly thermal

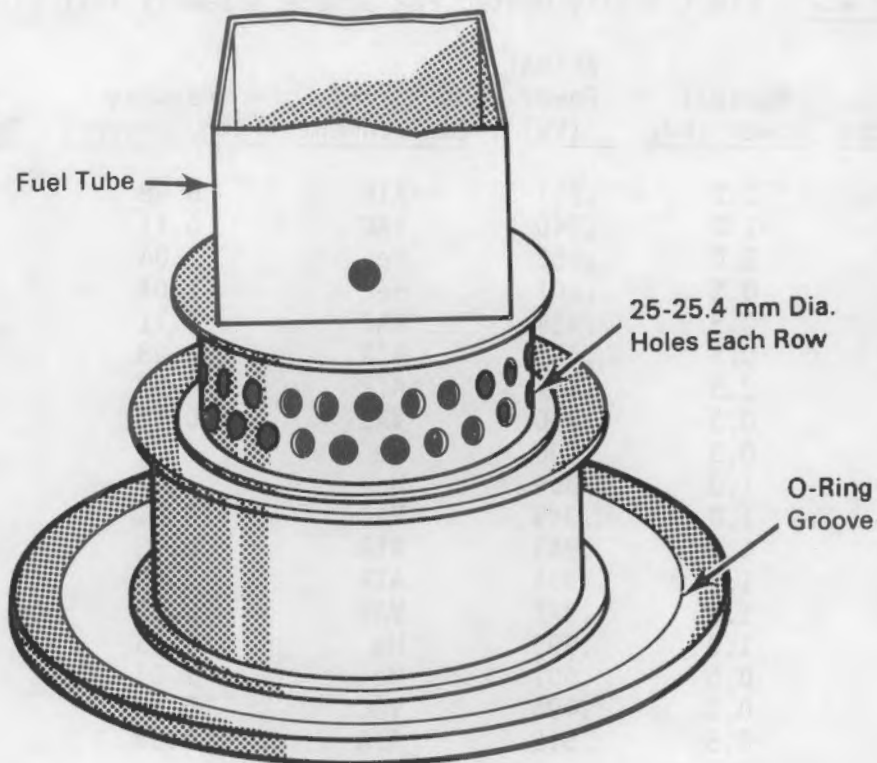


FIGURE 4.14. Fuel-Tube Transition Piece

response. For the helium test runs, the test section was sealed, evacuated, and repressurized with helium to approximately 1.1 atmospheres with a pressurized helium supply. An outline of the test matrix is presented in Table 4.2.

4.2.2 COBRA-SFS Computational Model Description

The COBRA-SFS computational model used to simulate the Electrically Heated Single Assembly Heat Transfer Test is presented in this section along with the modeling parameters and correlations employed. A brief discussion of the modeling uncertainties is also provided.

TABLE 4.2. Electrically Heated PWR Single Assembly Test Matrix

Test No.	Attitude	Nominal Power (kW)	Actual Power (kW)	Environment	Pressure (Atmospheres)	Ambient Temperature
1	25°	1.0	.951	AIR	0.98	28°C
2	25°	1.0	.940	VAC	0.11	30°
3	25°	1.0	.956	He	1.04	27°
4	25°	0.5	.501	He	1.04	23°
5	25°	0.5	.484	VAC	0.11	28°
6	25°	0.5	.477	AIR	0.98	24°
7	H	0.5	.487	AIR	0.98	23°
8	H	0.5	.486	VAC	0.12	26°
9	H	0.5	.500	He	1.04	21°
10	H	1.0	.964	He	1.03	23°
11	H	1.0	.949	VAC	0.11	23°
12	H	1.0	.943	AIR	0.98	27°
13	V	1.0	.994	AIR	0.98	19°
14	V	1.0	.977	VAC	0.10	17°
15	V	1.0	.995	He	1.03	21°
16	V	0.5	.501	He	1.03	21°
17	V	0.5	.496	VAC	0.11	22°
18	V	0.5	.515	AIR	0.98	22°

VAC = vacuum
H = horizontal
V = vertical

4.2.2.1 Nodal Representation

A three-dimensional model of the electrically heated single assembly test section was developed for the COBRA-SFS analysis. A transverse cross section of the computational cell arrangement is presented in Figure 4.15 that illustrates the subchannel and wall noding employed. A total of 24 uniform axial nodes were used to model the axial direction. Only the interior components were modeled since the inner wall temperatures were provided as boundary conditions.

The test section was modeled as two assemblies: the interior, or rod assembly, and the exterior, or downcomer assembly. In the interior assembly,

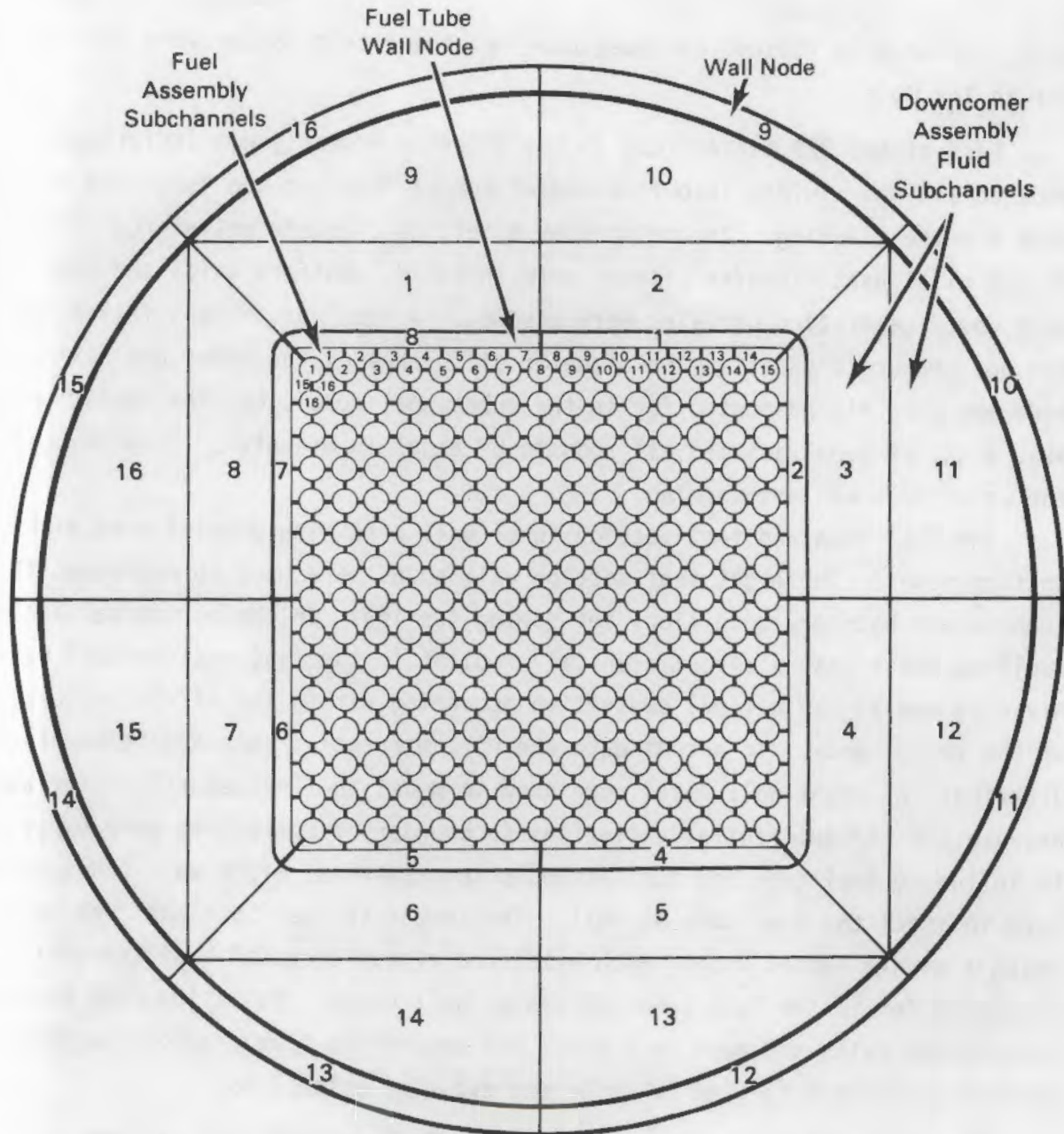


FIGURE 4.15. Transverse Cross Section of COBRA-SFS Computational Model for the Electrically Heated PWR Single Assembly Test

256 subchannels were used to describe the flow paths at each axial level; an additional 16 subchannels defined the downcomer flow paths. Conduction between fluid subchannels was accounted for in both assemblies. Rod and wall surface

drag, spacer grid losses, and fuel tube inlet and exit losses were all accounted for in the model.

Each of the 225 heater rods in the interior assembly was individually modeled and was divided into five radial nodes: four for the fuel, and a single node for the cladding. In the prelook model, no circumferential rod effects or rod axial heat transfer effects were included. Uniform axial and radial heat power generation profiles were assumed. A total of 15 rods failed and did not produce any heat. The diameter difference of the water and heater rods was properly accounted for in the subchannel model, but the radiation heat transfer model assumed all rods to be equal in diameter. Flow through the water rods was not modeled.

The fuel tube and test section inner wall were each modeled with eight uniform nodes. The eight test section wall nodes were used to represent the temperature boundary conditions set during testing. In the horizontal and inclined positions, a circumferential gradient in the test section wall was measured due to the natural convection occurring within the air-filled annulus of the vessel body. To accommodate the circumferential boundary temperature distribution, eight wall nodes were used to model the test section outer wall. Because the circumferential variations in boundary temperatures were expected to influence fuel tube and fuel assembly temperatures, eight wall nodes were used to model the fuel tube as well. The composite fuel tube wall was modeled using a single radial node. Both axial and circumferential heat transfer were accounted for in the fuel tube and vessel wall nodes. Radiation heat exchange between the walls and rods on a plane was determined from graybody exchange factors prescribed for the interior and exterior assemblies.

In the interior assembly, the exchange factors were derived from one-quarter rod surface segments, a more exact approach than the assumption of uniform radiosity over a surface. Proper subdivision of the fuel rod surface was determined in the PWR Single Spent Fuel Assembly Test comparisons to be significant in determining the proper radiative heat exchange within an enclosed assembly (Lombardo et al. 1986). The graybody exchange factors specified for the downcomer assembly were based on wall node surface areas equal to one-eighth

of the total heat transfer area. All gaseous fill media were considered nonparticipating with respect to radiation heat transfer.

As-measured temperatures along the test section interior wall were applied in the model by use of specified boundary temperature profiles in the downcomer assembly. Additional temperature measurements in the upper and lower plenums completed the prescribed boundary temperature field of the test section cavity.

Upper and lower plenums were employed to model the large mixing volumes and heat transfer areas that existed in the test section cavity above and below the model fuel assembly. The plenum models allowed for mixing of the upflow and down-flow channels and provided a means of adding or removing heat from these regions. No flow field was calculated within the plenums; however, one-dimensional radial and axial heat losses were modeled. Heat transfer from the upper and lower closure lids was simulated using this approach. Axial heat transfer from the fuel tube walls to the plenum region was also modeled.

4.2.2.2 Modeling Parameters and Correlations

The material properties used in the computational model, with the exception of emittances, were well defined. Fluid properties were input as functions of temperature and were updated continuously during the simulation. A range of emissivity values was identified for the solid structures within the test section. Emissivity is known to be dependent upon fabrication technique, oxidation buildup, and temperature. Unique values of emissivity were used for each of the stainless steel components: an emissivity of 0.25 was assumed for the stainless steel-clad fuel tube; whereas an emissivity of 0.6 was assumed for the heater rods. The larger value of emissivity chosen for the heater rods reflects the many hours of high-temperature operation in an oxidizing environment. The emissivity value used for the fuel tube lies in the range of experimental data previously obtained from a similarly constructed fuel tube (Taylor 1983) prior to exposure to high temperature. Allowing for some oxidation of the vessel stainless steel inner liner, an emissivity value of 0.6 was assumed.

Heat transfer from the rods and walls to the coolant was prescribed through use of a film heat transfer coefficient of the form $Nu = 3.66$ (Kays and Crawford 1980). This formulation is an exact solution of the energy equation for a constant surface temperature and fully developed velocity profiles in a circular tube. The film coefficient was evaluated as a function of temperature at each location. For the vacuum (low pressure air case), no enhancement of the heat transfer by convection was assumed; thus, $Nu = 1.0$.

The overall flow resistance of the test assembly was assumed to be a combination of:

- rod and wall surface drag
- spacer losses
- fuel tube inlet and exit losses
- model fuel assembly inlet and exit losses.

For the interior assembly, rod and wall friction were modeled from an analytical solution for fully developed laminar flow along cylinders arranged in a square array; $f = 100/Re$ (Sparrow and Loeffler 1959). This correlation was found to provide the best estimates of wall friction as determined in the PWR Single Assembly Spent Fuel Test post-test analysis (Lombardo et al. 1986). This estimate of form friction was also used in the downcomer for the helium and vacuum cases, but was not applied in the air case, as discussed below.

A substantially larger value of friction was required for the downcomer assembly in the air case to lessen the magnitude of numerically induced flow oscillations. Small changes in the system pressure drop produced corresponding large changes in the downcomer velocity field. The favorable buoyant properties of air and the large subchannel areas in the downcomer are thought to be responsible for the oscillations observed. To stabilize the flows, a friction factor of 100 was applied in the downcomer region. Evaluation of the effect of the increased downcomer flow resistance indicated a $\pm 10^\circ\text{C}$ change in peak clad temperature.

Spacer pressure losses were defined for both the egg-crate and bar-type spacers as $K = 1$ and $K = 8$, respectively. Losses due to the area changes at the model fuel assembly exit were modeled by a loss coefficient of 1.0. Losses

at the model fuel assembly inlet included losses due to area change as well as losses from the fuel tube-transition piece (Figure 4.14). A loss coefficient of 18 was used for the downcomer and model fuel assembly inlet (Idel'Chik 1966).

Heat losses from the plenum regions to the boundary required the specification of the thermal resistance from the bulk mixed-mean fluid temperature to the film boundary layer. For the air cases, a correlation of the form $Nu = 50$ was used to define this resistance for both plenum regions, and was based on results for air flowing in a pipe (Kreith 1965). A correlation of the form $Nu = 10$ was used in the helium backfill cases which incorporates an increase in the bulk-to-film thermal resistance due to the reduced natural convection characteristics of helium.

4.2.2.3 Modeling Uncertainties

The computational model developed for the analysis was based on drawings supplied by Allied General Nuclear Services, fabricators of the test assembly, and descriptions of the components, instrumentation, and test operation provided in the data report (Bates 1986). In developing the model, significant uncertainties were associated with the following important heat transfer and fluid flow parameters:

- material emissivities
- model fuel rod pitch
- plenum thermal resistance
- test section flow resistance.

Each of these uncertainties is addressed below.

The surface emissivity values were a major source of uncertainty in these simulations. A wide range of emissivity values was observed in the literature for the test section components and was found to be dependent upon oxidation buildup, fabrication technique, and temperature. Values used were 0.6 for the stainless steel cask inner wall, 0.25 for the stainless steel-clad fuel tube, and 0.6 for the stainless steel-clad heater rods. The values chosen represent best estimates. Confidence in these values is low, and variations

of emissivity from rod to rod probably exist. Uncertainty of the graybody assumption exists for all surfaces.

It is interesting to note that uncertainty in the fuel tube emittance affects the thermal resistance of both the rod assembly and downcomer region, whereas errors in the heater rod or test section inner wall emittance alters the thermal resistance for that region only. Additionally, because of the relatively low value of fuel tube emittance, 0.25, a small change in this parameter represents a large change in the radiative heat transfer to and from the fuel tube. Thus, the fuel tube emittance is a critical parameter in determining the proper radial temperature profile through the test section.

An additional parameter that influences the radiation and convection heat transfer within the test section is the model fuel rod pitch. Use of the bar-type grid spacers, in conjunction with the larger diameter guide tubes, effectively spreads the fuel assembly cross section so that the rod pitch is altered. The concentration of bar-type spacers in the upper elevations of the fuel assembly suggests that axial variation of the fuel rod pitch may exist. In fact, measurement of the as-built fuel rod pitch in the upper elevations indicates an increase from the nominal value of 14.3 mm (0.563 in.) to 14.76 mm (0.581 in.). The uncertainty in the fuel rod pitch is significant because radiation heat transfer within the enclosure is a function of the "view" each rod has of adjacent rods and the walls. When the pitch is increased, the views increase as well, enhancing the radiative heat removal. Uncertainty in the rod pitch also affects the convection established within the cask as the film coefficient and the friction factor are both functions of the equivalent hydraulic diameter. Thus, uncertainty in the rod pitch can affect the radiation and convection heat transfer within the cask. Other uncertainties resulting from the use of the bar-type spacers are the localized flow blockage, thermal radiation shielding, and radial conduction effects. No attempts were made to model these details. Elimination of these effects from the computational model represents another uncertainty.

A large degree of uncertainty existed in defining the plenum region heat transfer, due in part to the many simplifying assumptions that were made. Most importantly, it was assumed that the heat transfer from the plenums is a

function of the natural convection established; that is, backfill gasses with good buoyant properties are expected to produce higher fluid velocities, and thus, improved heat transfer. Values of the plenum bulk-to-film resistance were employed globally over the plenum surfaces, neglecting any local effects. The effect of solid structures within the plenums was also ignored. To complete the thermal model of the plenum regions, a plenum boundary temperature must be prescribed. Identifying a proper plenum boundary temperature was complicated because the cask closure pieces were not insulated and the cask heaters did not extend over the entire length of the test assembly. Therefore, very severe axial temperature gradients occurred within the plenum regions. The nonuniform plenum surface temperatures were approximated by an integrated temperature for the boundary, which represents another approximation.

The major uncertainty in flow resistances is associated with the fuel tube-transition piece. The complex geometry and multiple flow paths of this structure make specification of actual flow resistances difficult. Additional uncertainty exists with the loss coefficients applied to the bar-type grid spacers, and to the fuel tube exit. As discussed earlier, the artificially high flow resistance applied in the downcomer assembly to aid in the computational stability of the air backfill cases is also a cause of uncertainty.

One mode of heat transfer not well defined in these simulations is the rod axial conduction from the lower regions of the model rod to the heater rod flange. Large uncertainties exist in the heater rod-to-flange contact resistance as well as the contact heat transfer area. The version of COBRA-SFS used in this analysis does not include the capability of transferring heat axially from the rods to a plenum structure (the heater rod flange), so it was not modeled.

The electrically heated assembly was assumed to have uniform radial and axial heat generation profiles. Uniformity of the radial heat generation distribution was assured by individual electrical resistance measurements of all rods. However, the axial heat generation profiles of the heater rods were not verified. Therefore, by assuming a uniform heat generation profile

over the heated length, the effects of heater element resistance temperature dependence were ignored.

For this analysis, it was assumed that there was no fuel assembly/fuel tube contact, and that the fuel assembly remained centered within the fuel tube for all orientations. Both assumptions represent additional uncertainties in the simulation of the horizontal and inclined cases.

In addition to the major uncertainties described above, uncertainties exist in the heater rod and wall film coefficients, rod and wall friction, and in the test section geometry. Uncertainties in the graybody radiation model, and the finite difference treatment of the axial and transverse momentum equations, are implicitly contained within the COBRA-SFS code.

4.2.3 Comparisons of Predictions to Data

Predicted axial temperature profiles for selected instrumented model fuel rods and the test section wall are plotted with the experimental test data in Figures 4.16 through 4.18 for 3 of the 18 test cases. The cases presented illustrate the effect of orientation with an air backfill. In each figure, four axial profiles are presented which provide the cask radial temperature distribution along the fuel tube diagonal: a center heater rod (Row H, Pin 9, Figure 4.13), a corner rod (Row A, Pin 1), the fuel tube, and the test section inner wall. In all figures, the data are plotted as a function of elevation from the cask bottom.

All temperature data with the exception of center rod H9 were obtained from thermocouples welded directly onto the measurement surface. Data for rod H9 were obtained using thermocouple pads that measure the average temperature of two adjacent, neighboring rods. The code predictions represent temperatures of rod H9 only and, thus, should be slightly higher than the data. Additionally, data comparisons were complicated by the sparseness of temperature data at the lower elevations of the test assembly. Faulty and dislocated thermocouples eliminated four of the axial temperature data points for the hot center rod, leaving just three axial temperature measurements for comparison, all of which are above the 2.5 m (8 ft) elevation.

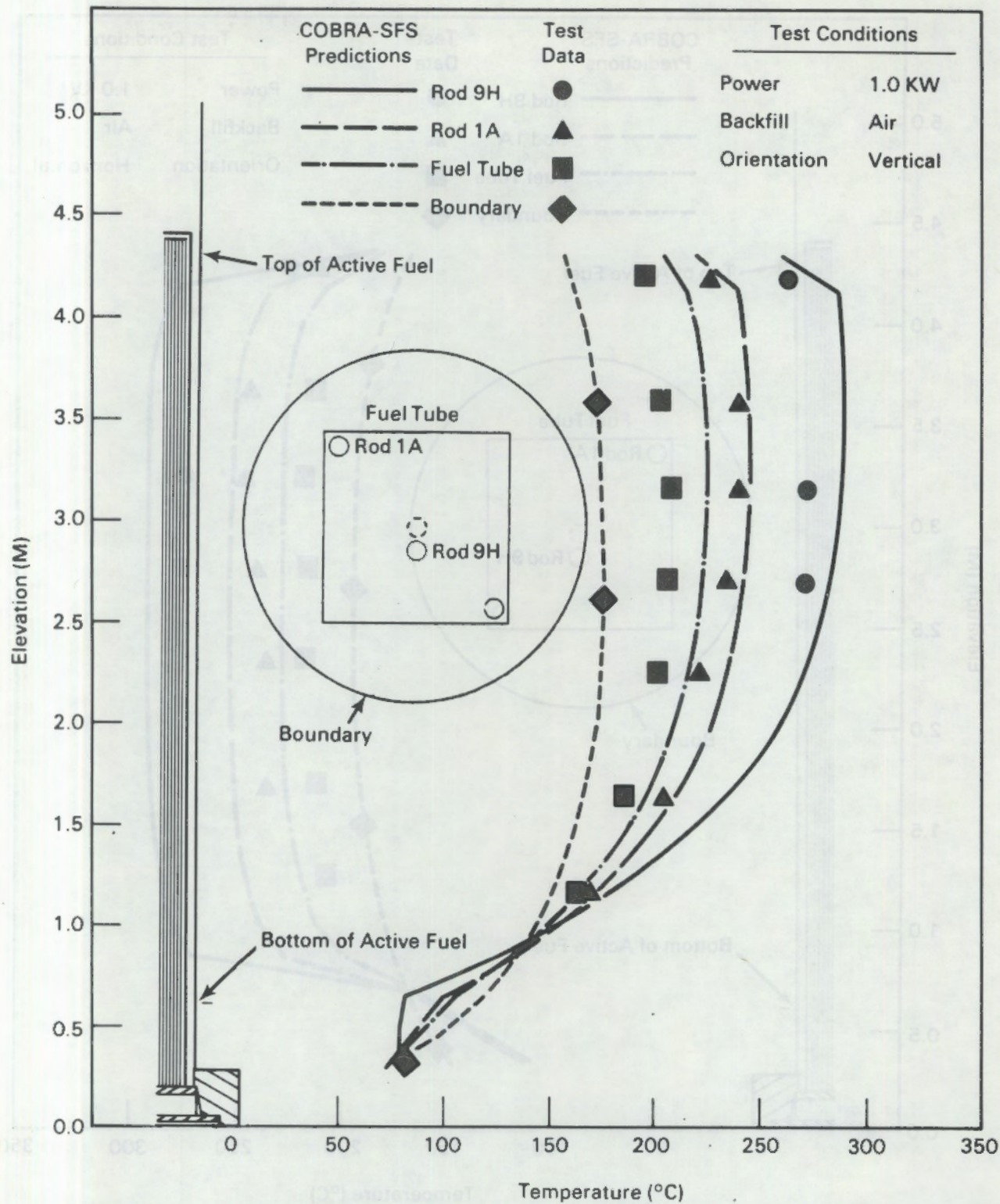


FIGURE 4.16. Predicted Axial Temperature Profile Compared to Electrically Heated PWR Single Assembly Vertical, 1 kW, Air Test Data

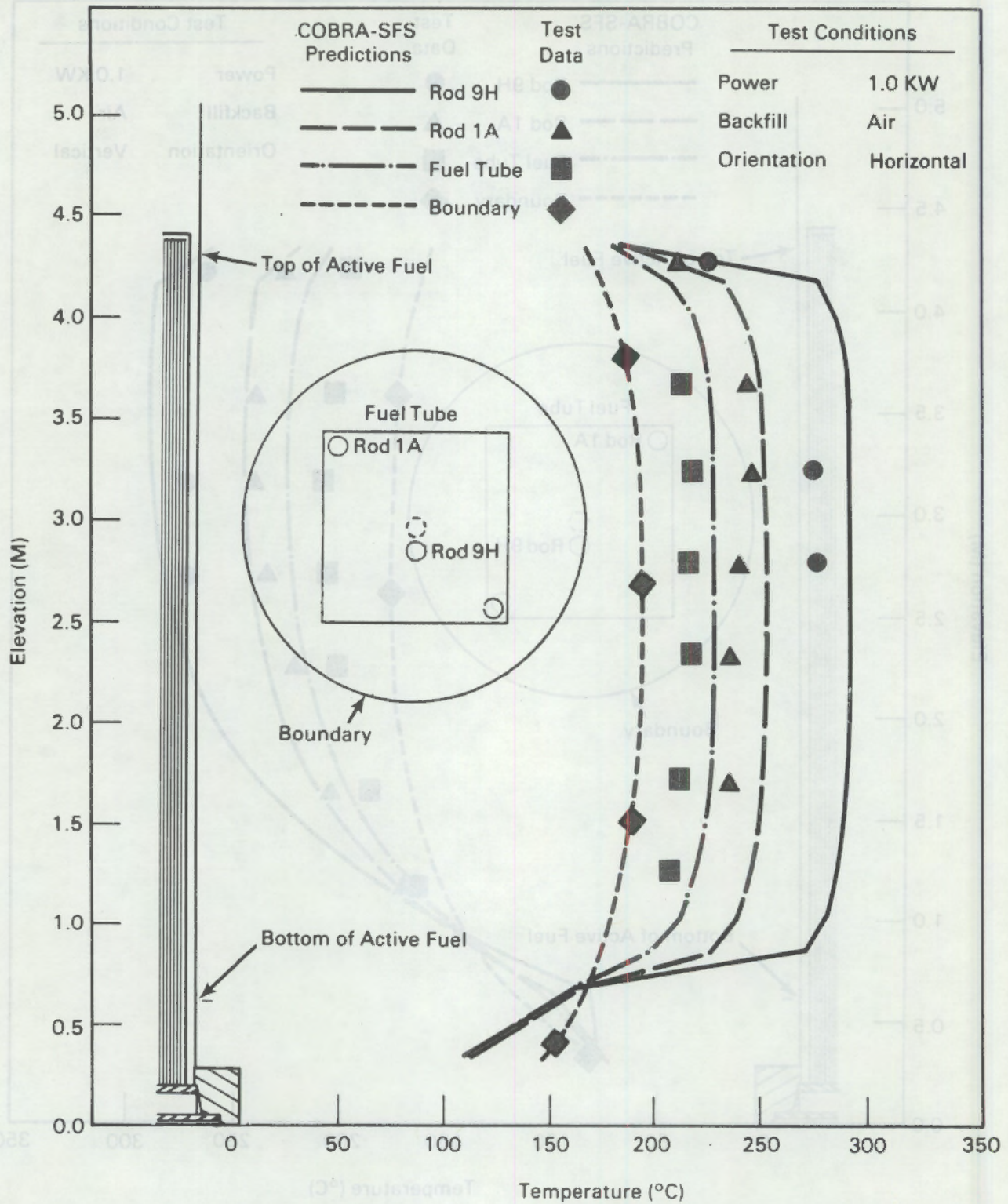


FIGURE 4.17. Predicted Axial Temperature Profile Compared to Electrically Heated PWR Single Assembly Horizontal, 1 kW, Air Test Data

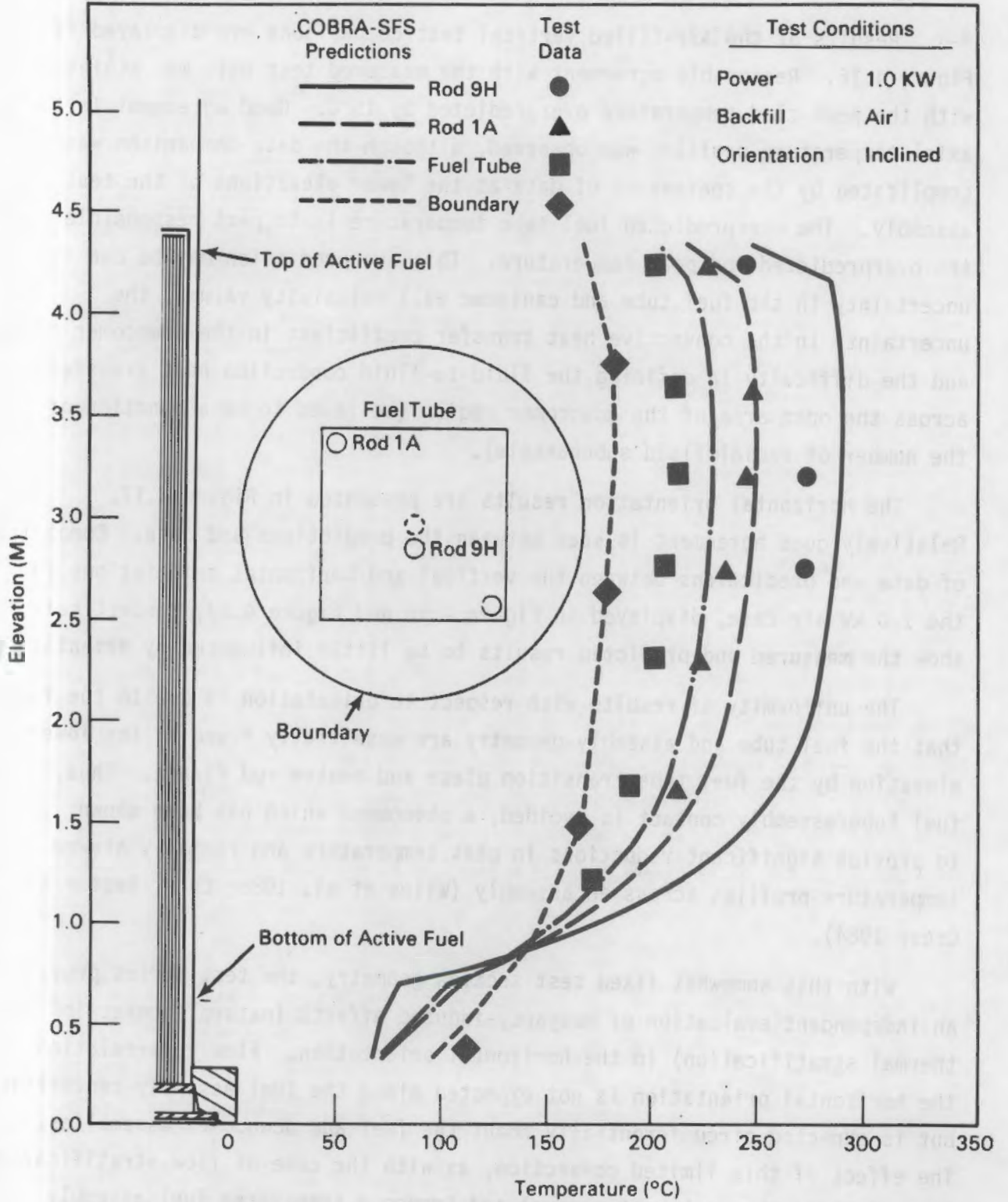


FIGURE 4.18. Predicted Axial Temperature Profile Compared to Electrically Heated PWR Single Assembly Inclined, 1 kW, Air Test Data

Results of the air-filled vertical test comparisons are displayed in Figure 4.16. Reasonable agreement with the measured test data was achieved with the peak clad temperature overpredicted by 15°C. Good agreement in the axial temperature profiles was observed, although the data comparison was complicated by the sparseness of data at the lower elevations of the test assembly. The overpredicted fuel tube temperature is in part responsible for the overpredicted rod peak temperature. This overprediction may be due to uncertainty in the fuel tube and canister wall emissivity values, the uncertainty in the convective heat transfer coefficient in the downcomer region, and the difficulty in defining the fluid-to-fluid conduction heat transfer across the open area of the downcomer region (believed to be a function of the number of radial fluid subchannels).

The horizontal orientation results are presented in Figure 4.17. Relatively good agreement is seen between the predictions and data. Comparisons of data and predictions between the vertical and horizontal orientations for the 1.0 kW air case, displayed in Figure 4.16 and Figure 4.17, respectively, show the measured and predicted results to be little influenced by orientation.

The uniformity of results with respect to orientation is due to the fact that the fuel tube and assembly geometry are essentially fixed at the lower elevation by the fuel tube-transition piece and heater rod flange. Thus, fuel tube/assembly contact is avoided, a phenomena which has been shown to provide significant reductions in peak temperature and radially skewed temperature profiles across an assembly (Wiles et al. 1986; Cuta, Rector and Creer 1984).

With this somewhat fixed test section geometry, the test series provides an independent evaluation of buoyancy-induced effects (natural convection and thermal stratification) in the horizontal orientation. Flow recirculation in the horizontal orientation is not expected along the fuel assembly centerline, but is expected circumferentially about the fuel and downcomer assemblies. The effect of this limited convection, as with the case of flow stratification, is to enhance the cask heat removal and impose a transverse fuel assembly temperature gradient. This effect is found to be minor as evaluated from a comparison of center rod temperature data for the horizontal air and vacuum

test cases. The peak rod temperature differences between these runs ranged from 8°C to 15°C for the 0.5 and 1.0 kW test series, respectively. Therefore, only modest thermal benefit is derived from the buoyancy-induced effects in this test. Thus, the limited effects of buoyancy and fuel tube/assembly contact greatly reduce the influence of orientation in this experiment. This trend was correctly predicted by COBRA-SFS.

Neither the predictions or data for the inclined orientation cases, displayed in Figure 4.18, differ significantly from the horizontal results. This effect is demonstrated by a comparison of the 1.0 kW inclined air case, displayed in Figure 4.18, with the horizontal air case shown in Figure 4.17. The differences in the modeling of horizontal and inclined orientations lie in the treatment of buoyancy effects which was possible in the inclined simulations. In the axial direction, the buoyancy term in the momentum equations was reduced by the direction cosine, whereas buoyancy effects in the transverse direction were not modeled. As a result, only an axial velocity component is modeled in this orientation. In spite of the longitudinal natural convection, very little difference in peak temperature was observed between the horizontal and inclined predictions, a trend also seen in the data. As in the horizontal simulations, the skew in the predicted transverse assembly temperature profile is a direct result of the asymmetric boundary temperatures assigned to the cask inner wall. Again, the relatively modest effect of buoyancy-induced flows observed in the horizontal and inclined runs suggests that buoyancy-induced effects can be eliminated in these orientations without the introduction of significant errors.

4.3 SINGLE CANISTER CONSOLIDATED SPENT FUEL TEST

In this test series the thermal performance of test sections modeling consolidated and unconsolidated spent fuel rods was investigated. The data used in this study were obtained by Ridihalgh, Eggers, and Associates (REA) (1983) and Eggers, Ridihalgh Partners, Inc. The data are derived from three test sections (one unconsolidated and two consolidated) containing electrically heated rods simulating fuel from 8x8 boiling water reactor (BWR) assemblies (Eggers 1985). The test sections were 61 cm (24 in.) long with the rods

oriented horizontally. Measurements were taken with air and helium as fill gases. In addition, two test runs were conducted with the unconsolidated test section evacuated to 10^{-2} mm Hg, and one vacuum case was run with one of the consolidated rod test sections.

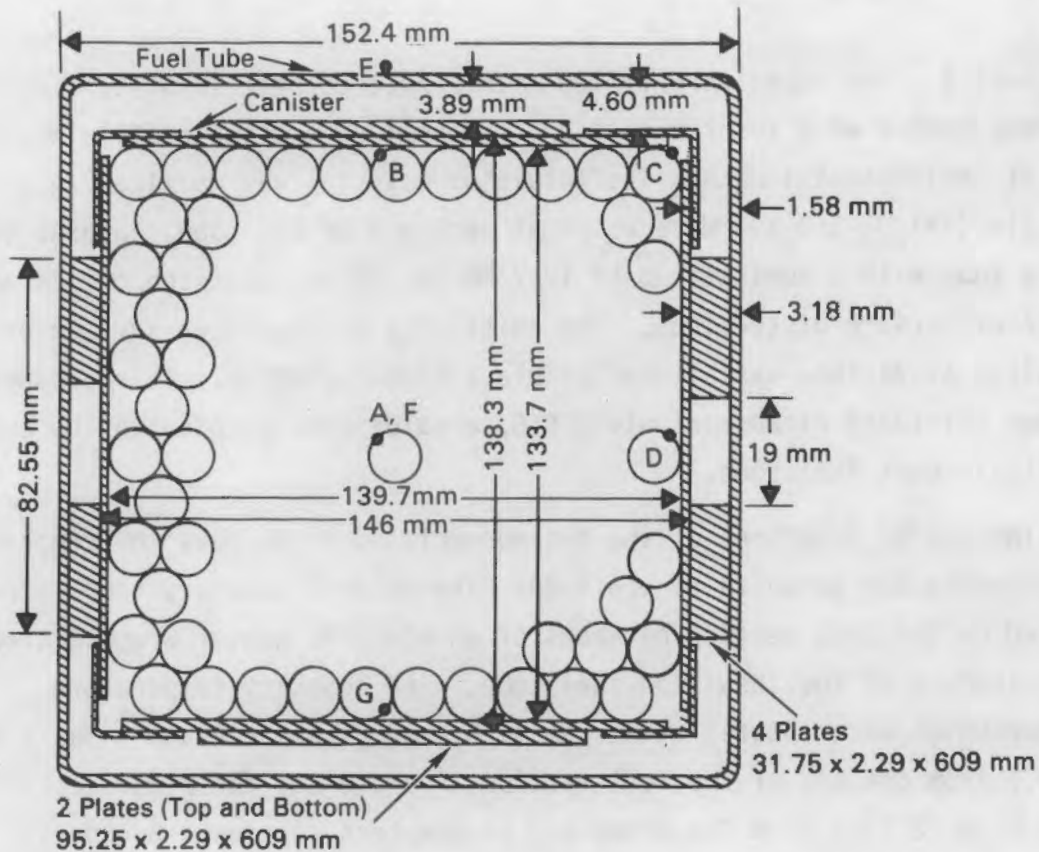
Measured temperatures were obtained in these test sections for 28 test runs. Seven of the runs were in the unconsolidated test section. Of the other 21, 5 were run in the consolidated assembly with the rods separated by a uniform gap of 0.254 mm (0.010 in.), and 16 were run in the consolidated assembly with zero gap between the rods.

For the purposes of this study, however, runs with consolidated fuel (zero gap) will be highlighted, as these runs provide unique insights into the capabilities of COBRA-SFS for consolidated spent fuel analysis. Comparisons of predictions with data are presented for the consolidated assembly with backfills of air and helium, showing the effect of fill media. For details on the other two test runs and the complete comparisons of COBRA-SFS predictions to data, refer to the applications report by Cuta and Creer (1986); the test procedure and data are discussed in detail in two reports by Eggers (1985). In the following sections, descriptions of the test apparatus, the COBRA-SFS computational model, and comparisons of predictions to data are presented. Input, representative output, and convergence listings of the cases presented herein are presented in Appendix C.

4.3.1 Test Description

A cross section at the midplane of the consolidated assembly with zero gaps between the rods is shown in Figure 4.19. The canister was positioned in the fuel tube by means of small steel shims under the four corners of the canister's bottom face. In addition, four plates, 3.18 cm (1.25 in.) by 0.23 cm (0.090 in.) by 61 cm (24 in.) were inserted in the vertical sides of the annulus, two on each side, as illustrated in Figure 4.19. The plates were intended to prevent any possibility of natural convection in the annulus.

The dimensions given in Figure 4.19 are based on a "perfect fit" of the rods into the triangular array. The as-built dimensions of the test section, however, indicate that it is not all that easy to stack rods precisely in a



A,B,C,D,E,F,G Thermocouple Locations

Note: Drawing is Not to Scale

FIGURE 4.19. Cross Section of Consolidated Fuel Test Assembly

triangular array inside a rectangular box. The measured width of the annular gap between the canister and the fuel tube was 0.51 to 1.02 mm (0.020 to 0.040 in.) on the sides, in contrast to the calculated value of 1.58 mm (0.0625 in.) in the unblocked segment of the annulus. The measured width of the gap at the top and bottom was 2.54 to 3.05 mm (0.100 to 0.120 in.), compared to the calculated value of 3.88 mm (0.153 in.). In spite of these differences, however, the calculated temperature gradient across the annulus was in every case too small to be significantly affected by such a small difference in the geometry, so the calculated values were used in the COBRA-SFS geometry model.

The rods for the consolidated test runs were stainless steel 304 tubing with a nominal OD of 12.7 mm (0.500 in.), and wall thickness of 0.89 mm

(0.035-in.). The tubes were filled with 2-hole ceramic insulators containing nichrome heater wire to provide a uniform heat generation profile along the full 61 cm (24 in.) length. The insulator material was mullite, an aluminum silicate ($3\text{Al}_2\text{O}_3\text{-SiO}_2$). Wire wraps at each end of the tube centered the mullite in the tube with a nominal gap of 12.7 mm (0.050 in.) between the ceramic and the inner surface of the tube. The emissivity of the outer surface of the stainless steel tube was altered by black nickel plating. This produced a surface emittance of approximately 0.8, a value consistent with the emissivities of actual spent fuel rods.

The radial locations of the thermocouples used to make the temperature measurements are shown in Figure 4.20. The desired boundary temperature was imposed on the test section by means of an electric heater wrapped around the outer surface of the insulated fuel tube. The boundary temperature thermocouples were located at Planes A, B, and C--where Plane A was 5.1 cm (2 in.) from one end of the test section, Plane B was the midplane, and Plane C was 5.1 cm (2 in.) from the other end of the test section. Boundary

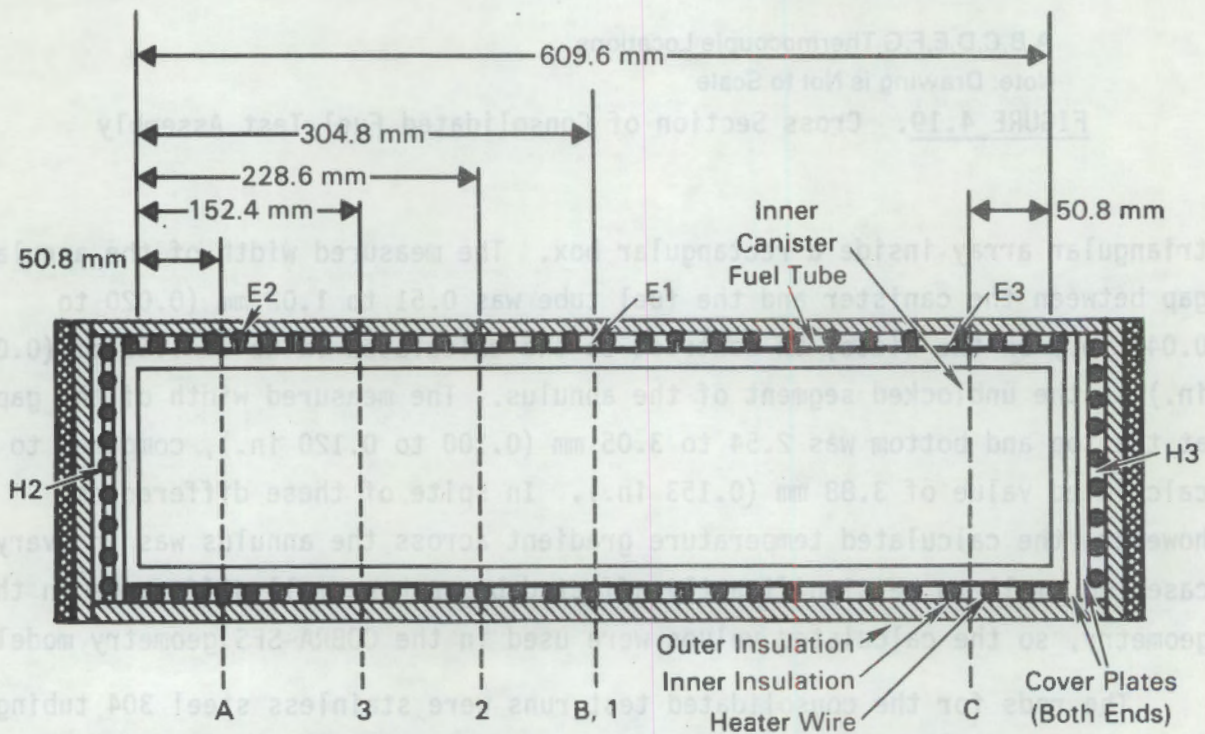


FIGURE 4.20. Consolidated Assembly Test Section E_1 , E_2 , E_3 , H_2 , H_3 Thermocouple Locations

temperatures were also measured on the top surface of the test section, (E), and at the center of each end of the test section (thermocouples H2 and H3). The rod thermocouples were located at three different axial positions in one half of the test section. Plane 1 was the midplane of the test section, Plane 2 was 22.9 cm (9 in.) from the end of the test section, and Plane 3 was 15.2 cm (6 in.) from the same end of the test section. The diagram in Figure 4.20 shows the relative axial locations of the rod and boundary measurement planes.

A total of sixteen test runs were conducted with the zero rod gap geometry. Seven runs were performed with the canister axisymmetric in the fuel tube with air and helium backfills at equivalent decay heat levels of 100 W, 400 W, and 800 W. One vacuum test run was also performed with this geometry, with an equivalent decay heat of 400 W. Four test runs were conducted with the canister off-center in the fuel tube, so that the annulus was 2.03 to 0.254 mm (0.08 to 0.10 in.) wide on the left side, 0.54 to 1.04 mm (0.02 to 0.04 in.) wide on the right side, 0.61 to 0.66 mm (0.24 to 0.26 in.) wide on the bottom, and 0.54 to 1.04 mm (0.02 to 0.04 in.) on the top. Four additional test runs were performed with the canister axisymmetric within the fuel tube, but painted with a high emissivity paint on its outer surface.

To demonstrate how well COBRA-SFS predicts the consolidated fuel data, simulations of the zero rod gap assembly centered within the canister were performed for the air and helium backfills at the 800 W heat generation level. Comparisons were made at the highest decay heat level to provide larger rod-to-rod temperature gradients across the assembly, thereby reducing some of the experimental error. Predictions were made with both the air and helium backfills to demonstrate the effect of fill media on consolidated assembly heat transfer. Prelook COBRA-SFS predictions and test data for all 28 cases with both the zero rod gap assembly and the 0.254-mm rod gap assembly have been reported earlier (Cuta and Creer, 1986) and will not be repeated here. A description of the zero-rod gap assembly model and comparisons of predictions using the document version of COBRA-SFS with data are presented below.

4.3.2 Computational Model Description

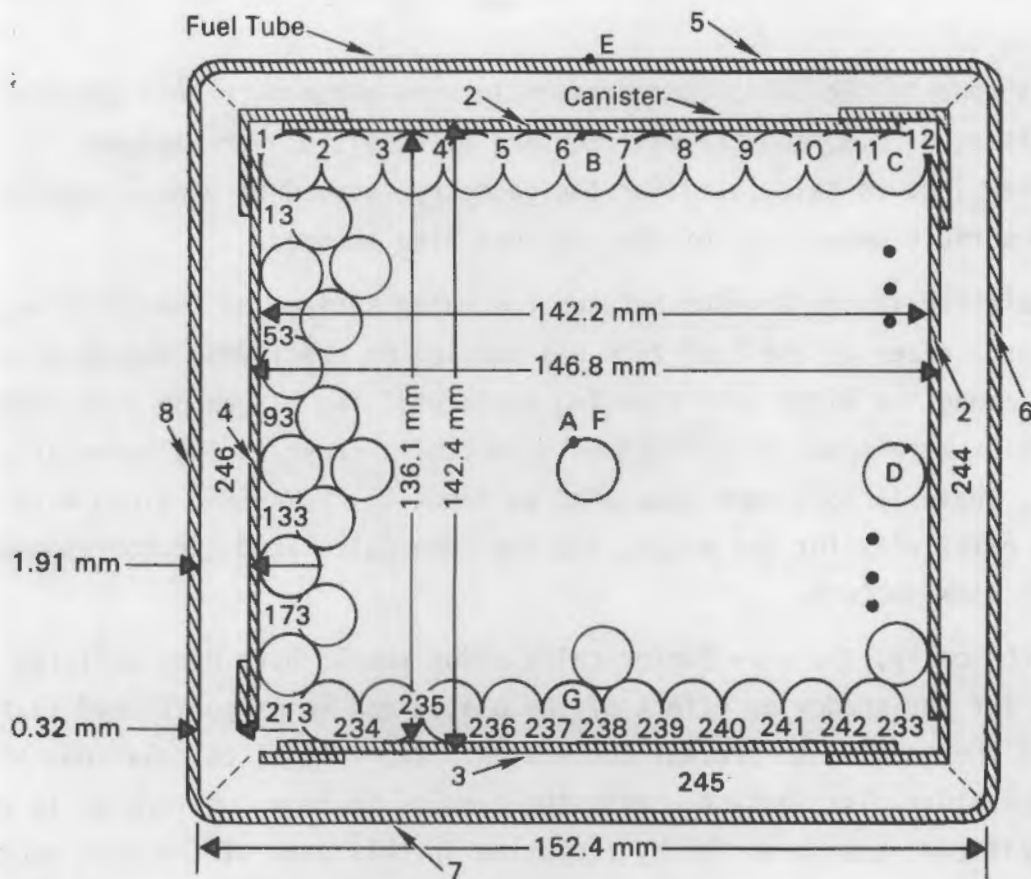
The computational model can conveniently be considered in two main parts: the geometry model, which describes the physical shape of the flow paths and solid materials in the system, and the constitutive heat transfer models, which describe how energy is transported through the system. A description of each of these models is presented below, along with a discussion of the modeling uncertainties.

4.3.2.1 Nodal Representation

It was assumed that test section geometries could be accurately represented with two-dimensional models. The test section was designed to minimize axial gradients and convective heat transfer, and thus was oriented horizontally, with sealed ends. All, or nearly all, heat transfer was to be in the radial direction. For these boundary conditions, the geometry was modeled in COBRA-SFS as a cross-section at the midplane, two nodes long. A detailed subchannel model was developed for the "slice" of the test section and is described below.

The subchannel layout for the consolidated assembly required 237 subchannels and 126 rods, as illustrated in Figure 4.21. The walls of the canister were modeled with a single node for each face of the canister. The annulus between the canister and the fuel tube was modeled with four subchannels, as shown. To be absolutely precise, the annular channels in the model of the test section should have taken into account the presence of the steel plates inserted in the sides of the annulus--as shown in Figure 4.19. However, because the calculated temperature gradient across the annulus was so small, the minor differences in the geometry were neglected. The fuel tube was modeled with four nodes, using a single node per side. The boundary temperature for a given test run was imposed by specifying, via input instructions, the temperature on the outer surface of the wall nodes of the fuel tube.

Radial and axial heat generation profiles were specified as uniform, and the rods in the consolidated geometry were modeled with stainless steel and mullite thermal properties. Both the canister and the fuel tube were modeled with stainless steel properties.



Note: Drawing is Not to Scale
FIGURE 4.21. COBRA-SFS Subchannel Model of the Zero Gap Consolidated Test Section

4.3.2.2 Modeling Assumptions, Parameters, and Correlations

Graybody view factors for radiation heat transfer are specified in COBRA-SFS as an array of exchange factors for every surface. These view factors are calculated from blackbody view factors determined using the crossed-string correlation method of Hottel (Cox 1977) and the specified emissivity of the surface. The blackbody and graybody factors are computed by first treating each rod surface as consisting of four separate quadrants, calculating the exchange factors for each quarter-rod surface, then appropriately summing the factors to obtain a value for the radiation exchange between any given rod or wall surface and all other surfaces in view. The radiation view factors are a function of the physical geometry of the assembly and the surface emissivities of the rods and walls.

The rods in the consolidated assembly were assumed to have surface emissivities of 0.8, and the wall surface emissivities were assumed to be 0.2. View factors calculated for the geometry assumed zero gaps between rods. Uniform surface emissivity of the rods was also assumed.

Radiation in the annulus between the outer surface of the canister and the inner surface of the fuel tube was modeled by specifying blackbody view factors among the eight participating surfaces. The blackbody view factors for the annulus were again calculated using Hottel's cross-string correlation method. These factors were specified as input to COBRA-SFS, along with the surface emissivity for the walls, and the code calculated the corresponding graybody view factors.

Technically, the view factor calculation should have been modified to account for the shadowing effect of the plates and shims positioned in the sides of the annulus to prevent convection. But initial calculations showed the temperature distribution across the annulus to be so uniform as to obviate any significant heat transfer by radiation in this part of the test section. For this reason, the effect of the shims on radiation exchange in the annulus was ignored.

Heat transfer between the solid surfaces (i.e., rods and wall nodes) and the fluid is calculated in COBRA-SFS as a heat flux driven by a temperature difference. It is formulated in terms of a heat transfer coefficient, which, in steady state, reduces to the familiar equation,

$$q'' = h (T_{\text{wall}} - T_{\text{fluid}}) \quad (4.1)$$

where q'' = heat flux, (Btu/hr-ft²)

h = heat transfer coefficient, (Btu/hr-ft²-°F)

T_{wall} = rod or wall surface temperature, (°F)

T_{fluid} = fluid temperature in the subchannel, (°F)

This formulation reflects the antecedents of COBRA-SFS as being concerned primarily with forced convection heat transfer. The heat transfer coefficient,

h , is expressed in the code as some Nusselt number known (from empirical sources) as

$$Nu = \frac{hD_h}{k} \quad (4.2)$$

where Nu = Nusselt number

D_h = hydraulic diameter of the channel, (ft)

k = thermal conductivity of the fluid, (Btu/hr-ft-°F)

The Nusselt number is specified by input to the code, and can be expressed as a constant, or as some function of the Reynolds and Prandtl number of the fluid.

Assuming no axial flow, the heat transfer coefficient, h , can be replaced by the equivalent term for conduction, $h = k/\Delta x$ (Fourier's Law), where k is the thermal conductivity, and Δx is the distance between conducting surfaces. Equating the conductances between convection and conduction-only formulations, it is possible to determine a relationship to describe conduction heat transfer with a Nusselt number. That is, if $h = Nu(k/D)$, [(from Equation 4.2)], and $h = k/\Delta x$, then

$$Nu = \frac{D_h}{\Delta x} \quad (4.3)$$

This formula should yield an appropriate Nusselt number to model heat transfer from the rods or walls to the fluid. The trick, of course, is to determine the appropriate value for Δx .

If it is assumed that the main heat transfer path between the rods and the fluid is from the subchannel center to the rod surface, then the Nusselt number can be approximated as follows. For rods in a triangular array with pitch, P , and rod diameter, D_r :

$$\Delta x = 0.5 (P/\cos 30^\circ) - 0.5 D_r \quad (4.4)$$

$$D_h = 4(0.4 P^2 \sin 60^\circ - 0.5 (0.25 \pi D_r^2)) / (0.5 \pi D_r) \quad (4.5)$$

For the case of consolidated rods in contact, $P = 12.7 \text{ mm}$ (0.50 in.), and $D_r = 12.7 \text{ mm}$ (0.5 in.), resulting in a fluid heat transfer correlation of the form $Nu = 1.3$. This value was used to describe the heat transfer from the rods to adjacent fluid for all rods within the enclosure. For the open annulus exterior to the fuel assembly, heat transfer from the walls to fluid was described by $Nu = 2.0$. No buoyancy effects were modeled within the test section, thus, the effects of thermal stratification and natural convection (axial and radial directions) were not accounted for.

An additional constitutive heat transfer parameter that must be specified in these simulations is the contact conductance. This parameter is not required for unconsolidated assembly thermal analyses, as all conduction heat transfer proceeds from the rods to the fluid and then to the walls. In a consolidated spent fuel assembly, however, there are several conduction paths. In a consolidated test section, the rods are in contact with the inner surface of the enclosing canister, and the rods touch one another in a close-packed array. Within the assembly, a rod is in physical contact with the six neighboring rods that surround it. It is obvious that not all the heat flows from the rods to the fluid in the channel. Some of the heat will flow directly from rod surface to rod surface, or rod surface to wall surface, at the point of contact.

The appropriate contact heat transfer coefficient, h_c , and contact area, A_c , for a given case are far from obvious, however. There are a number of physical models available for determining the contact heat transfer coefficient between two surfaces, but these are usually highly empirical and restricted to particular geometries or materials. In addition, they often depend on esoteric physical properties of the surfaces, such as roughness, statistical wavelength, and hardness. The contact area is similarly difficult to define precisely, particularly for curved surfaces in precarious contact. So, in practical terms, it is more efficient to simply select a value of thermal conductance, H_c ,

thus lumping the uncertainties in h_c and A_c into one parameter, and determining a suitable value by comparisons to appropriate experimental data.

For the geometries considered here, it is unreasonable to expect extremely good contact conductance. The simulated fuel rods were straightened to a tolerance of less than 0.083 mm/m (0.001 in./ft) before assembly, which would tend to promote uniformity of contact, but the rods were merely stacked in the triangular array without any particular effort to squeeze them into tight contact. A contact conductance of $1.02 \times 10^{-4} \text{ W/cm}^2\text{-}^\circ\text{C}$ ($0.5 \times 10^{-4} \text{ Btu/s-ft}^2\text{-}^\circ\text{F}$) was selected to model the heat transfer by direct rod-to-rod and rod-to-wall conduction. Previous experience (Cuta, Rector, and Creer 1984) has shown that this value yielded reasonable results when applied in consolidated geometries. In actual BWR consolidated fuel rods, contact conductances may be significantly different than this assumed value because crud is present on rod surfaces and actual rods are not necessarily straight within the 0.0833 mm/m (0.001 in./ft) tolerance of this model test.

4.3.2.3 Modeling Uncertainties

The computational model developed for this analysis was based on design information supplied by Eggers (1985). In developing the model, uncertainties were associated with the following heat transfer and fluid flow parameters:

- material emissivities
- contact conductances
- axial heat losses.

As in the simulations of other spent fuel heat transfer tests described previously, there can be considerable uncertainty in the emissivity values since they were not experimentally determined. Again, more uncertainty is associated with the wall surface emissivity due to its small value compared with the rods. In addition, the consolidated rods radiation is relatively ineffective due to rod shadowing, thus limiting the effect of the rod emissivity uncertainty. The values selected are best-estimate values deduced from the literature and limited parameter studies with COBRA-SFS.

Several types of contact occur within the consolidated assembly (i.e., rod-to-rod, rod-to-wall) and uncertainties are associated with each type.

Parameter studies of rod-to-rod contact performed (Cuta and Creer 1986) showed that, over a range of contact conductances from 0 to 1×10^{-3} Btu/sec-°F, the peak rod temperature was predicted to vary 29°C (52°F) for the vacuum test with zero rod gaps (400 W). This is equivalent to 14% of the predicted peak clad temperature. Thus contact conductance is an important parameter in the consolidated assembly simulations.

The geometry and boundary temperature was assumed uniform, allowing the test assembly to be modeled with two axial nodes. In actuality, however, the measured boundary temperature showed a significant skew at the end regions due to heat losses from the test section ends. The nonuniformity of the boundary also affects the measured rod temperatures and therefore can account for some of the discrepancy of predictions with data.

An additional source of uncertainty in this test is the unmodeled shim pieces used to inhibit convection within the assembly. By omitting the presence of the shims in the model, the radiation shielding and conduction effects of these pieces are ignored. This is not expected to influence the predictions significantly in that temperature gradient across the annulus is quite flat.

4.3.3 Comparisons of Predictions to Data

Results of COBRA-SFS predictions are presented in Figure 4.22 for the consolidated assembly with zero rod gap in air and helium (800 W). Excellent agreement is seen in both the peak clad temperature and the radial temperature distribution across the test section for the two media. Further evidence of the code's ability to successfully predict the temperature distribution in a consolidated fuel assembly is presented in Figure 4.23, which illustrates the relative temperature differences across the assembly.

Despite their more complex geometry, consolidated assemblies actually pose a simpler problem in heat transfer analysis for COBRA-SFS than do unconsolidated assemblies. The consolidated rods are essentially a lumped heat source, with a relatively flat radial temperature profile, and the predominant mode of heat transfer for this geometry is conduction. Radiation is relatively ineffective, due to rod shadowing, and free convection is prevented by the

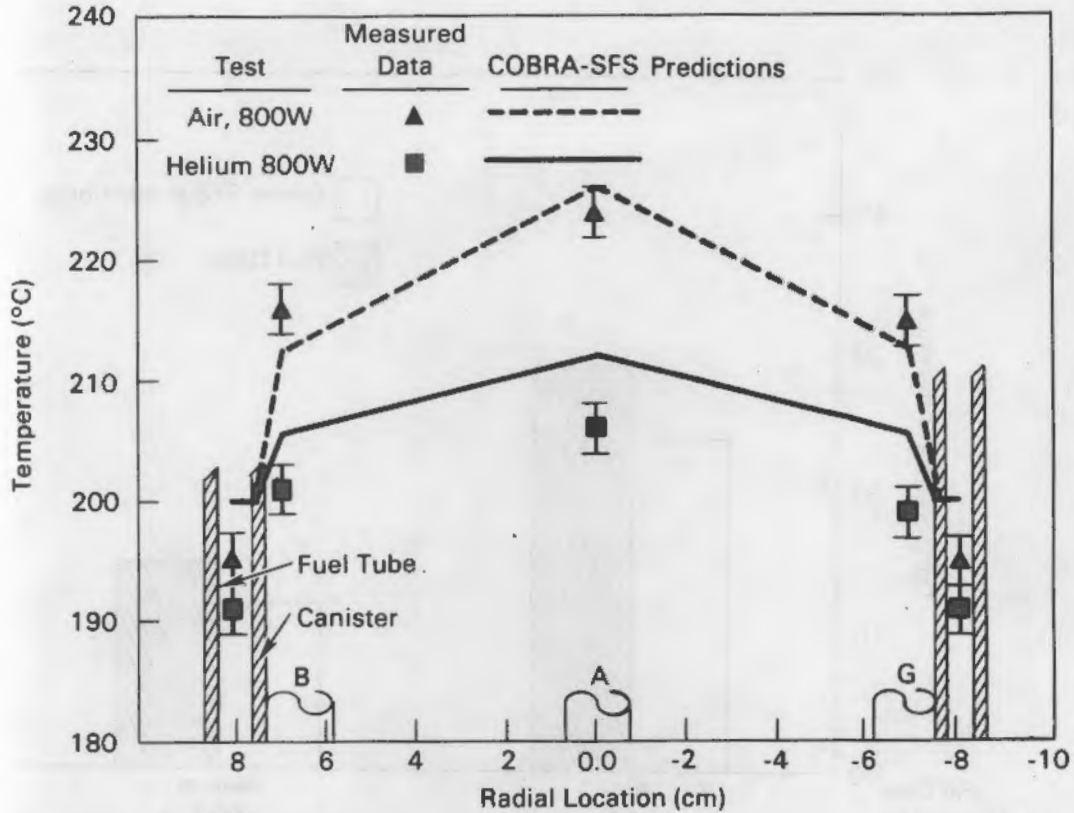


FIGURE 4.22. Comparisons of Calculated and Measured Radial Temperature Profiles in a Consolidated Assembly with Zero Rod Gaps

close packing of the rods, the horizontal orientation, and the sealed ends of the test section. Heat flows in the radial direction by conduction through the fluid (i.e., from rod-to-fluid channel-to-rod-to-fluid channel radially from the center of the assembly), and also, in the zero rod gap cases, by conduction from rod-to-rod at the areas of contact.

For COBRA-SFS to calculate temperatures in good agreement with the data, the code needs to correctly model the conduction heat transfer from the rods to the fluid, and the contact conductance rod-to-rod and rod-to-wall for the consolidated geometry. The rod-to-fluid conduction is governed by the Nusselt number, and rod-to-rod or rod-to-wall conduction is governed by the contact conductance. Both of these parameters, Nusselt number and contact conductance,

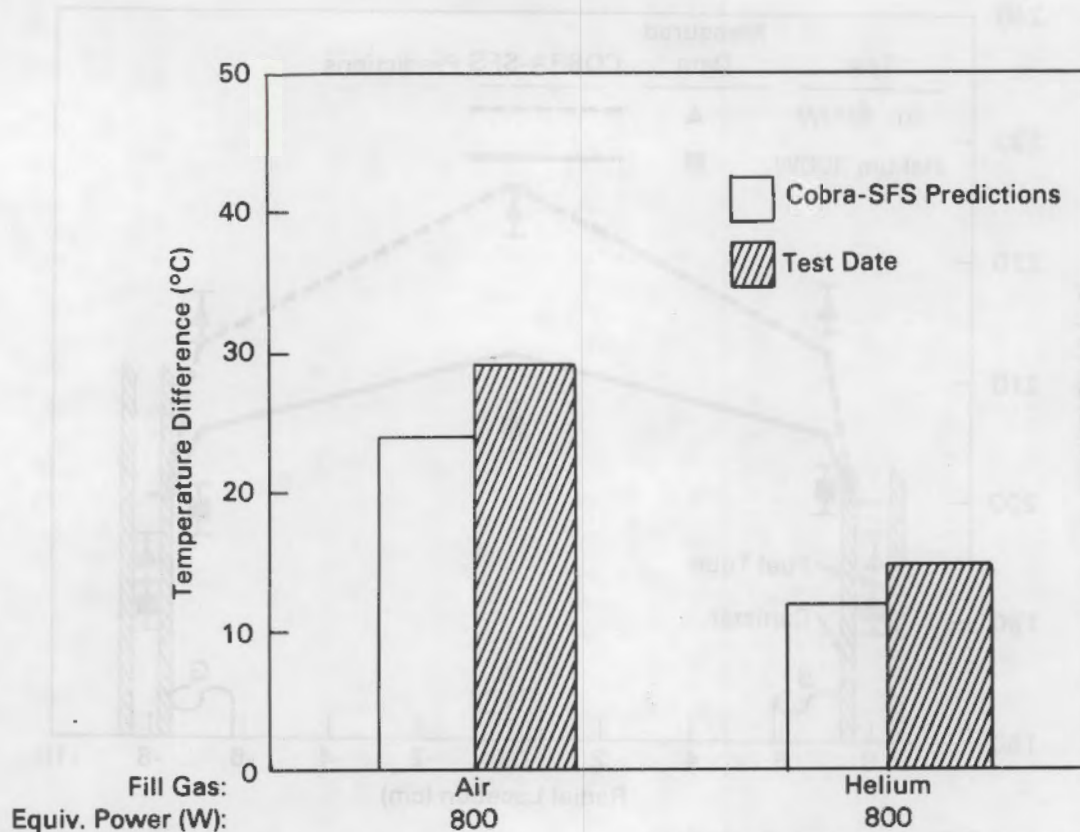


FIGURE 4.23. Comparisons of Predictions to Measured Temperature Differences (Thermocouple Positions A to E) in a Consolidated Assembly with Zero Rod Gaps

are specified by input. The values used in the calculations were selected based on reasonable assumptions regarding the test section geometry. The good agreement between the calculations and experimental results shown above indicates that appropriate values were selected for these parameters and that the code is capable of correctly calculating the heat transfer in a consolidated assembly.

5.0 MULTIASSEMBLY EVALUATION TESTS

To be a truly useful analytical tool, COBRA-SFS must also be validated against data from multiassembly storage systems. As with single assembly spent fuel thermal analyses, the combined roles of conduction, convection, and radiation heat transfer must be adequately represented. These models, however, must now perform over a wider and more varied range of parameters, geometries and complexities of the thermal systems.

To demonstrate the capability of COBRA-SFS to analyze the more difficult multiassembly storage systems, comparisons of code predictions with experimental test data from three multiassembly dry storage system tests are presented. Comparison of code predictions and data are provided for one run of the CASTOR-1C Spent Fuel Storage Cask Performance Test (16 BWR assemblies), 3 runs from the REA-2023 BWR Cask Performance Test (52 BWR assemblies), and 2 runs from the TN-24P Spent Fuel Storage Cask Performance Test (24 PWR assemblies). In total, the runs selected demonstrate the ability of COBRA-SFS to predict the thermal performance of complex multiassembly storage systems under a variety of loadings, fill media, and cask orientations. In the following sections, evaluations of COBRA-SFS predictions for the CASTOR-1C, REA-2032, and TN-24P multiassembly storage systems are presented.

5.1 CASTOR-1C SPENT FUEL STORAGE CASK PERFORMANCE TEST

To add to the current body of knowledge and to gain operational experience in dry spent fuel storage, a program for handling and monitoring spent fuel containers was initiated by the Federal Republic of Germany, using a cask of the CASTOR-1C type. This program was carried out at the Wurgassen Nuclear Power Plant by the German Association for the Reprocessing of Nuclear Fuels in conjunction with the Preussen Elketra utility.

In this series of tests, temperature distributions of the CASTOR-1C cask, loaded with 16 BWR spent fuel assemblies, were recorded continuously during a two-year period, thereby providing information on the cask thermal response as a function of decay heat level. For purposes of this study, only the maximum decay heat level prediction run will be compared to data since this case

provides cask temperatures closest to allowable limits. The CASTOR-1C spent fuel storage cask and cask performance test conducted at the Wurgassen plant are briefly described in this section, along with results of comparisons of code predictions with data. Results of prelook and post-test results from previous COBRA-SFS simulations are presented in an application report by Rector et al. (1986a). Input, representative output, and convergence lists of the run presented herein are provided in Appendix D.

5.1.1 CASTOR-1C Cask and Test Description

The General fur Nuklear Services (GNS) CASTOR-1C cask (GNS 1985) is designed to safely store and remove the decay heat from 16 BWR spent fuel assemblies for extended time periods. An elevation view of the CASTOR-1C cask is shown in Figure 5.1. The cask consists of a thick-walled nodular cast-iron body, which is cast in one piece. The body physically protects the fuel assemblies and provides radiation shielding. The central cavity of the cask contains a stainless steel basket that separates and supports the spent fuel assemblies. The top of the cask is sealed using a multiple-lid system. The overall cask dimensions and design specifications are summarized in Table 5.1. Each major component of the cask is described in more detail below.

A transverse cross section of the CASTOR-1C cask is shown in Figure 5.2. The nodular cast-iron body has an overall length of 5510 mm (18 ft) and a maximum outside diameter of 1730 mm (5.7 ft). The side wall thickness (without fins) is approximately 440 mm (17.3 in.). Gamma and neutron radiation are shielded by the cast-iron wall of the cask. For improved neutron shielding through the side, two concentric rows of axial holes in the cask body wall are filled with polyethylene rods (moderator material). The rods are 60 mm (2.4 in.) in diameter and extend axially from the bottom of the cask to above the top elevation of the fuel assemblies.

The outside surface of the cask varies as a function of axial level. Near the top and bottom of the cask, the surface is a cylinder 1905 mm (6.25 ft) in diameter with four flat surfaces machined so the minimum flat-to-flat distance is 1730 mm (5.7 ft). In the axial region of the fuel assemblies, a

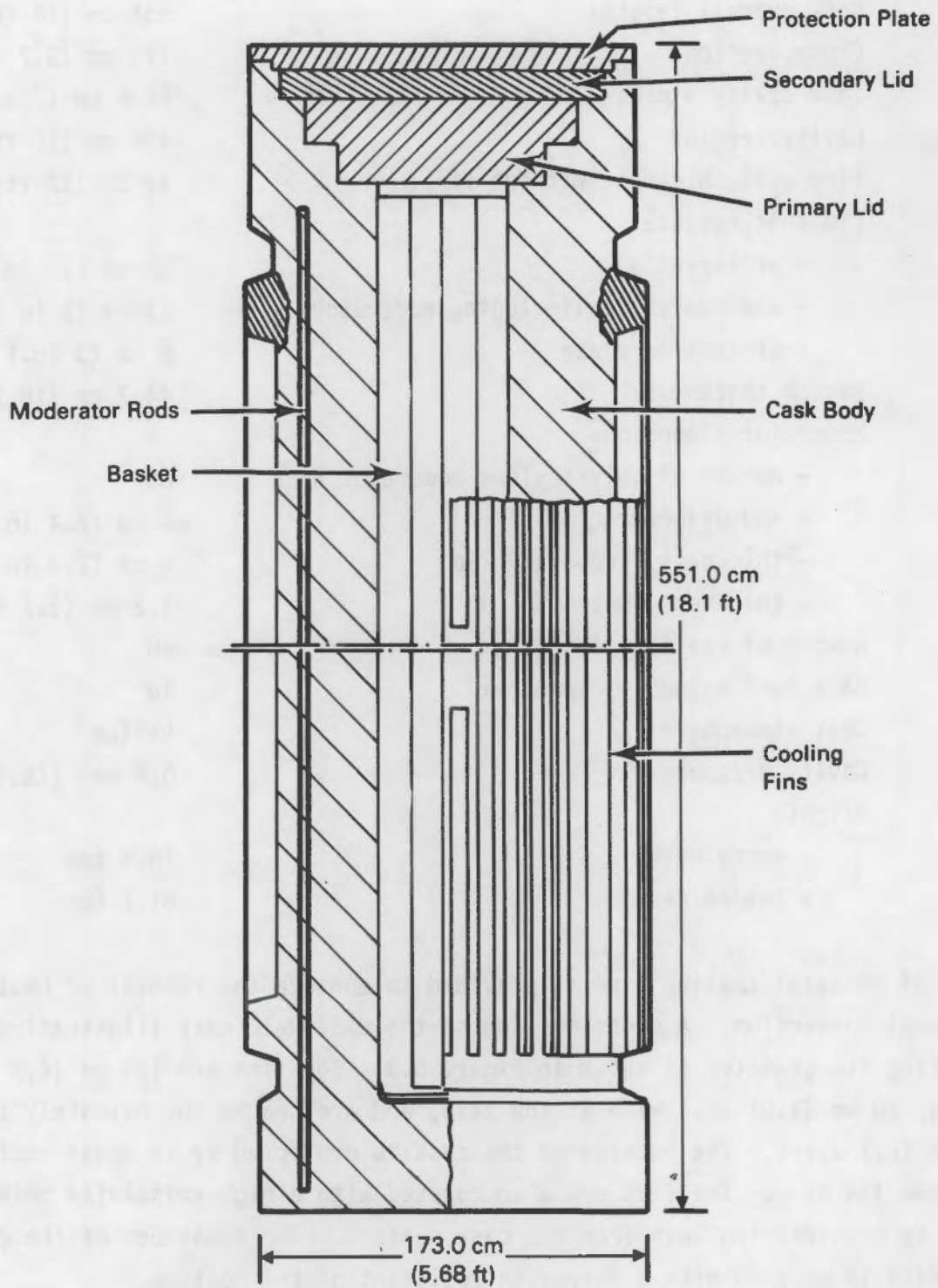


FIGURE 5.1. Elevation View of the CASTOR-1C Cask

TABLE 5.1. CASTOR-1C Cask Dimensions and Design Specifications

Cask overall length:	551 cm (18 ft)
Cross section:	173 cm (5.7 ft)
Cask cavity width:	66.6 cm (2.2 ft)
Cavity length:	456 cm (15 ft)
Side wall thickness without fins:	44 cm (17 ft)
Lid thicknesses:	
- primary lid	34 cm (13 in.)
- secondary lid (including moderator)	13 cm (5 in.)
- protection plate	8 cm (3 in.)
Bottom thickness:	44.7 cm (18 in.)
Moderator dimensions:	
- number of polyethylene moderator rods	80
- rod diameter	6 cm (2.4 in.)
- thickness, secondary lid	6 cm (2.4 in.)
- thickness, bottom	4.2 cm (1.7 in.)
Number of cooling fins:	48
Cask fuel assembly capacity:	16
Cask atmosphere:	helium
Cavity pressure:	0.8 bar (11.76 psia)
Weight:	
- empty cask	76.6 ton
- loaded cask	81.1 ton

set of 48 axial cooling fins is provided to enhance the removal of heat by natural convection. A cross section of the CASTOR-1C cask illustrating the cooling fin geometry is shown in Figure 5.3. The fins are 120 mm (4.7 in.) long, 50 mm (1.97 in.) wide at the base, and are spaced approximately 112 mm (4.4 in.) apart. The outside of the cask is protected by an epoxy resin coating in the fin area. The fins are also covered with a high-emissivity paint to aid in transferring heat from the cask surface. The remainder of the cask surface is covered with a corrosion-resistant nickel coating.

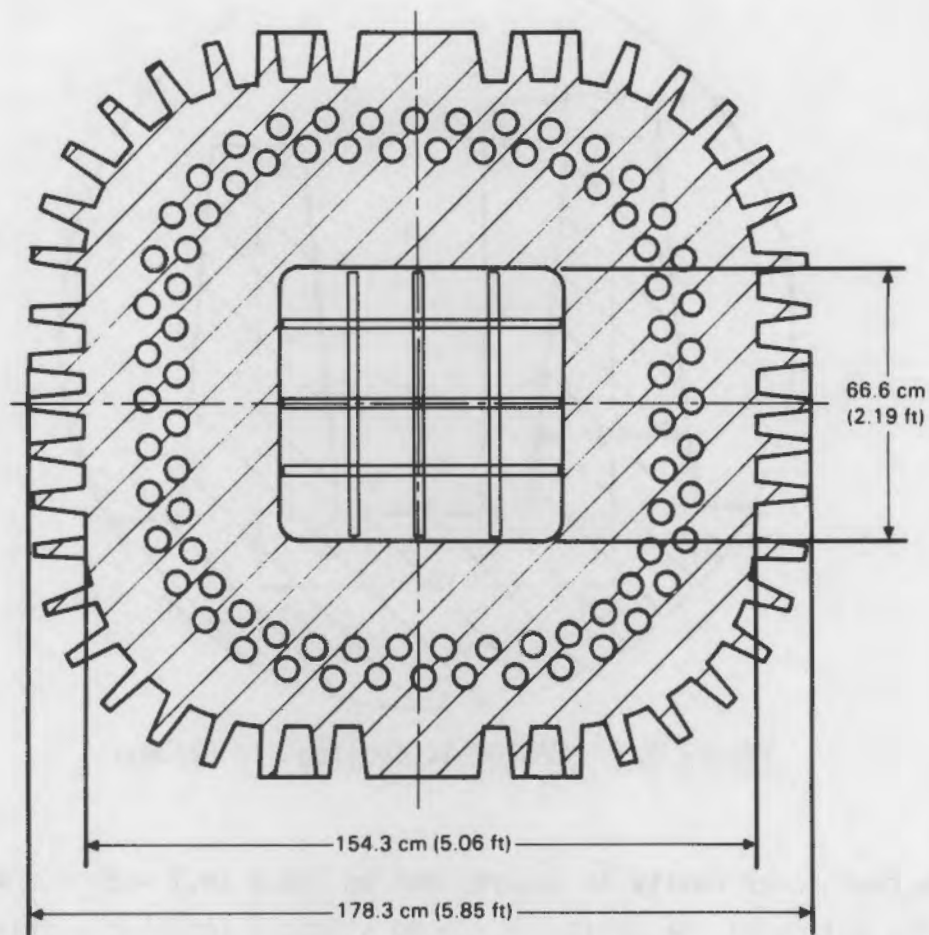


FIGURE 5.2. Transverse Cross Section of the CASTOR-1C Cask

The thickness of material from the bottom of the inner cavity to the exterior bottom of the cask is approximately 450 mm (17.7 in.). The major portion of this is cast iron. However, some of the cast iron is machined from the bottom of the cask and is replaced by concentric rings of polyethylene that serve as neutron shields. A semi-permanent steel cover plate is secured over the rings to hold them in place.

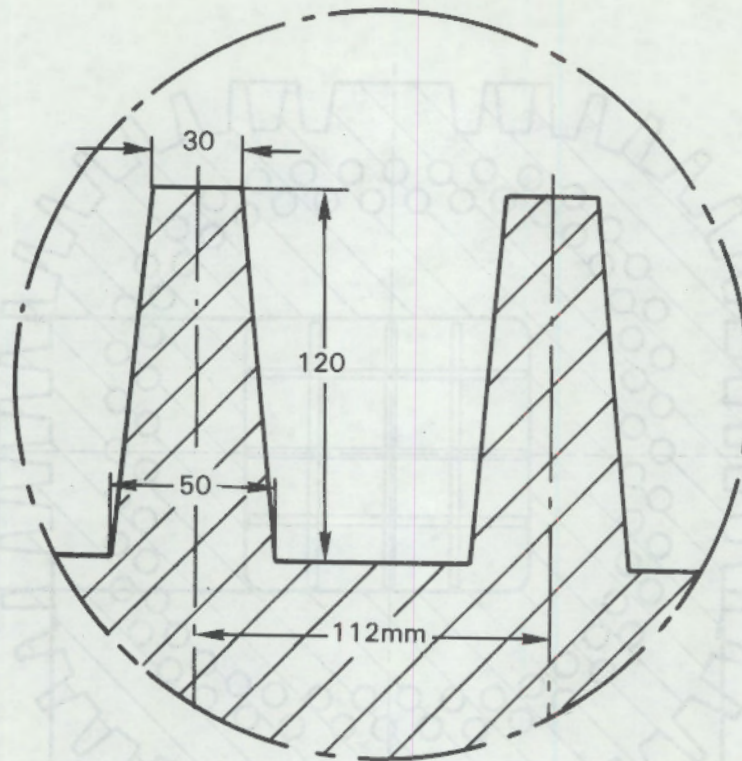


FIGURE 5.3. CASTOR-1C Cooling Fin Geometry

The cask inner cavity is square, 666 mm (26.2 in.) wide and 4560 mm (15 ft) long. The bottom of the cavity is sloped slightly to enhance draining of fluid. The inside of the cask, including the sealing surfaces, has a nickel coating for corrosion protection. A support plate is placed on the bottom of the cavity to provide a level support for the basket and fuel assemblies.

The basket is of welded construction and is made of borated stainless steel. The basket divides the cavity into 16 regions, each designed to contain a single BWR spent fuel assembly. A cross section of the fuel basket is visible in Figure 5.2. The stainless steel plates used to construct the basket are 10 mm (0.4 in.) thick, and the overall basket width is 640 mm (25 in.). This leaves a gap between the basket and cavity wall of approximately 13 mm (0.5 in.) on all sides. The basket is designed to allow the top and bottom portions of the cavity to be open. This allows gas flow between adjacent assembly tubes and natural circulation inside the cavity. The basket also serves as a path for conduction heat transfer from the center assemblies to the cask body.

The CASTOR-1C cask is sealed with a multiple-lid system consisting of a primary lid, a secondary lid, and a protection plate. The three lids are shown in Figure 5.1. The primary cover is constructed of stainless steel and has an outside diameter of 1200 mm (3.9 ft) and an overall thickness of about 340 mm (13.4 in.). The secondary cover is made primarily of stainless steel and has a 1415-mm (4.6 ft) diameter and a 130-mm (5.1-in.) thickness. Some of the stainless steel in the secondary cover is replaced with concentric polyethylene rings that act as neutron shields. The protective plate is made of carbon steel and serves as a general mechanical protection against outside forces as well as dust and humidity. Each lid is bolted directly to the cask body. During normal operation the cask is filled with helium with a cavity pressure of 0.8 atmospheres.

The sixteen spent fuel assemblies used in the Wurgassen CASTOR-1C cask test were GE 7x7 and 8x8 assembly types. The design characteristics of these two assembly types are listed in Table 5.2. Each fuel assembly contained fuel rods (and one center water rod in the 8x8 assembly only) spaced and supported in a square array by the lower and upper tie plates. A typical GE 8x8 fuel assembly is shown in Figure 5.4. Besides the standard fuel rods, two other rod types are used in the fuel assembly: tie rods and a nonfuel water rod. The eight tie rods in each assembly have lower end plugs that thread into the lower tie plate casting and upper end plugs that extend through the upper tie plate casting. These tie rods support the weight of the assembly only during fuel handling when the assembly hangs by the handle; during operation, the fuel rods are supported by the lower tie plate. The ORIGEN2 code (Croff 1980a, 1980b) was used to predict decay heat generation rates of the 16 Wurgassen BWR spent fuel assemblies used in the CASTOR-1C cask performance test. Decay heat rates for the assemblies were determined from end-of-cycle burnup values and from the reactor operating history (Rector et al. 1986a). The predicted assembly decay heat generation rates on three dates are shown in Table 5.3 for each of the 16 Wurgassen assemblies. The average predicted assembly decay heat rates were 837 W, 452 W, and 369 W, for the three dates, corresponding to cooling times of 434, 887, and 1100 days, respectively. At 434 days cooling time, the standard deviation of the predicted decay heat

TABLE 5.2. Characteristics of Typical General Electric BWR Fuel Assemblies

	<u>7x7 Assembly</u>	<u>BxB Assembly</u>
Assembly length	4354 mm (171.40 in.)	4354 mm (171.40 in.)
Fuel rods		
Number	49	63
Length	3964 mm (156 in.)	3964 mm (156 in.)
Active length	3683 mm (145 in.)	3733 mm (147 in.)
Outside diameter	14.3 mm (0.563 in.)	12.5 mm (0.493 in.)
Wall thickness	0.89 mm (0.035 in.)	0.86 mm (0.034 in.)
Pitch	18.7 mm (0.738 in.)	16.3 mm (0.640 in.)
Material	Zr-2	Zr-2
Tie rods - fueled		
Number	8	8
Outside diameter	14.3 mm (0.563 in.)	12.5 mm (0.493 in.)
Wall thickness	0.89 mm (0.035 in.)	0.86 mm (0.034 in.)
Material	Zr-2	Zr-2
Spacer capture rods		
Number	1	1
Outside diameter	14.3 mm (0.563 in.)	12.5 mm (0.493 in.)
Material	Zr-2	Zr- 2
Spacers		
Number	7	7
Material	Zr	Zr-4
Springs	Inconel-X	Inconel-X
Tie plate material	304 SS	304 SS

rate is $\pm 6.0\%$, which reduces to $\pm 4.4\%$ for the longest cooling period. The associated axial decay heat profile used for the simulations is presented in Figure 5.5 and was determined using reactor activity scans and ORIGEN2.

5.1.2 Computational Model Description

A three-dimensional, half-symmetry sector model of the CASTOR-1C cask was used for the COBRA-SFS analysis. A half-symmetry model was dictated by

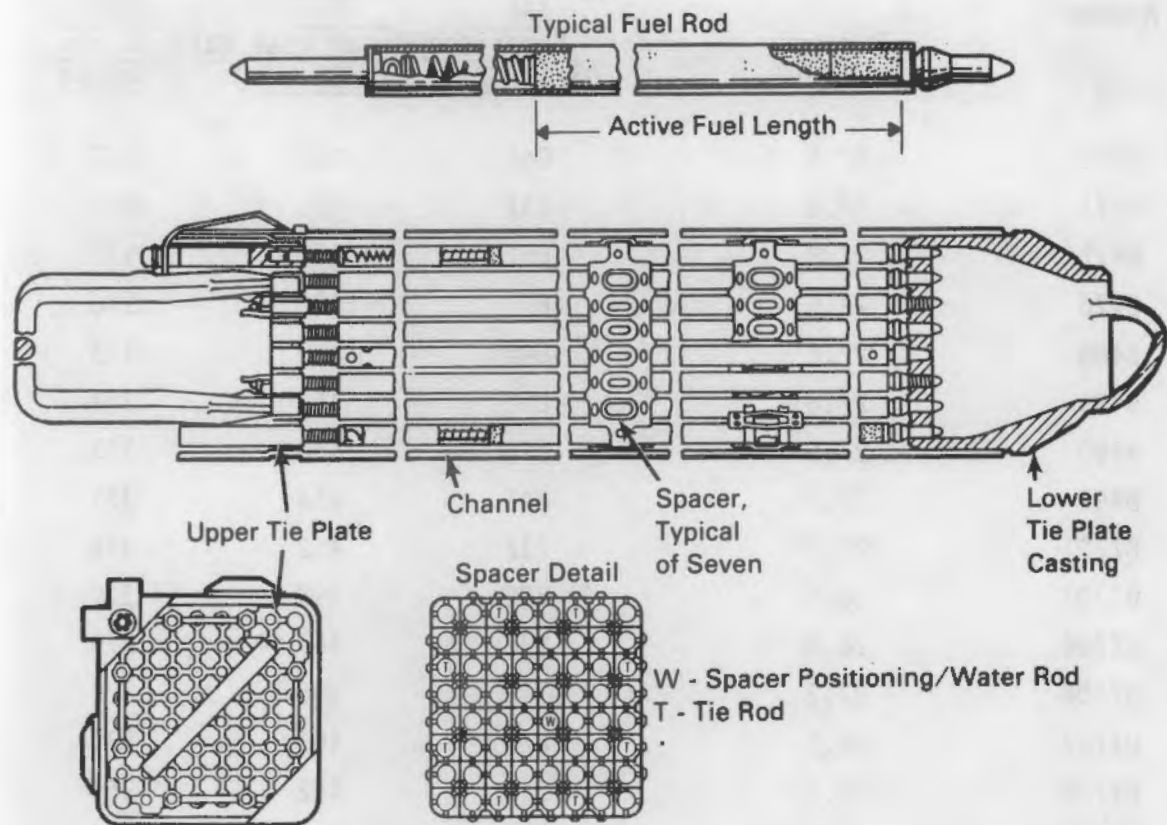


FIGURE 5.4. Typical General Electric 8x8 Fuel Assembly

the arrangement of 7x7 and 8x8 BWR fuel assemblies and by the cask loading pattern. The model, the boundary specifications, and properties used, are described in detail below.

5.1.2.1 Nodal Representation

A transverse cross section of the computational cell arrangement used to represent the cask body is presented in Figure 5.6. A total of 136 wall nodes at each axial level is used to model the heat transfer through the cask body. Of these, 40 are zero-thickness nodes that represent the temperatures on the outside and inside surfaces of the cask body. These surface nodes are necessary to accurately calculate the radiation heat transfer between cask surfaces.

TABLE 5.3. Predicted Wurgassen BWR Assembly Decay Heat Rates

Assembly ID (a)	Burnup, GWD/MTU	Cooling Time, Days		
		434	887	1100
		Predicted Decay Heat Rate, W		
		03/10/82	06/06/83	01/05/84
B476	27.6	846	456	373
B471	27.6	851	460	376
B472	27.8	852	461	377
B476	27.6	851	460	376
B486	27.6	846	460	373
B489	27.8	852	454	377
B490	27.5	846	460	373
B493	27.5	841	454	371
BZ701	27.2	717	452	329
BZ703	28.5	838	398	369
BZ704	28.3	877	467	379
BZ706	27.2	712	396	328
BZ707	28.3	877	467	379
BZ708	28.5	838	452	369
BZ709	28.3	877	467	379
BZ710	28.3	877	467	379
Total		13,398	7,231	5,907
Average	27.8	837	452	369
Std. Dev:	+0.45	+50	+22	+16
%SD of Avg:	+1.6	+6.0	+4.9	+4.4

(a) Identification numbers starting with B denote 7x7 rod assemblies; numbers starting with BZ denote 8x8 rod assemblies.

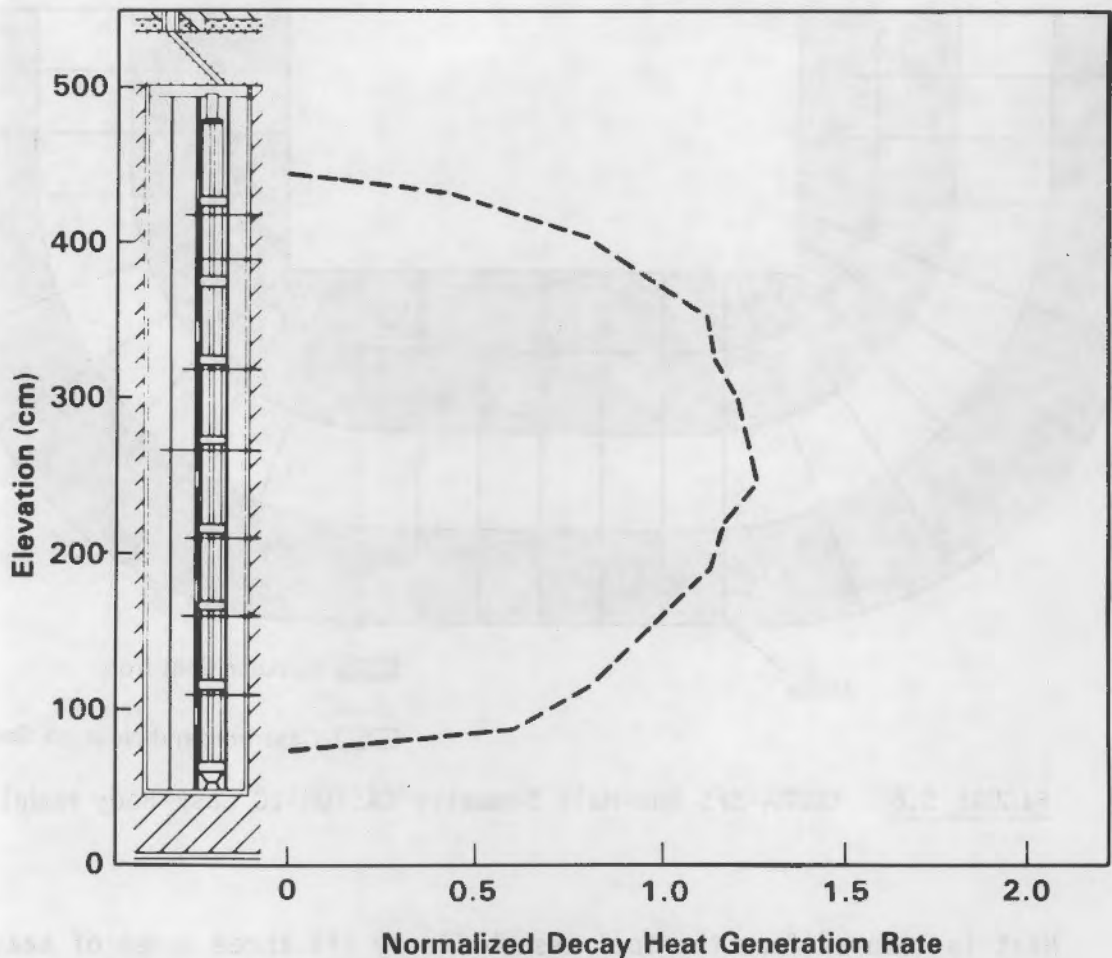


FIGURE 5.5. Axial Decay Heat Profile Used for CASTOR-1C Analysis

A transverse cross section of the computational cell arrangement used to represent the cask basket and fuel assemblies is presented in Figure 5.7. The stainless steel basket is represented by 34 wall nodes at each axial level. The BWR fuel assemblies are modeled using a detailed rod and subchannel nodalization. A typical 7x7 assembly is modeled using 49 rods and 60 fluid subchannels. A typical 8x8 assembly is modeled using 64 rods and 77 fluid subchannels. The resulting half-symmetry cask model consists of a total of 170 wall nodes, 452 rod, and 548 subchannel nodes at each axial level. The basket and fuel assembly region of the cask is modeled using 18 uniform axial nodes.

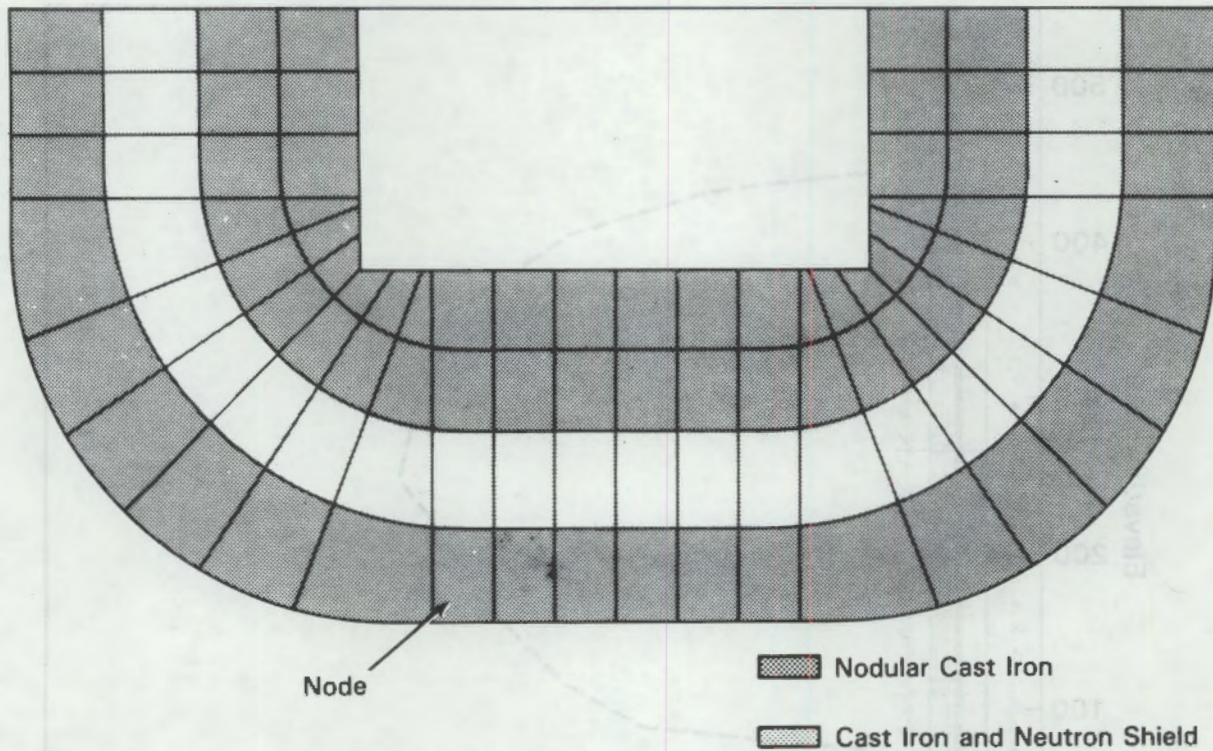


FIGURE 5.6. COBRA-SFS One-Half Symmetry CASTOR-1C Cask Body Model

Heat is removed from the fuel assemblies by all three modes of heat transfer: conduction, convection, and radiation. Within each assembly, heat is transmitted from the rods to the basket by conduction through the fluid. Fluid conduction between adjacent subchannels is modeled based on a transverse control volume of specified gap width and centroid-to-centroid length.

Conduction heat transfer through the basket and cask body is modeled by specifying the appropriate thermal resistance between adjacent wall nodes. The input thermal resistance values may reflect a composite of materials and parallel and/or series heat transfer paths. For example, wall nodes containing both polyethylene neutron absorber cylinders and cast iron are modeled using a composite conductivity. In developing these resistances, it was assumed that there was no additional thermal resistance at the welded junctions between

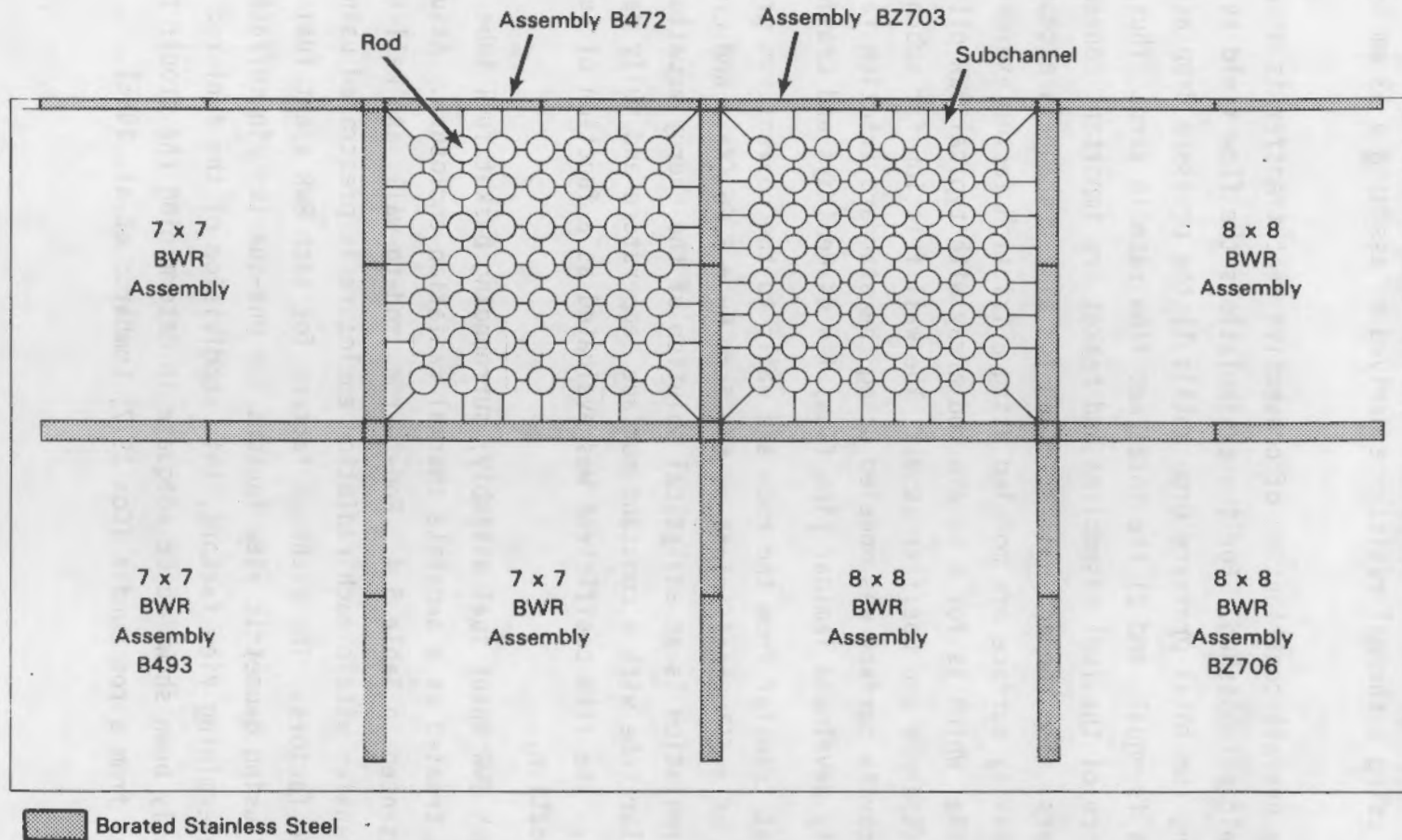


FIGURE 5.7. COBRA-SFS One-Half Symmetry CASTOR-1C Cask Cavity and Basket Model

the basket plates. Heat transfer from the basket to the cask inner wall was modeled using a thermal resistance derived by assuming a 13 mm helium-filled gap.

The overall contribution of convective heat transfer is dependent on the flow field established. For these simulations the flow field is obtained by adjusting the total pressure drop until: 1) the pressure drop across all channels is equal, and 2) the total net flow rate is zero. Thus, the flow resistance of the fuel assemblies and basket are important convection component parameters. The rod and wall friction for all subchannels except those adjacent to the cavity surface are modeled using a friction factor expression of $f = 100/Re$, which is for a square rod array with typical BWR pitch-to-diameter ratios (Sparrow and Loeffler 1959). The wall friction for subchannels adjacent to the cavity surface was modeled using the standard friction factor expression for fully developed laminar pipe flow; $f = 64/Re$ (Kays and Crawford 1980).

Heat transfer from the rods and walls to the coolant was prescribed through the use of a film coefficient of the form $Nu = 3.66$ (Kays and Crawford 1980). This formulation is an analytical solution of the energy equation for flow in a circular tube with a constant surface temperature and fully developed velocity profile. The film coefficient was evaluated as a function of temperature at each location.

Each BWR spent fuel assembly, surrounding basket fuel tube, and cavity wall is treated as a separate thermal radiation enclosure. Assumed emissivities are presented in Table 5.4. Rod-to-rod, rod-to-wall, and wall-to-wall radiative heat transfer within each radiation enclosure is prescribed using graybody exchange factors. The exchange factors for each BWR spent fuel assembly are derived using geometric view factors for one-quarter pin surface segments. When determining view factors, this subdivision of the fuel rod surface has previously been shown to be adequate in determining the proper radiative heat transfer from a rod bundle (Cox 1977, Lombardo et al. 1986).

TABLE 5.4. Assumed CASTOR-1C Cask Surface Emissivities

<u>Surface Emissivities</u>	
Fuel Rods =	0.8
Fuel Basket =	0.4
Nickel Plated Surfaces =	0.25

5.1.2.2 Boundary Specifications and Material Properties

The computational nodding model described earlier extends radially outward to the cask surface. Within this model the wall and fluid energy equations are solved simultaneously. Boundary conditions are provided to the model by specifying heat transfer coefficients which describe the heat transport from the cask surface to the ambient air. The two coefficients of interest are: 1) heat transfer from the cask barrel to the ambient, and 2) heat transfer from the cask ends to the ambient.

The outside surface of the cask varies as a function of axial level. In the axial region of the fuel assemblies, a set of 48 axial cooling fins are provided to assist in removing heat by natural convection. The amount of heat being removed by natural convection from a finned surface is calculated using the Nusselt number expression (Chaddock 1970):

$$Nu = 0.112 (Ra \cdot b/L)^{0.534} [1 - e^{-129/(Ra \cdot b/L)}]^{0.284} \quad (5.1)$$

where Ra is the Rayleigh number, b is the distance between vertical fins and L is the total vertical length of the fin.

Near the top and bottom of the cask, the outer surface of the cask is essentially a smooth cylinder. The amount of heat removed by natural convection is calculated using the Nusselt number expression for vertical cylinders in air (Lindeburge 1981):

$$Nu = 0.13 (GrPr)^{0.33} \quad (5.2)$$

where Gr is the Grashof number, and Pr is the Prandtl number.

The top surface of the cask can be represented by a horizontal flat plate. The Nusselt number expression for this geometry in air (Lindeburge 1981) is

$$Nu = 0.14 (GrPr)^{0.33} \quad (5.3)$$

The bottom of the CASTOR-1C cask rested on a supporting surface. Since the surface temperature and contact resistance were unknown, it was conservatively assumed that the bottom surface of the cask as an adiabatic boundary.

To properly evaluate code predictions and the cask models, comparisons of relative temperature differences among the various cask components are required. One obvious result of the pretest predictions is the overprediction of the measured surface-to-ambient temperature difference. The results from the correlations presented above and similar correlations used in the REA 2023 cask analysis (Wiles et al. 1986) have been found to typically underpredict the heat transfer from these large cask bodies by 30 to 40%. Because the radiation component from these surfaces is fairly well defined (measured surface emissivities and constant radiation exchange factors), the differences between the pretest predictions of surface-to-ambient temperatures are attributed to deficiencies in the convective heat transfer component. This is not surprising since the correlations were developed based on ideal geometries and test conditions, and are being applied outside their intended range of applicability. Thus, to facilitate the cask component temperature difference comparisons, the convective correlations listed above were increased by approximately 40% to provide reasonably close agreement between the predicted and measured surface temperatures. The correlations presented here are typical of what is available in the literature and what might be employed in conservative applications of the code.

Heat is also removed from the fins by thermal radiation. The amount of heat removed is calculated using a composite graybody exchange factor. This factor is calculated using Hottel's method (Cox 1977) and is based on the surface emissivities and the blackbody view factors between the cask and fin

surfaces and ambient air. The radiation heat transfer from the top and smooth side surfaces is also accounted for. The emissivity of the outer painted surface of the cask was measured by GNS to be 0.93, the emissivity of the outer nickel plated surfaces was measured to be 0.25 and, the ambient air was assumed to be a blackbody surface ($\epsilon = 1.0$). A list of the surface emissivities for the fuel and various cask components is presented in Table 5.4.

The material properties used to develop the CASTOR-1C model are presented in Table 5.5. Most of these properties were obtained from GNS. Constant thermal conductivities are specified for cast iron and neutron moderator. However, the thermal conductivity for the fuel basket is specified as a function of temperature. As stated earlier, the thermal conductivities are not used in the COBRA-SFS code directly but are used to determine the resistance coefficient between adjacent wall nodes. A preliminary CASTOR-1C simulation was performed using average values for thermal conductivities. Specific temperatures from this run were then used to evaluate the thermal conductivity at each location and subsequently for each thermal connection.

TABLE 5.5. CASTOR-1C Cask Material Properties

Thermal Conductivities

Nodular Cast Iron = 0.35 W/cm²°K

Neutron Moderator = 0.15 x 10⁻² W/cm²°K

Fuel Basket = $(9.503 + 1.445 \times 10^{-2}T - 4.989 \times 10^{-2}T^2 + 3.33 \times 10^{-9}T^3) \times 10^{-2}$ W/cm²°K

where T is temperature in °C

5.1.2.3 Modeling Uncertainties

In the design information used to develop the CASTOR-1C cask model, a number of uncertainties exist that affect the ability to accurately predict the cask thermal performance. The following parameters introduce uncertainty into the analysis:

- The basket-to-cask wall gap is assumed to be a nominal 13 mm (0.51 in.). No effort has been made to account for thermal expansion or eccentric positioning of the basket within the cavity.
- The fuel assemblies are assumed to be vertical and positioned in the center of each basket fuel tube. In reality, the fuel assemblies will probably lean against the side of the fuel tube for support. The resulting eccentricity will affect the heat transfer from the assembly to the basket and the resulting temperature distribution.
- Natural convection heat transfer from the outside surface of the cask is difficult to predict accurately. The correlation selected is based on vertical rectangular fins extending from a flat surface in a static environment. The actual geometry and test conditions do not match these ideal assumptions.
- The bottom surface of the cask is assumed to be adiabatic. In reality, the heat transfer to the supporting surface will depend on the contact resistance between the surfaces.

5.1.3 Comparisons of Predictions to Data

For purposes of this study, only the highest decay heat level data are presented. To perform the predictions, cask internal pressure, loading pattern, assembly decay generation rates and profiles, and ambient temperatures were supplied. Comparisons of the peak clad axial temperature profiles are presented in Figure 5.8 along with the predicted and measured surface temperatures. Excellent agreement between predictions and test data can be seen, with the predicted temperature drop (peak cladding-to-ambient) falling within 1% of the test data. Excellent agreement is also seen in the axial temperature profiles. Equally good agreement was also obtained for assembly BZ704, but is not shown because of the symmetry of results.

To complete the evaluation of the code predictions and the cask model, comparisons of temperature differences between cask components at 266 cm (104 in.) above the cask bottom are displayed in Figure 5.9. Through the basket and cask body, exceptionally good agreement between predictions and data

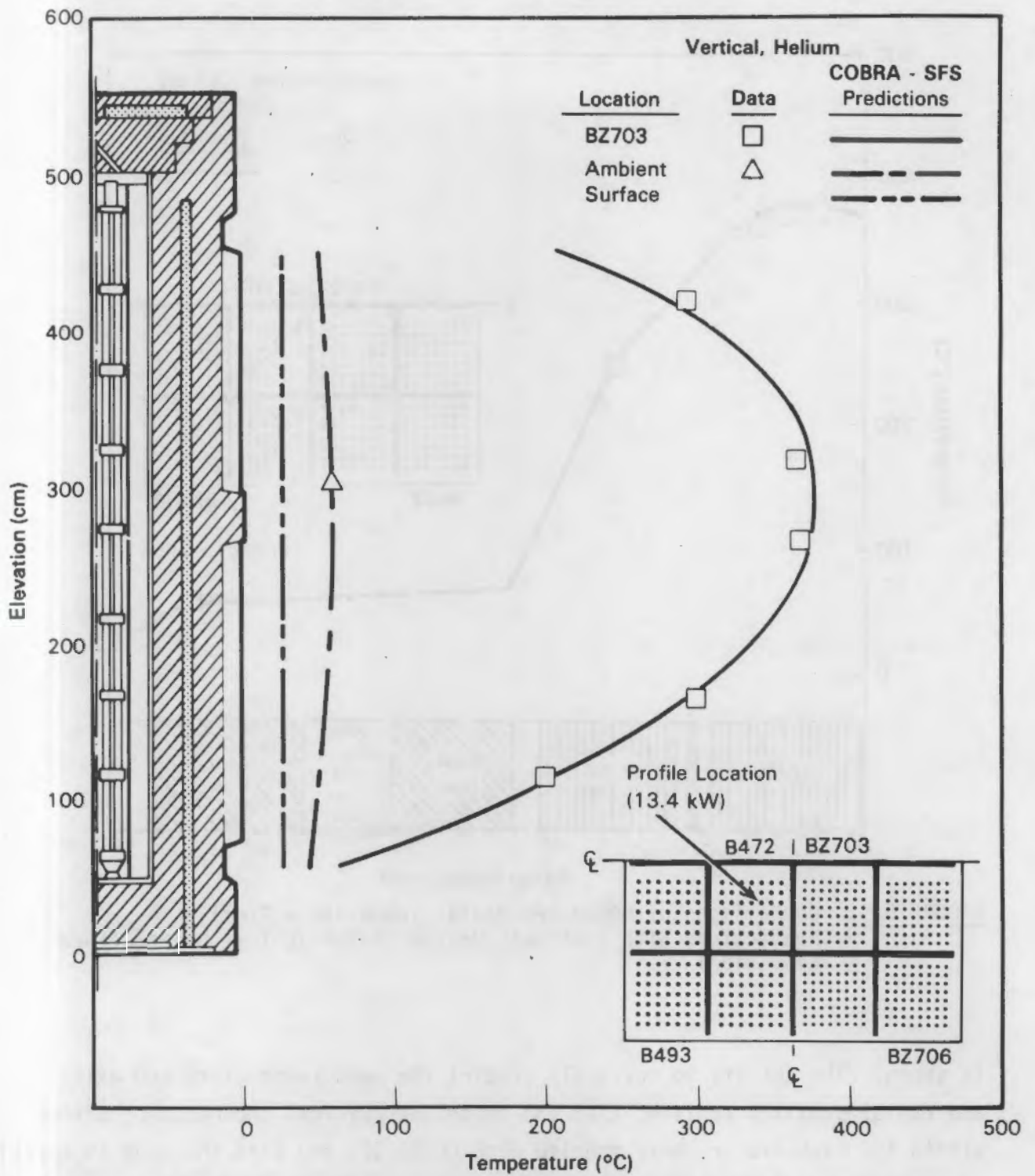


FIGURE 5.8. Comparisons of COBRA-SFS Axial Temperature Profile Predictions with Vertical, Helium CASTOR-1C Test Data

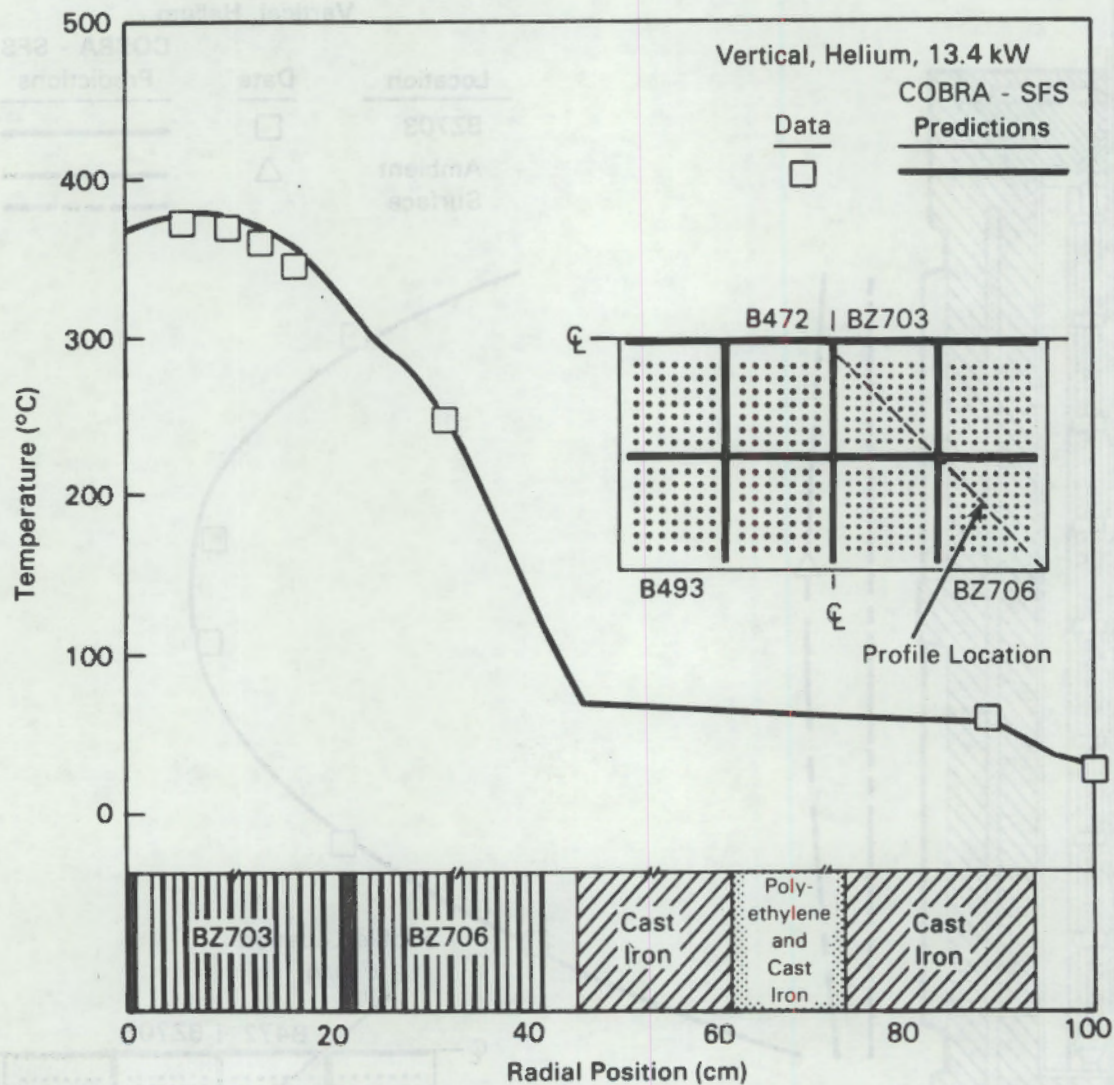


FIGURE 5.9. Comparisons of COBRA-SFS Radial Temperature Profile Predictions with Vertical, Helium CASTOR-1C Test Data (266-cm Elevation)

is shown. The ability to correctly predict the peak temperature and axial and radial profiles confirms that the important physical phenomena occurring within the cask are properly modeled with COBRA-SFS and that the code is capable of analyzing the added complexities of multiassembly storage systems.

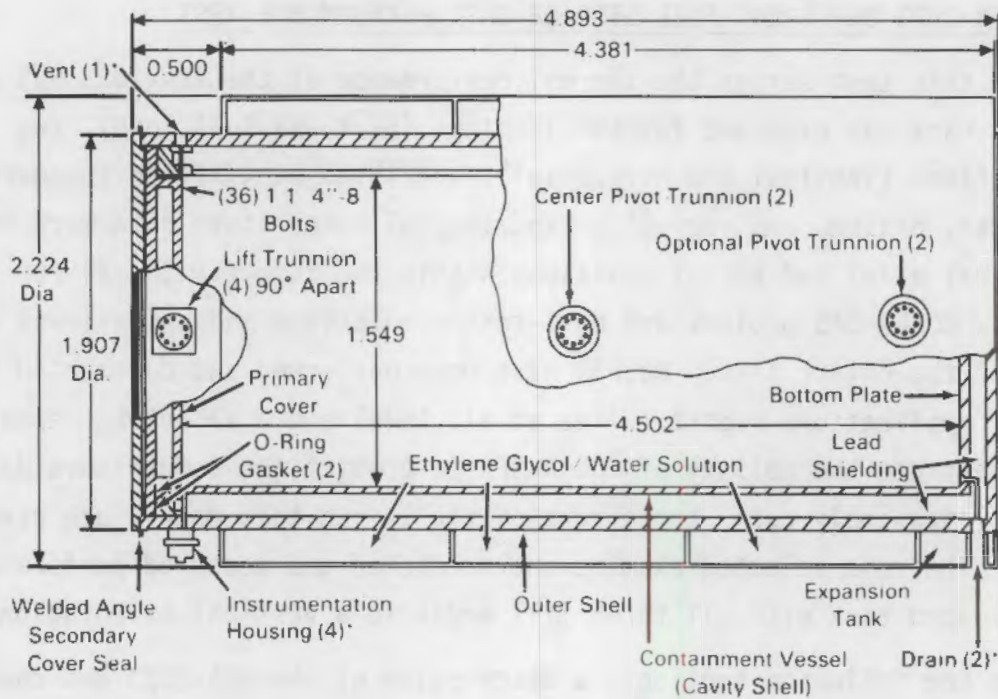
5.2 REA-2023 BWR SPENT FUEL STORAGE CASK PERFORMANCE TEST

In this test series the thermal performance of the REA-2023 BWR Spent Fuel Storage Cask was examined for two loadings (part and full load), two orientations (vertical and horizontal), and three backfill environments (nitrogen, helium, and vacuum). Experimental temperature data were recorded at several axial and radial positions within the cask for the 14-run test matrix. COBRA-SFS prelook and post-test predictions and comparisons with data for the entire 14-run matrix have been performed and documented in an earlier applications report (Wiles et al. 1986) and will not be repeated here. To demonstrate the ability of COBRA-SFS to predict the temperature distributions of a multiassembly cask, three runs of the 14-run test matrix are presented below. The runs selected examine the predicted and measured performance of a fully-loaded cask with all three fill media in a vertical orientation.

In the following sections, a description of the REA 2023 BWR cask and performance test is presented, along with details of the COBRA-SFS computational model, assumptions, and correlations employed. Comparisons of code predictions with test data for the three test cases are then presented and the results discussed. Listings of the input, representative output, and convergence lists for the cases simulated and reported here are presented in Appendix E. Additional details of the REA cask performance test and analyses can be found in detailed reports by McKinnon et al. (1986b) and Wiles et al. (1986).

5.2.1 REA 2023 Cask and Test Description

The REA 2023 BWR spent fuel storage cask is shown in Figure 5.10 and is discussed in detail in REA's topical report submittal to the U.S. Nuclear Regulatory Commission (REA 1983). The cask is of the double containment design with silicone elastomer O-rings to seal the inner cavity and a seal-welded final closure as a secondary cover. The cask has a smooth, painted, outer shell, an ethylene glycol/water neutron shield, and a lead gamma shield. The spent fuel basket is constructed of stainless steel clad Boral for criticality control, copper plates to conduct heat to the cask inner wall, and stainless steel for structural strength. The cask is approximately 2.25 m (8 ft) in



Dimensions are in Meters

* Rotated From True Position

FIGURE 5.10. REA 2023 BWR Spent Fuel Storage Cask

diameter, and 5 m (16 ft) long, and can accommodate 52 unconsolidated BWR spent fuel assemblies.

The inner cask containment shell is 1.91-cm (0.75-in.) thick stainless steel. The cask inner bottom plate, outer bottom plate, and outer shell are 5-cm (2-in.) thick stainless steel. Lead gamma shielding, 10.8 cm (4.25 in.) thick in the sidewall, 8.26 cm (3.25 in.) thick in the bottom, and 7.62 cm (3.0 in.) thick in the primary lid, is provided.

The neutron shield outer shell is a 0.64-cm (0.25-in.) thick stainless steel plate approximately 399 cm (157 in.) long. The shield itself is a 15.24 cm (6 in.) annulus containing a 50/50 ethylene glycol/water solution. Within the neutron shield are trunnion supports, to which the trunnions may

be externally bolted. Connected to the lower end of the neutron shield is the expansion tank, which communicates with the neutron shield by a siphon pipe.

The inner or primary lid, which is recessed into the cask cavity, has a bottom plate 2.54 cm (1.0 in.) thick, a top plate 5.08 cm (2.0 in.) thick, and a 7.62 cm (3.0 in.) layer of lead between the plates. The lid is bolted to the cask body with high-strength bolts; sealing is accomplished by two silicone elastomer O-rings. An outer or secondary lid made of 5.08-cm (2.0-in.) thick stainless steel was clamped to the cask body for these tests.

The basket is fabricated in four sections that are located in the cask inner cavity as shown in Figures 5.11 and 5.12. Contact is made with the inner wall of the cask, thus minimizing thermal resistance. Each basket section has thirteen 15.2-cm (6-in.) square Brooks and Perkins fuel tubes, each of which contains one BWR spent fuel assembly. Each tube consists of concentric inner and outer square "shrouds", which integrally encapsulate Boral neutron absorber plates. The Boral neutron absorber plates, which extend above and below the active length of the fuel, are 0.185 cm (0.073 in.) thick, and contain a ^{10}B content of 0.02 g/cm^2 to provide adequate neutron attenuation.

The outer shell of each basket section and two internal ribs are constructed of 0.64-cm (0.25-in.) thick copper plates for conduction of heat out to the inner wall of the cask (Figure 5.12). Other structural members of the basket are fabricated from stainless steel. The basket rests on the bottom of the cask, and has cutouts to permit drainage of water and circulation of gas.

All 52 BWR spent fuel assemblies used in the cask performance test were from Nebraska Public Power District's Cooper Nuclear Station. The fuel assemblies were of the General Electric 7x7 design as shown in Figure 5.13, with design characteristics given in Table 5.6. Besides standard fuel rods, each assembly has eight fuel rods that are used as tie rods that thread into the lower tie plate casting. The upper ends of the fuel/tie rods extend through and are fastened to the upper tie plate with stainless steel nuts and locking

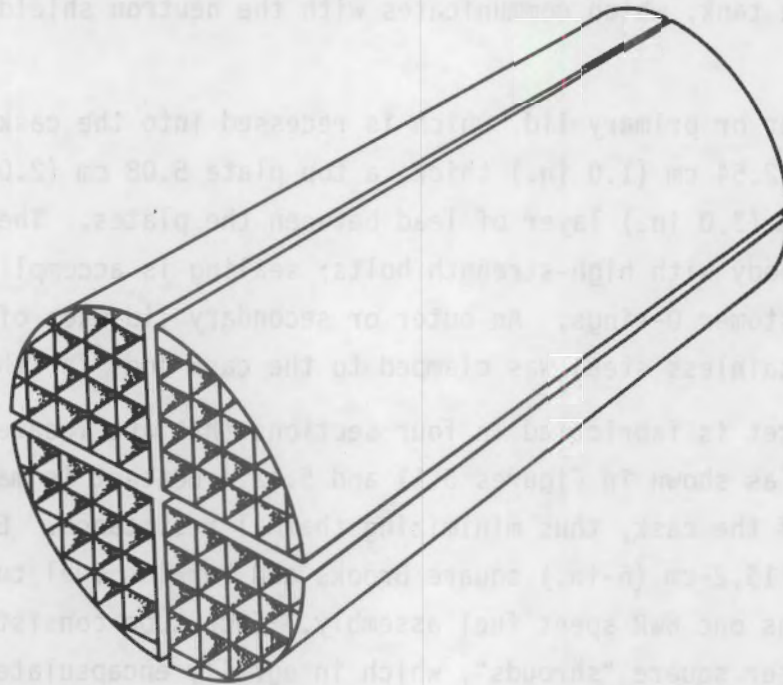


FIGURE 5.11. REA 2023 Cask Basket for 52 BWR Fuel Assemblies

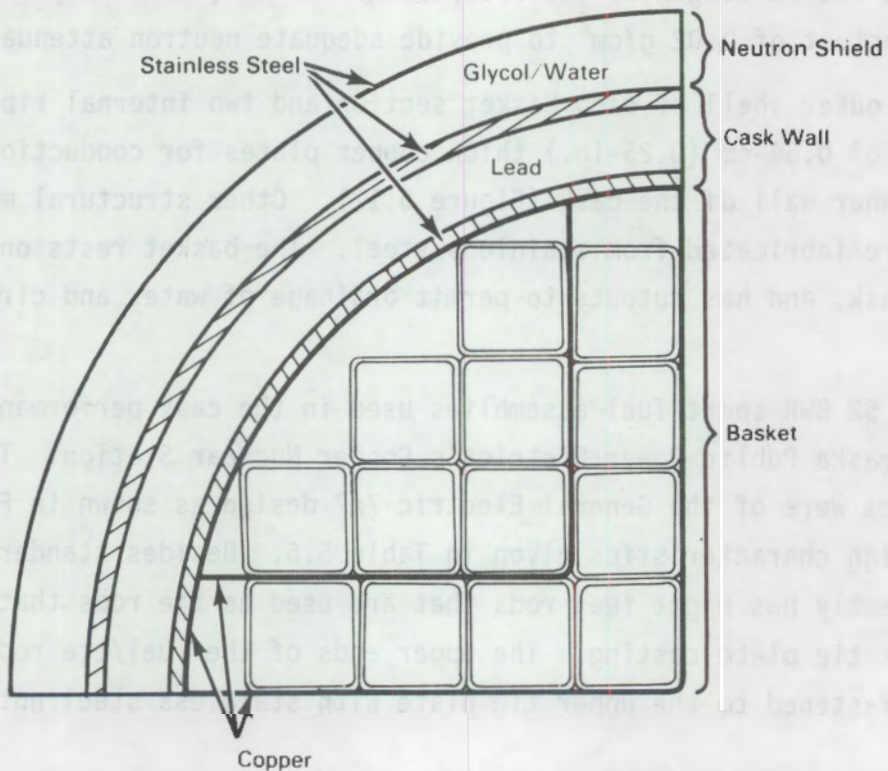


FIGURE 5.12. Quarter Section Plan View of REA 2023 BWR Cask

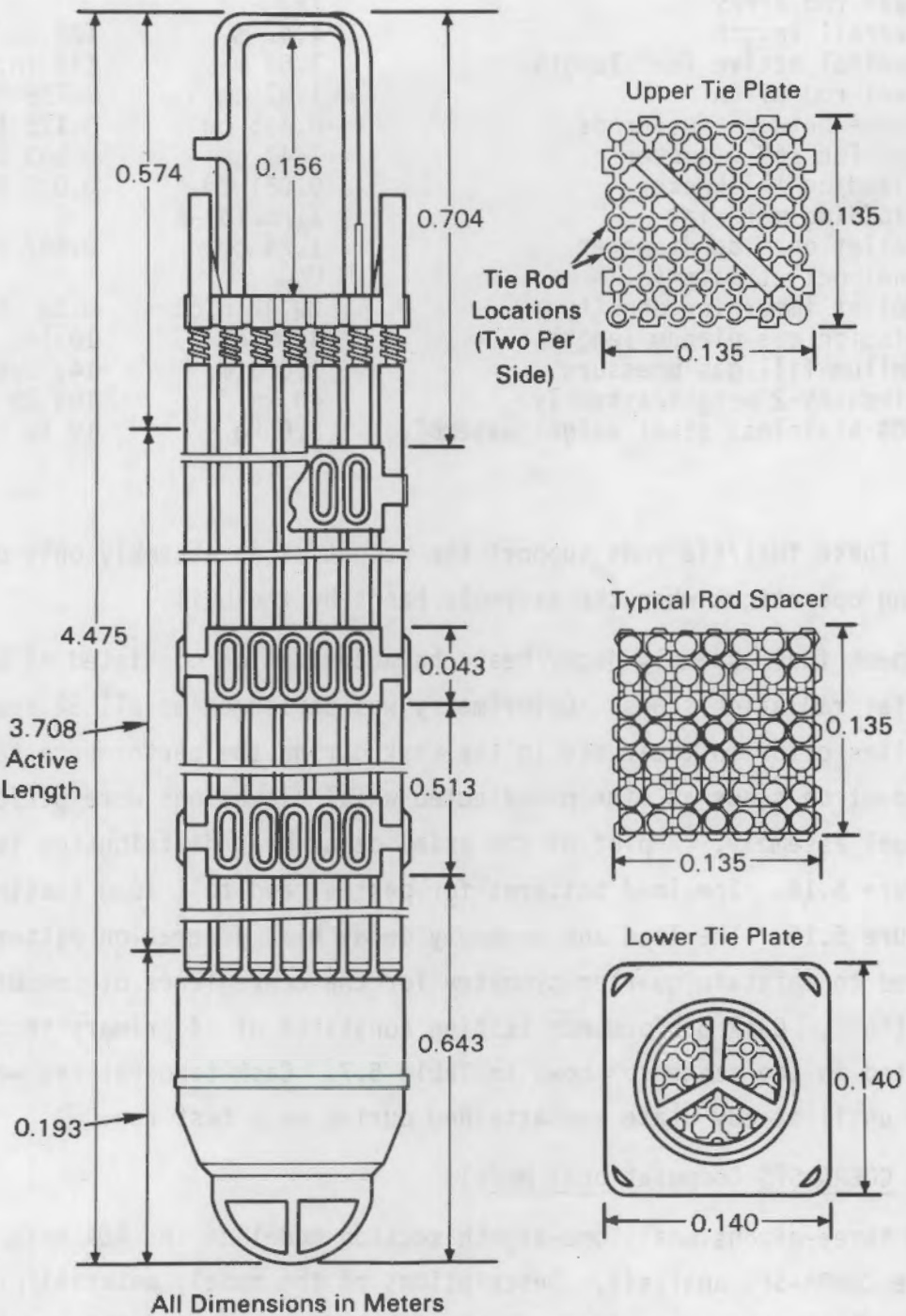


FIGURE 5.13 Cooper BWR Spent Fuel Assembly

TABLE 5.6. Cooper BWR Spent Fuel Assembly Design Parameters

Fuel rod array	7x7	
Overall length	4.47 m	175.83 in.
Nominal active fuel length	3.66 m	144 in.
Fuel rod pitch	1.87 cm	0.738 in.
Space between fuel rods	0.445 cm	0.175 in.
Outside rod diameter	1.43 cm	0.563 in.
Cladding thickness	0.081 cm	0.032 in.
Cladding material	Zircaloy-2	
Pellet outside diameter	1.24 cm	0.487 in.
Fuel pellet material	UO ₂	
Pellet immersion density	10.42 g/cc	0.38 lb/in. ³
Fission gas plenum length	40.6 cm	16 in.
Helium fill gas pressure	1.0 atm.	14.7 psia
Zircaloy-2 weight/assembly	48 kg	106 lb
304 stainless steel weight/assembly	8.6 kg	19 lb

tabs. These fuel/tie rods support the weight of an assembly only during fuel handling operations when the assembly hangs by the bail.

Spent fuel assembly decay heat characterization consisted of calorimetry and axial radiation scans. Calorimetry was performed on all 52 spent fuel assemblies prior to their use in the cask during the performance test. Gamma/neutron scans at nine preselected axial elevations were performed on each fuel assembly. A plot of the axial decay heat distribution is presented in Figure 5.14. The load patterns for partial and full load testing are shown in Figure 5.15. The load and assembly decay heat generation patterns were selected to maintain quarter symmetry for the convenience of computer code simulations. Cask performance testing consisted of 14 primary test runs conducted in the sequence shown in Table 5.7. Cask temperatures were recorded hourly until steady state was attained during each test run.

5.2.2 COBRA-SFS Computational Model

A three-dimensional, one-eighth section model of the REA cask was developed for the COBRA-SFS analysis. Descriptions of the model, material properties, and correlations are provided, along with a discussion of the modeling uncertainties.

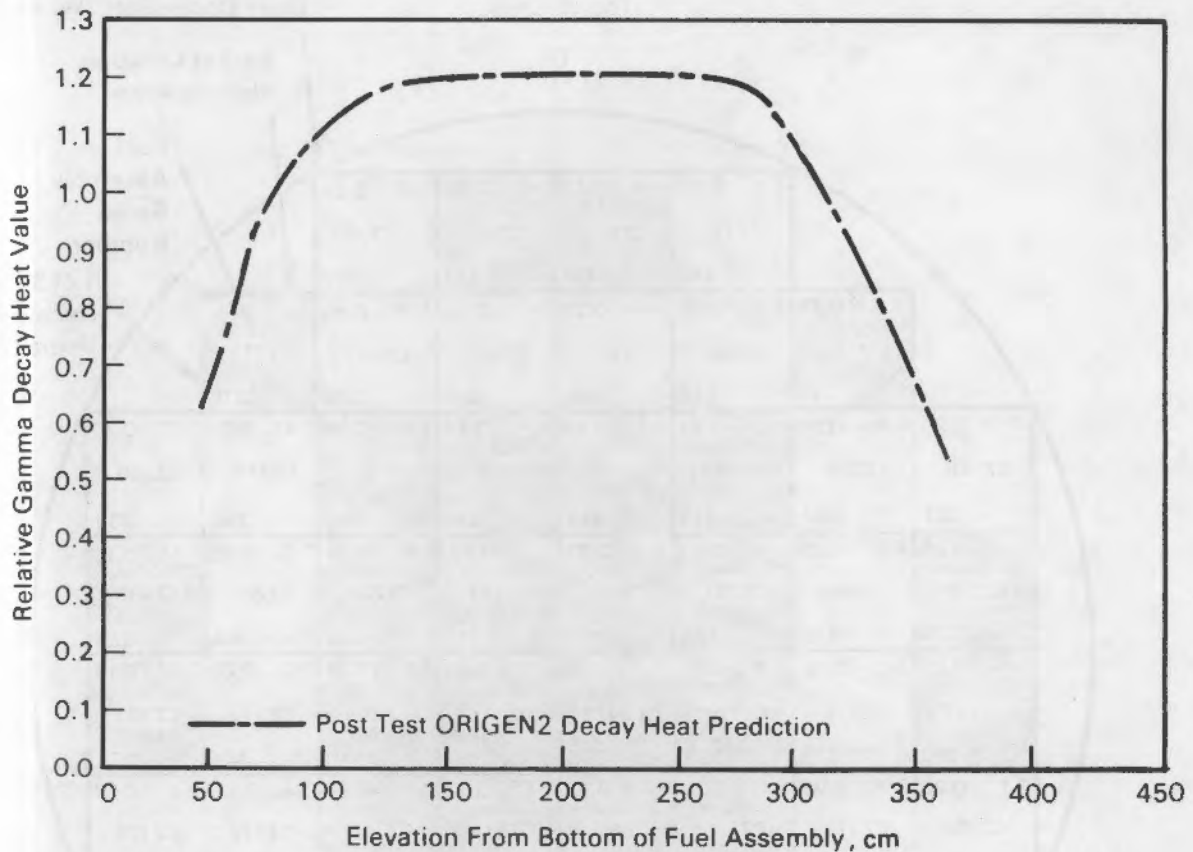


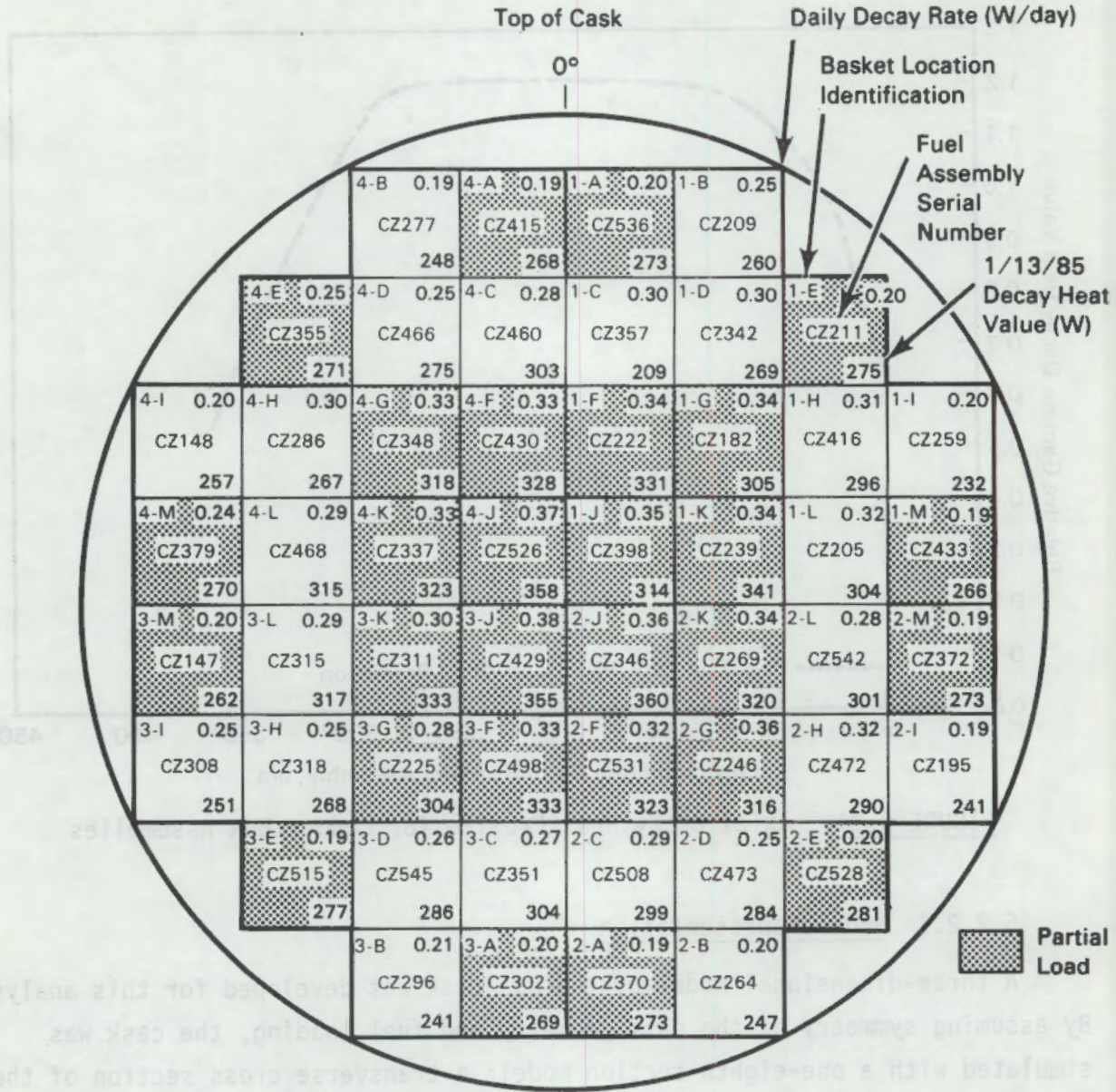
FIGURE 5.14. Axial Decay Heat Profile for Cooper BWR Assemblies

5.2.2.1 Nodal Representation

A three-dimensional model of the REA cask was developed for this analysis. By assuming symmetry of the cask geometry and fuel loading, the cask was simulated with a one-eighth section model; a transverse cross section of the computational cell arrangement is presented in Figure 5.16. The subchannel noding used in modeling the spent fuel assemblies is illustrated in Figure 5.16 along with the wall noding employed for the cask structural members. A total of 24 uniform nodes were used in the axial direction, as shown schematically in Figure 5.17. Approximately 300 fluid subchannels were used to describe the flow paths at each axial level for the fully loaded cask. For the partially loaded cask, flow areas of empty fuel tubes were modeled as single subchannels. Flow areas created by basket spacers were also treated as single subchannels.

Quadrant #4

Quadrant #1



Quadrant #3

Quadrant #2

FIGURE 5.15. REA 2023 BWR Cask Partial and Full Load Patterns

To describe the cask and basket structural members at each axial level, 106 slab nodes were used. Radiation and/or conduction heat transfer between wall nodes was included within a plane by specifying the appropriate thermal conductance terms. Wall axial conduction along with fluid-to-fluid conduction

TABLE 5.7. REA 2023 BWR Cask Performance Test Matrix

<u>Run Number</u>	<u>Number of Assemblies</u>	<u>Backfill</u>	<u>Cask Orientation</u>
1	28	Vacuum	Vertical
2	28	Nitrogen	Vertical
3	28	Nitrogen	Horizontal
4	28	Helium	Horizontal
5 (a)	28	Helium	Vertical
6 (a)	52	Vacuum	Vertical
7	52	Nitrogen	Vertical
8 (b)	52	Nitrogen	Vertical
9	52	Nitrogen	Horizontal
10	52	Helium	Horizontal
11 (a)	52	Helium	Vertical
12	52	Helium	Vertical-Insulated
13	52	Helium	Vertical-Insulated
14	52	Vacuum	Vertical-Insulated

(a) Two runs at different environmental conditions were obtained.

(b) Repeat of Run 7 after cask had been rotated to shift fuel assemblies.

between adjacent fluid subchannels was also accounted for. The fuel tube walls and adjacent heat conduction strips were split into two circumferential nodes. For the complex geometry of the basket-cask interface, finer noding was employed to allow more complete modeling of conduction and radiant heat exchange within this region. Coarser noding was employed within the relatively simple geometry of the cask body.

Each rod in each fuel assembly was individually modeled; a total of 329 rods were used in the fully loaded cask model. Each fuel rod consisted of five radial nodes: four for the fuel and a single node for the cladding. Circumferential noding was not used in the rods. The heat generation rates were based on spent fuel calorimetry data (McKinnon et al. 1986b). The values used reflected the elapsed time from the calorimeter measurements to the steady-state test time (the decay rate of change values was obtained from ORIGEN-2 predictions). The loading patterns, assembly heat rates, and daily decay rates for the partially and fully loaded cask are presented in Figure 5.15. The fuel assembly numbering scheme also is shown in Figure 5.15.

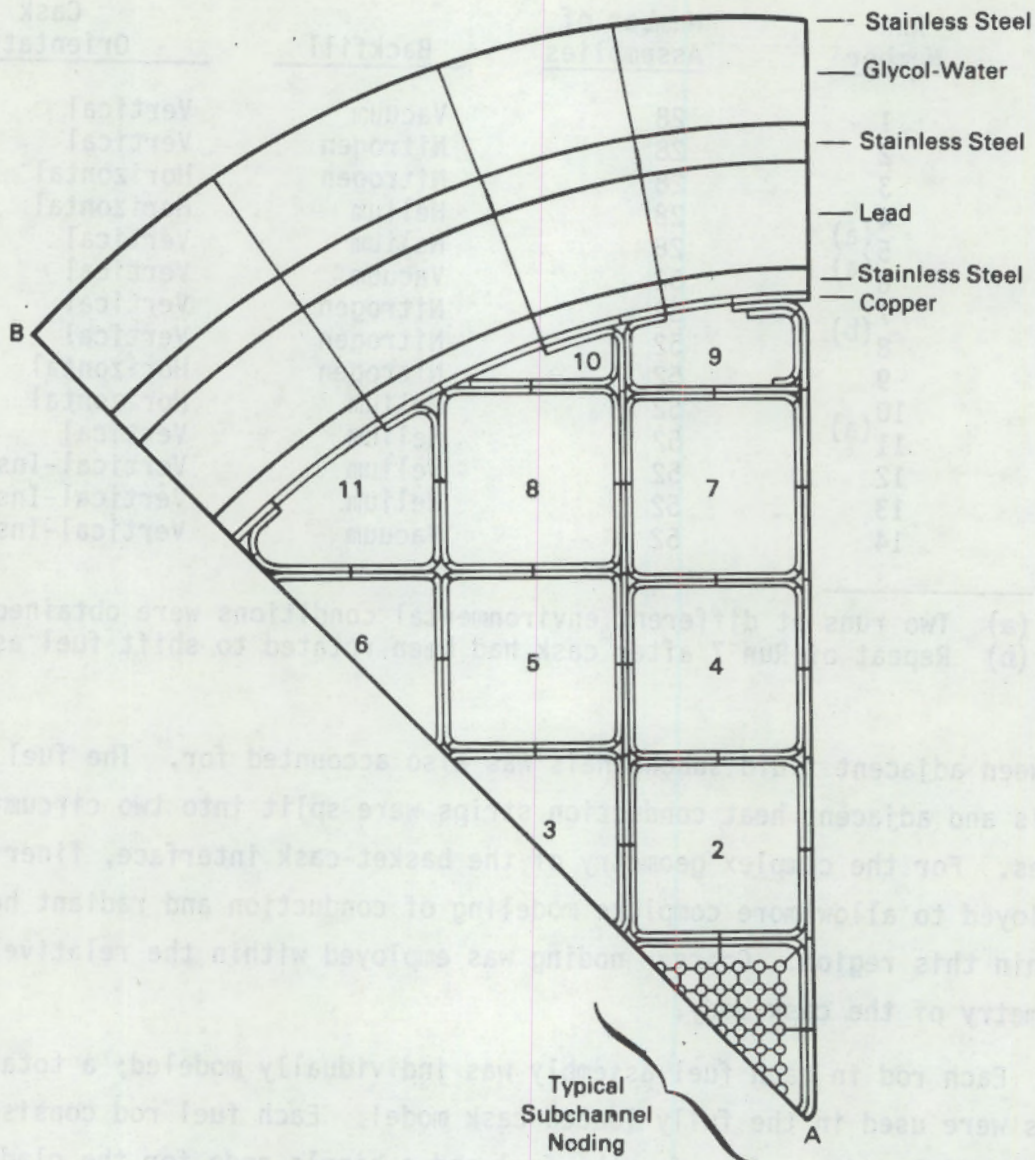


FIGURE 5.16. COBRA-SFS One-Eighth Section Model of the REA 2023 BWR Cask

Decay heat values used in the one-eighth sector model represent the average loading for cask quadrant 2, and ranged from 0.28 kW to 0.38 kW per assembly. The axial decay heat profile displayed in Figure 5.14 was applied to all assemblies. A uniform radial power distribution within a fuel assembly was assumed.

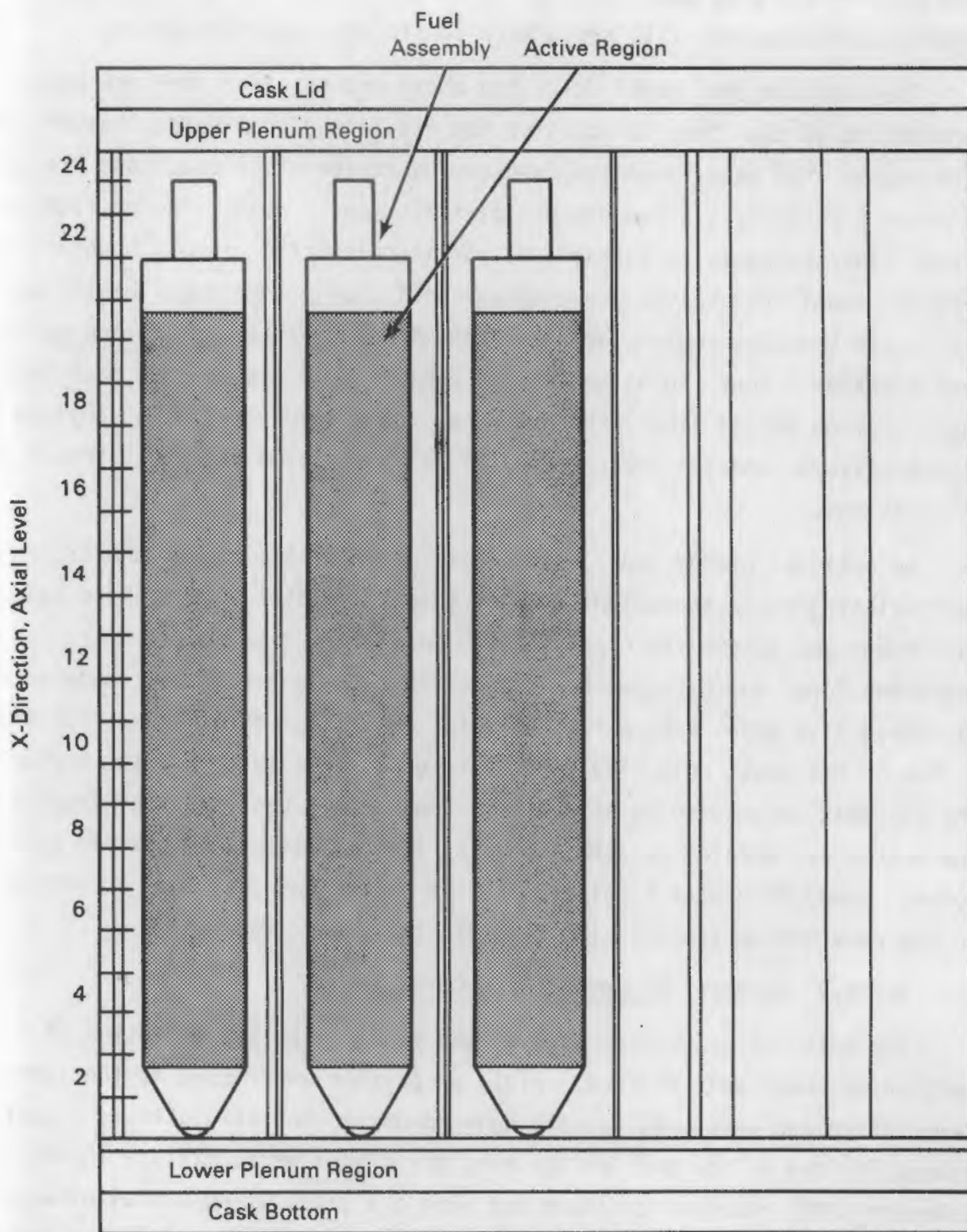


FIGURE 5.17. COBRA-SFS Axial Noding Scheme of the REA 2023 BWR Cask

The radiant heat exchange between rods and fuel tube walls was computed from prescribed, gray body exchange factors based on one-quarter rod surface segments. All gaseous fill media were considered nonparticipating.

The computational model described above extends into the cask body, terminating at the inner boundary of the ethylene glycol/water chamber. Within this region, the mass, momentum, and energy conservation equations are solved to predict velocity and temperature distributions. Heat transfer from the glycol inner boundary to the ambient air is calculated using a boundary heat transfer model that solves a one-dimensional energy equation. Heat transfer within the boundary region includes radiation and natural or forced convection heat transfer. Four radial nodes were employed: a single node each for the inner neutron shield liner, the outer neutron shield liner, the ethylene glycol/mixture, and the ambient air. Solar insolation was neglected in the calculations.

An optional plenum model was used to describe the heat transfer from the recirculating fluid-to-ambient in the regions immediately above and below the fuel tubes and assemblies. As with the boundary region model, only one-dimensional energy equations are solved. The upper lid was modeled with 10 nodes; five nodes apiece for the axial and radial directions. For the bottom of the cask, only five nodes were used, because the bottom surface of the cask was assumed to be adiabatic. The overall heat transfer from the lid and bottom was modeled by specifying the thermal resistance between plenum nodes. Conduction heat transfer from the basket and cask body to the lid and to the cask bottom is also simulated via the plenum model.

5.2.2.2 Material Properties and Correlations

The material properties used in the model, with the exception of emittances, were well defined. Fluid properties were input as functions of temperature and were continuously updated during the simulations; property values for the solids and for the ethylene glycol/water mixture (Curme and Johnston 1952) remained constant and were evaluated using a preliminary predicted cask temperature distribution. Wall heat transfer in the radial and circumferential directions was modeled by specifying appropriate thermal

resistances. The input value of resistance for a composite of materials is a combination of parallel and/or series paths. The resistances were obtained as functions of temperature, but remained constant during the simulation. As-measured emissivity values were provided for the fuel tube and the high-emissivity paint used to coat the outer surface of the neutron shield (Taylor 1983, 1984). A wide range of emittances is possible for the other cask components; these emittances are dependent on fabrication technique, temperature, and oxidation buildup. A tabulation of the emittances used in the analysis is presented in Table 5.8; emittances not experimentally determined are assumed values.

As with simulations of other cask performance tests described previously, heat transfer from the rods and walls to the gas coolant was prescribed using a film coefficient of the form $Nu = 3.66$ (Kays and Crawford 1980). This value is a solution of the energy equation for a constant surface temperature and fully developed velocity and temperature profiles in a circular tube. The film coefficient was evaluated as a function of temperature at each location.

TABLE 5.8. REA 2023 BWR Cask Test Material Emittance Values

<u>Component</u>	<u>Emittance</u>
Fuel rods	0.8
Fuel tubes (stainless steel)	0.2 (measured)
Other stainless steel surfaces	0.2
Copper	0.5
Lead	0.6
High emissivity paint	0.78 (measured)
Cask surface (stainless steel)	0.3

The overall contribution of convective heat transfer is dependent on the flow field established. For these simulations the flow field is obtained by adjusting the total pressure drop until 1) the pressure drop across all subchannels is equal and 2) the total net flow rate is approximately zero. Thus,

the flow resistance of the cask becomes an important convection parameter. The overall cask flow resistance is assumed to be a combination of:

- rod and wall surface drag
- spacer losses
- fuel tube inlet and exit losses
- fuel assembly inlet and outlet losses.

Rod and wall friction were modeled using an analytical solution for fully developed laminar flow along cylinders arranged in a square array, $f = 100/Re$ (Sparrow and Loeffler 1959). Spacer and fuel assembly inlet and outlet losses were included by specification of a pressure loss coefficient of 1.0. The major source of uncertainty, however, was the fuel tube inlet and outlet flow resistances. Loss coefficients for the fuel tube inlet and outlet were obtained from a handbook of hydraulic resistance (Idel'Chik 1966); uniform values of $K = 9$ and $K = 3$ were assigned for the fuel tube inlets and outlets, respectively.

Heat transfer from the subchannel model to the boundary requires specification of the heat transfer across the glycol/water annulus, and from the cask surface to the ambient. Heat transfer from natural convection in the partitioned glycol/water annulus was modeled as a function of the temperature difference across the annulus using

$$Nu = 0.22A^{-1/4} \frac{Pr}{0.2 + Pr} Pr Gr^{0.28} \quad (5.4)$$

where Pr is the Prandtl number, Gr the Grashof number, and A the annulus aspect ratio, defined as the ratio of the annular height to width (Catton 1978). Because of uncertainties associated with application of this correlation to the neutron shield, Equation 5.4 was assumed to apply with the cask oriented either horizontally or vertically.

Heat transfer from the cask surface to the ambient included both radiation and convection components. Forced convection heat transfer from the vertical cask surface to the ambient was likened to a cylinder in crossflow; because the direction of crossflow was not constant throughout the test, an average

film coefficient was required. An empirical relationship developed by McAdams (1954) of the form

$$\text{Nu} = B (\text{Re})^N \quad (5.5)$$

where $B = 0.0239$ and $N = 0.805$ was chosen for the REA cask, since it provides an estimate of the average convection heat transfer coefficient around a cylindrical cask body (Welty, Wicks, and Wilson 1969). For horizontal surfaces exposed to crossflow, specifically the cask lid, Reynolds' analogy was applied giving a correlation of the form:

$$\text{Nu} = 0.036 \text{PrRe}^{0.8} \quad (5.6)$$

The forced convection coefficients listed above were calculated using wind data at the time of steady state for each run. The effects of cask orientation on the outer surface convection were ignored because Equations (5.5) and (5.6) give similar results regardless of orientation. The bottom of the cask was assumed adiabatic because the plywood sheet on which the cask rested resulted in a high thermal resistance.

Again it should be said that these standard correlations for convection heat transfer were inadequate in predicting the actual cask surface heat transfer. Therefore, simulations reported here and in the detailed cask analysis report (Wiles et al. 1986), used detailed cask analyses convection coefficients that were appropriately increased ~40% to provide close agreement in the predicted and measured cask surface temperatures. The correlations presented above were shown to provide insight into the uncertainties of modeling cask surface convective heat transfer with available standard correlations.

Radiation heat transfer to the ambient was included in addition to the natural/forced convection component described above. The radiation component was based on radiative heat exchange between gray bodies and was determined as a function of heat transfer area and cask emissivity. Two cask surface emissivities were used: 0.78, an as-measured value of the high-emissivity paint used to cover the surface of the neutron shield (Taylor 1984), and 0.3,

the assumed emissivity for the unpainted stainless steel cask surfaces (Taylor 1983). The ambient was assumed to be a black body ($\epsilon = 1.0$).

5.2.2.3 Modeling Uncertainties

The computational model for this analysis was developed from design drawings supplied by REA, predicted and measured assembly heat generation rates, and predicted and measured axial heat generation profiles. In developing the model, uncertainties associated with five important heat transfer and fluid flow parameters were encountered:

- contact resistances
- material emissivities
- surface-to-ambient thermal resistance
- ambient conditions
- flow resistances.

Contact heat transfer was assumed to be a function of material type, gap size, surface finish, contact pressure, and the effective contact area. Areas not in contact transferred heat through a gap via radiation and conduction through the fluid. In cases where partial contact is assumed, the relatively low thermal resistance of the contact path dominates the parallel thermal resistance term, making the uncertainty in gap size relatively insignificant. Thus, uncertainties in the contact heat transfer are primarily a function of the materials in contact and the effective contact area.

The cask basket components subject to large uncertainties in contact heat transfer are 1) fuel tubes, 2) basket spacers, 3) conduction strips, and 4) fuel assemblies. Fuel tube contact heat transfer (fuel tube-to-fuel tube, fuel tube-to-basket spacer, and fuel tube-to-conduction strip) is possible only from the fuel tube bead surface area. Because the bead surface is a small fraction of the total fuel tube surface area, no contact between the fuel tubes was assumed.

Contact heat transfer for the basket spacers (spacer-to-spacer and spacer-to-basket) is ensured by use of special proprietary fasteners. Measurement of the contact conductance for a similar fastened joint was experimentally determined and reported in an REA proprietary document. Because it is unlikely

that the conductances in the cask will be as high as those measured on a benchtop model, the conductance used in this analysis was arbitrarily taken to be 80% of the as-measured value. Contact heat transfer for the conduction strips (strip-to-basket and strip-to-basket spacer) also is ensured with fasteners. Again, the conductance used was assumed to be 80% of the as-measured value.

For this analysis, it was assumed that fuel assemblies are centered within the fuel tubes so that no contact exists between fuel rods and fuel tubes. This assumption will result in conservatively high cladding temperatures, especially when the cask is horizontally oriented.

Other regions where contact heat transfer is subject to large uncertainties are 1) basket-cask interface and 2) lead-stainless steel interface. Basket-cask contact heat transfer uncertainty is due to the fabrication techniques employed; contact is not ensured because of the differing basket and cask radii of curvature. In determining the contact conductance, an average of the measurements of the as-built gaps was used. No contact was assumed along the basket-cask interface.

The uncertainty in the geometry of the lead within the stainless steel annulus of the cask body again results from the fabrication technique. Molten lead is poured and allowed to solidify in place; during cooling, contraction of the lead from the outer stainless steel shell is expected. Thus, no contact was assumed; an estimated value of the lead-stainless steel gap was provided by the lead pourer, E. L. Manufacturing, Peebles, Ohio.

As-measured emissivity values were provided for the fuel tubes and for the high emissivity paint used to coat the outer surface of the neutron shield (Taylor 1983 and 1984). A wide range of emissivity values was found in the literature for other cask structures (e.g., strips, spacers, fuel). The values were found to be dependent upon fabrication technique, oxidation buildup, and temperature. Thus, a large degree of uncertainty exists in the emissivity values. However, the uncertainty in the fuel rod emissivity has been shown to have little effect on the radial temperature distribution in an enclosed assembly (Wiles et al. 1986).

Heat transfer from the outer cask surface includes radiation and forced convection components. The cask geometry, however, suggests that large Grashof numbers will result from the large vertical height of the cylinder, and that free convection will continue to play an important role in the overall heat transfer; i.e., both free and forced convection should be considered simultaneously. Additionally, studies have shown significant increases in surface heat transfer with increased turbulence intensities. Thus, the lack of turbulence data and a means to correlate the data, plus the difficulty in defining a method for correlating the combined convection effects, results in a large uncertainty in the cask surface heat transfer coefficient. Definition of the cask surface heat transfer is complicated also by the ambient weather conditions, i.e., insolation, rain, and snow. No attempts were made to model the effect of these natural phenomena on the cask thermal response.

The major uncertainty in flow resistance comes from the contribution of the fuel tube inlet and outlet flow losses. This uncertainty is due in part to the slight bowing of the as-built cask bottom, which results in inlet flow area variations from fuel tube to fuel tube.

5.2.3 Comparisons of Predictions to Data

Axial temperature profiles for the three different fill media (vertical orientation) are displayed in Figures 5.18 through 5.20. In each figure, predicted and measured temperature profiles are given as a function of elevation from the cask bottom for the centerline of assemblies 2J and 1A (see Figure 5.14), the cask surface, and the ambient. The figures are presented in order of increasing system temperature, i.e., helium, nitrogen, and a vacuum.

To facilitate data comparisons within the cask body and basket, the predictions again include a modified cask surface convection coefficient that has been increased to provide relatively close agreement between predicted and measured cask surface temperatures. Note that data points above 4.5 m and below 0.5 m represent gas temperatures, whereas corresponding predictions represent assembly temperatures and, thus, are expected to read higher than data. The results for the helium and nitrogen cases are shown to underpredict the peak cladding temperatures by some 16°C, in part due to the underpredicted

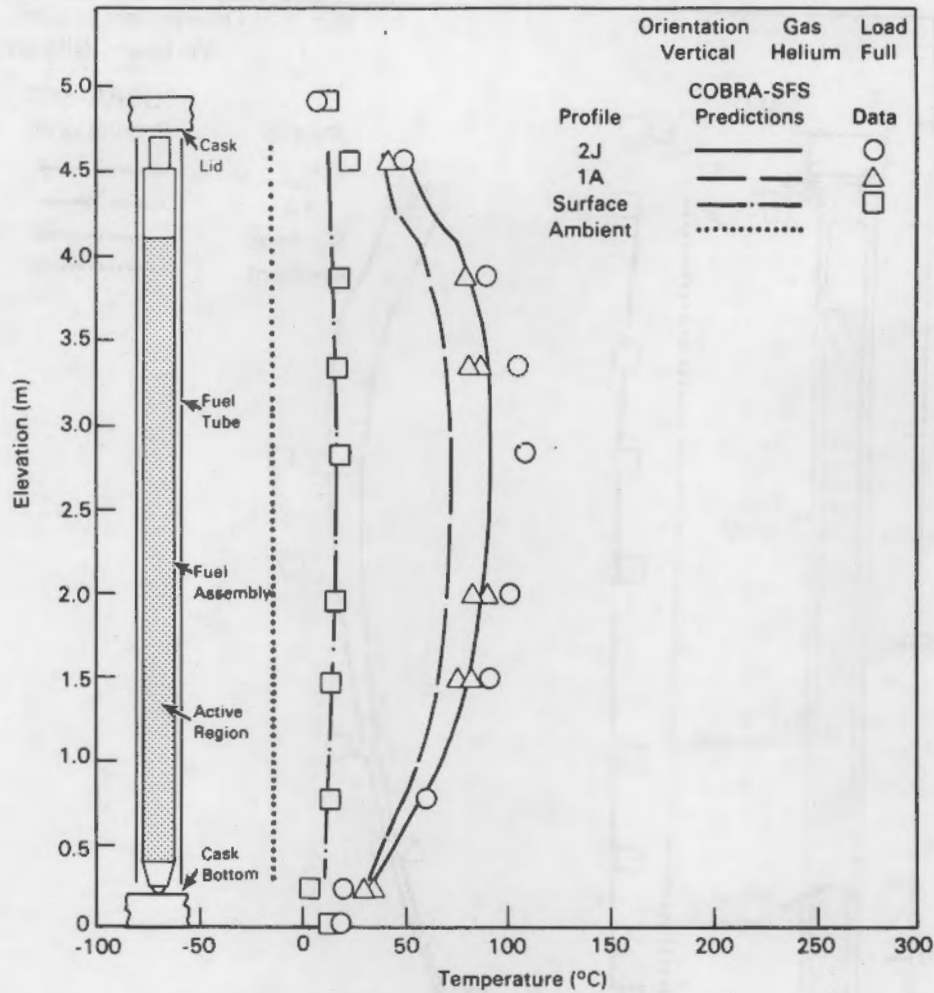


FIGURE 5.18. COBRA-SFS Predictions of Axial Temperature Profiles Compared to Full Load, Vertical, Helium, REA 2023 Test Data

basket temperatures (as indicated by the edge fuel assembly temperature, location 1A). The results for the vacuum case, on the other hand, overpredict the data by 16°C, this time due to overpredicted basket temperatures (fuel assembly location 1A). The disagreement between the predictions and data in these cases is attributed to uncertainties in the cask geometry and contact resistances. A more uniform basket-to-cask thermal resistance value (assumed media dependent) would improve the predictions for all media.

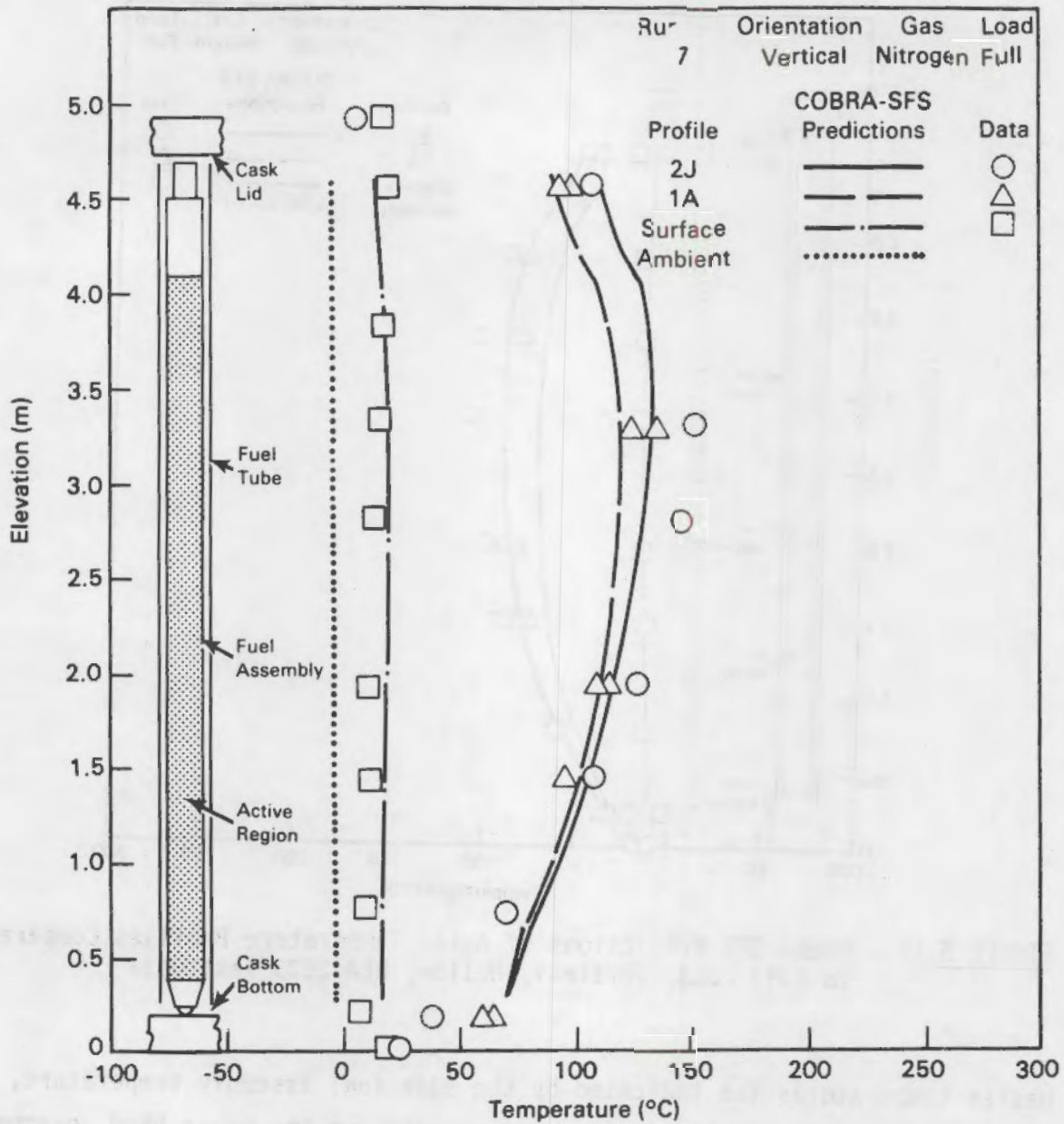


FIGURE 5.19. COBRA-SFS Predictions of Axial Temperature Profiles Compared to Full Load, Vertical, Nitrogen, RIA 2023 Test Data

In general, there is good agreement between the predicted and measured axial temperature profiles. Improvement in the axial profiles in the nitrogen case may be obtained with refinements in the cask flow resistances, or the plenum region heat loss models.

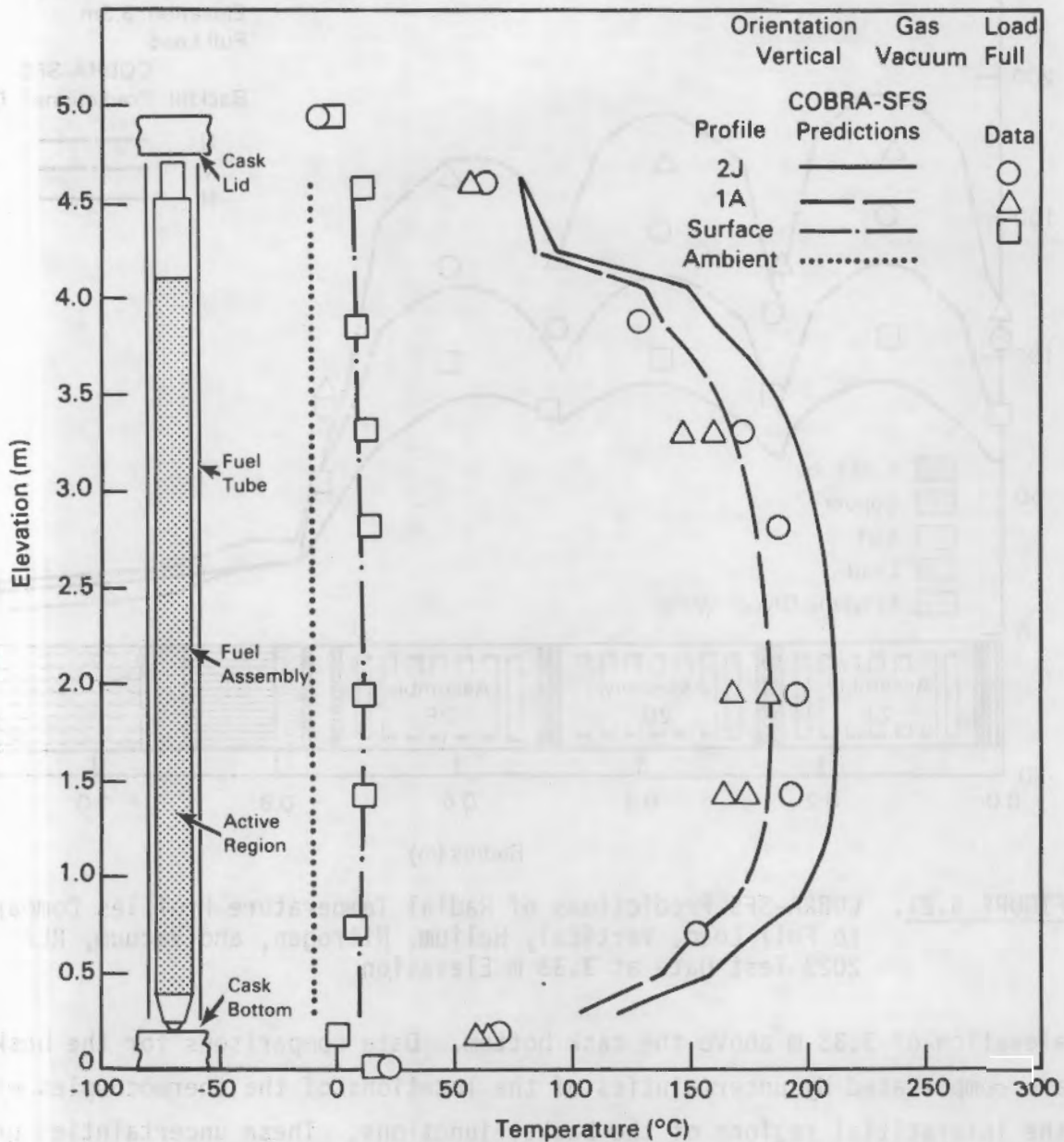


FIGURE 5.20. COBRA-SFS Predictions of Axial Temperature Profiles Compared to Full Load, Vertical, Vacuum, REA 2023 Test Data

Comparisons of the predicted and measured radial temperature profiles along the diagonal of quadrant 2 (Figure 5.14) from the center of the cask to the ambient are presented in Figure 5.21 for all three fill media, at an

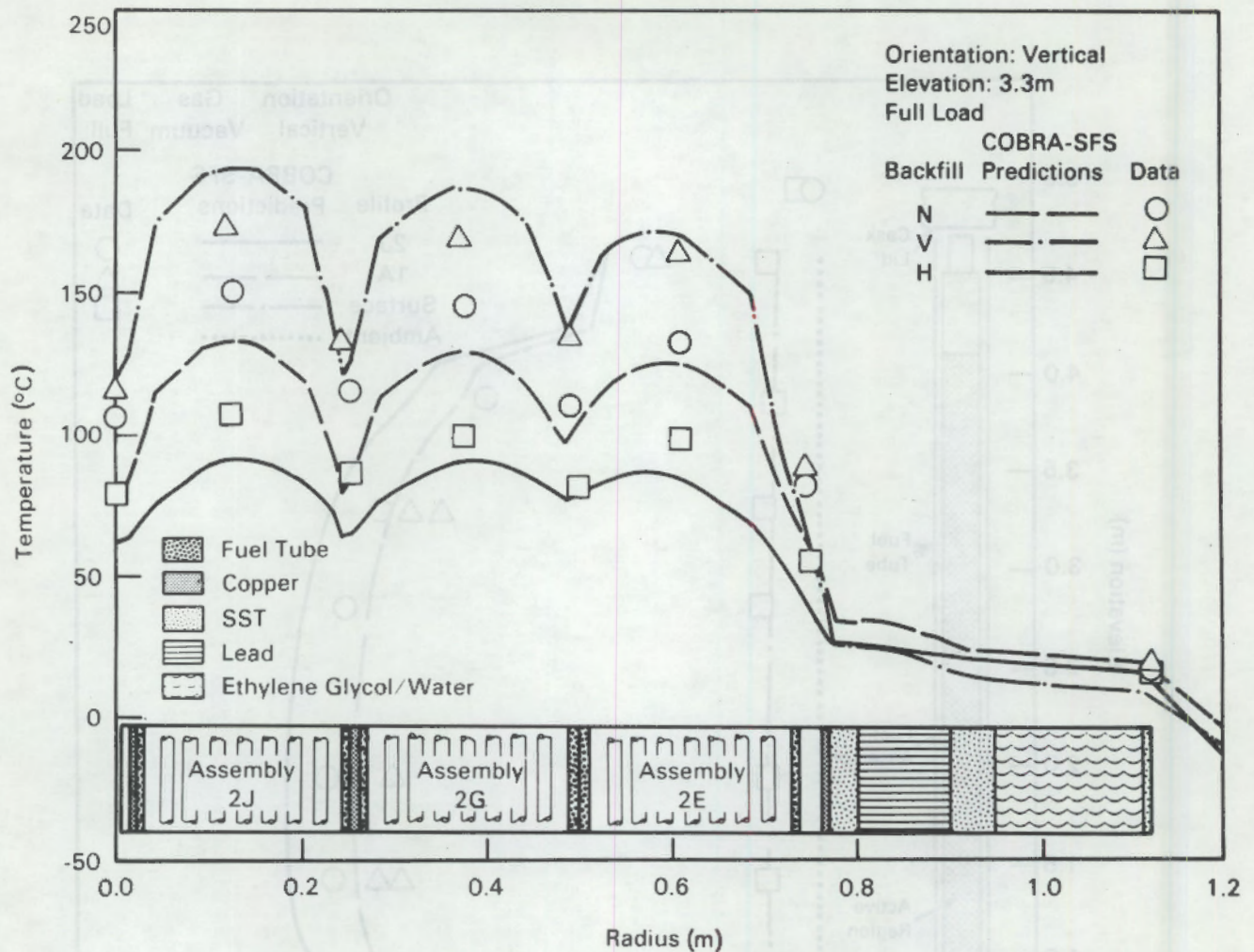


FIGURE 5.21. COBRA-SFS Predictions of Radial Temperature Profiles Compared to Full Load, Vertical, Helium, Nitrogen, and Vacuum, REA 2023 Test Data at 3.33 m Elevation

elevation of 3.33 m above the cask bottom. Data comparisons for the basket are complicated by uncertainties of the locations of the thermocouples within the interstitial regions of the basket junctions. These uncertainties greatly affect data comparisons where radial temperature gradients are severe, i.e., basket node 2E (Figure 5.14). For lack of alternative information, thermocouples were assumed to measure interstitial gas temperatures, thereby representing average temperatures of exposed junction surfaces. The predicted results, on the other hand, are given for the copper strips along the diagonal of the basket junctions, which, because of their high thermal conductivity

and connection to the low temperature of the gas exterior, are at substantially lower temperatures than the surrounding junction walls. As a result, code predictions fall consistently below the data at the basket locations, as expected.

The radial profiles shown in Figure 5.21 indicate trends similar to axial profile results--underpredicted helium and nitrogen results, and overpredicted vacuum results. Correcting the agreement between predictions and data at the basket/cask interface (radial location $r/R = 0.75$) would be expected to improve the predictions for locations within the basket, and more importantly, peak clad temperature. The trend toward increasing assembly temperatures with decreasing radial position in the cask was correctly predicted by COBRA-SFS.

5.3 TN-24P CASK PERFORMANCE TEST

In this test series, the thermal performance of a fully loaded (21 kW total) TN-24P cask was investigated with three backfills (helium, nitrogen, and vacuum) in vertical and horizontal orientations. Experimental temperature data were recorded at several axial and radial positions within the cask for a 6-run test matrix. COBRA-SFS prelook and post-test simulations of the entire test series have been documented previously (McKinnon et al. 1986a) and will not be repeated here. To demonstrate the ability of COBRA-SFS to predict the effect of orientation in a multiassembly cask, results of vertical and horizontal cases with a helium backfill are presented and compared against the test data.

In the following sections, a description of the TN-24P cask and cask performance test is presented, along with a description of the COBRA-SFS computational model, assumptions, and correlations employed. Uncertainties in the model are then discussed, followed by predictions of the two selected cases. Listings of the input, representative output, and convergence lists for the reported cases are presented in Appendix F.

5.3.1 TN-24P Cask and Test Description

The cask body is a one piece cylindrical structure composed of forged steel. The overall external dimensions of the cask body are 5068 mm (16.6 ft)

long and 2281 mm (7.5 ft) in diameter as shown in Figure 5.22. All surfaces except sealing surfaces are coated with a deposit of zinc-aluminum alloy. Sealing surfaces are clad with stainless steel. Internal surfaces have an aluminum titanium oxide overcoat; exterior surfaces are covered with white silicone paint.

The cask body consists of a 270-mm-thick (10.6-in.) cylindrical shell welded to a 280-mm (11-in.) bottom plate. A neutron shield containing L-shaped copper plates is welded to the cylindrical shell. The copper plates are welded to the inner surface of the neutron shield and provide enhanced heat conduction through the resin compound of the neutron shield. The cask can accommodate six bolted trunnions for handling and tie-down, four near the top and two near the bottom. Finally, the cask body has an instrumentation orifice sealed by a metallic gasket.

The diameter of the inner cavity is 1455 mm (57.3 in.), and the overall inner cavity length is 4150 mm (163.4 in.). Precision-machined surfaces are provided at the open end of the cask cavity for positive gasket sealing, and bolt holes are included at these locations to secure the cask lid and protective cover.

The basket comprises an array of 24 fuel tubes and channels that provide structural support and positive positioning of the fuel assemblies. The basket, shown in Figure 5.23, is composed of stacked interlocking plates constructed of borated aluminum. The plates are 10 mm (0.4 in.) thick, 160 mm (6.3 in.) wide, and vary in length depending on their position in the basket. Each layer of the basket is bolted to four uprights that are used to support and tie the basket together in the axial direction. The uprights provide a 45-mm (1.8-in.) gap between the bottom of the basket and the bottom of the cask. This gap, plus the 29-mm (1.1-in.) gap between the top of the basket and the cask lid, provides convection paths for the gas in the cask. The basket overall height is 4121 mm (162.2 in.). The position of the basket within the cask is maintained by bars welded to the interior surface of cask. The bars act as guides for the interlocking plates.

Two aluminum tubes are welded to the aluminum basket in two locations that are unoccupied by fuel. The tube locations match penetrations in the

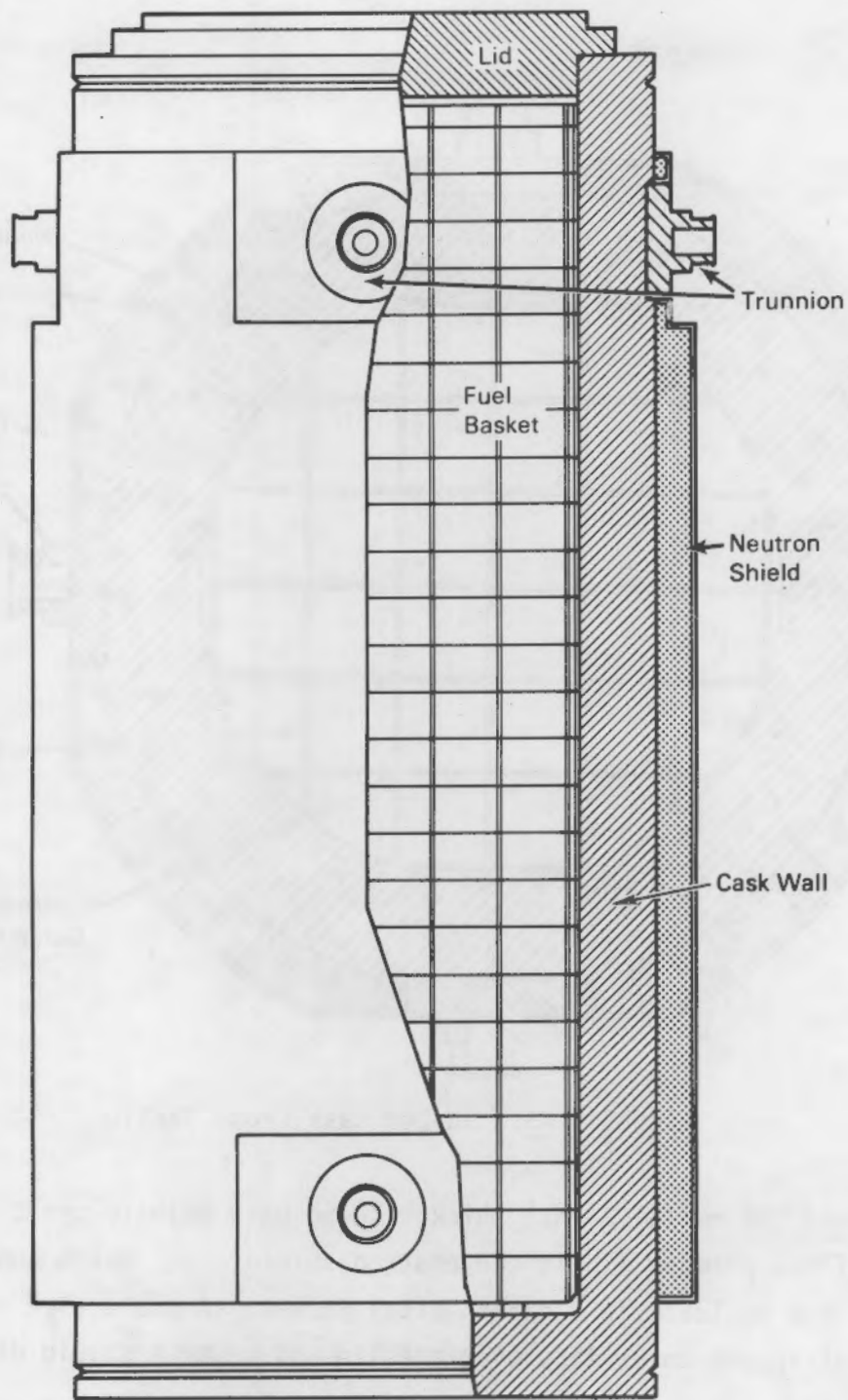


FIGURE 5.22. TN-24P PWR Spent Fuel Storage Cask

lid used to insert thermocouple lances and provide temperature readings representative of the basket. A carbon steel lid, 1720 mm (67.7 in.) in

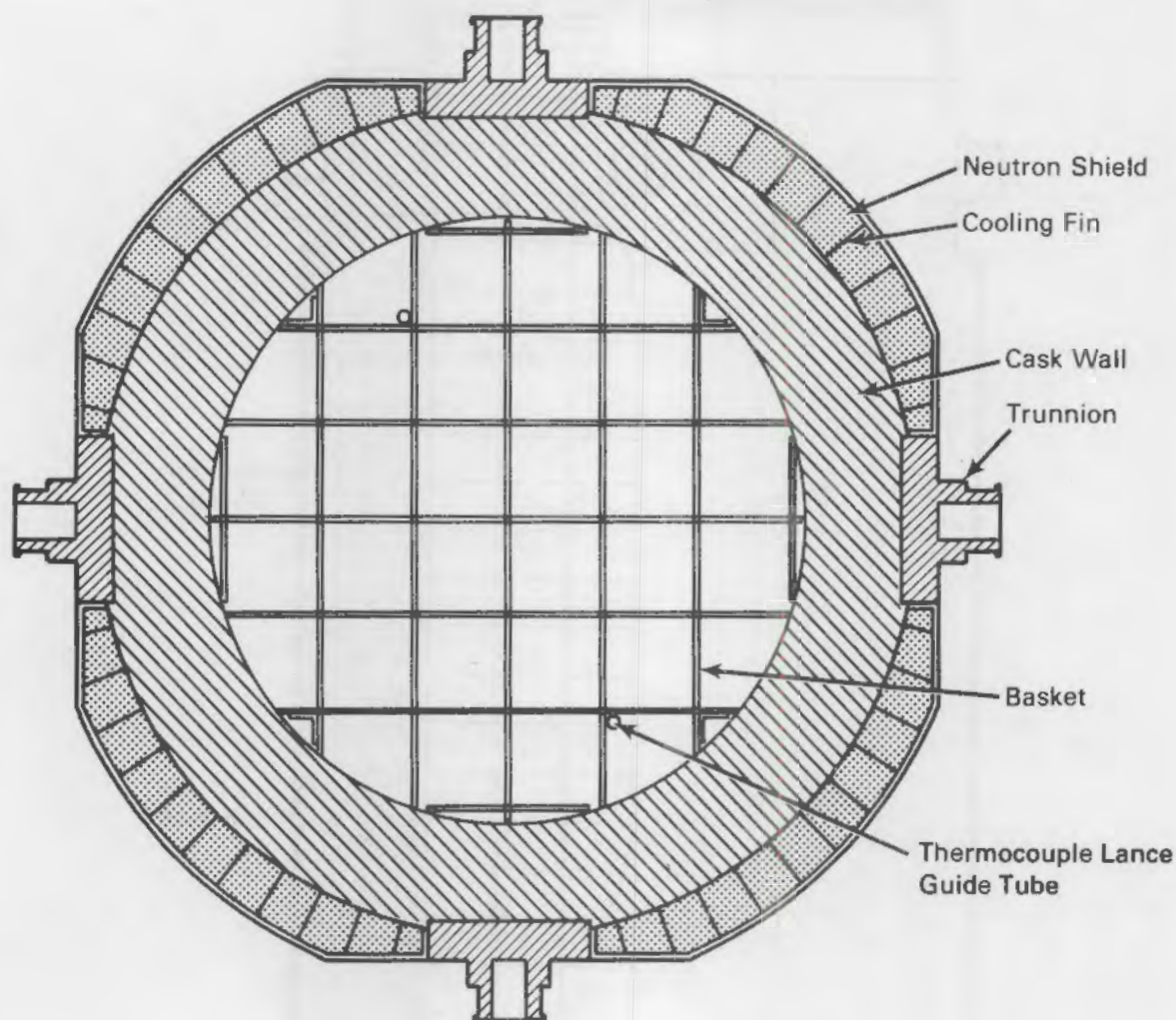


FIGURE 5.23. TN-24P Cask Cross Section

diameter and 285 mm (11.2 in.) thick, is the cask primary seal. Bolted to the top of the primary lid is the neutron shield disc, which contains granular polypropylene enclosed in a carbon-steel jacket. A protective carbon-steel, ellipsoidal-shaped cover fits over the lid and neutron shield disc and acts as a secondary seal.

Fourteen type K thermocouples were permanently attached to the inner wall and basket of the cask, as indicated in Figure 5.24. An additional 54 thermocouples were inserted in the fuel assemblies and basket using thermocouple lances. Each lance had six thermocouples installed at various axial positions

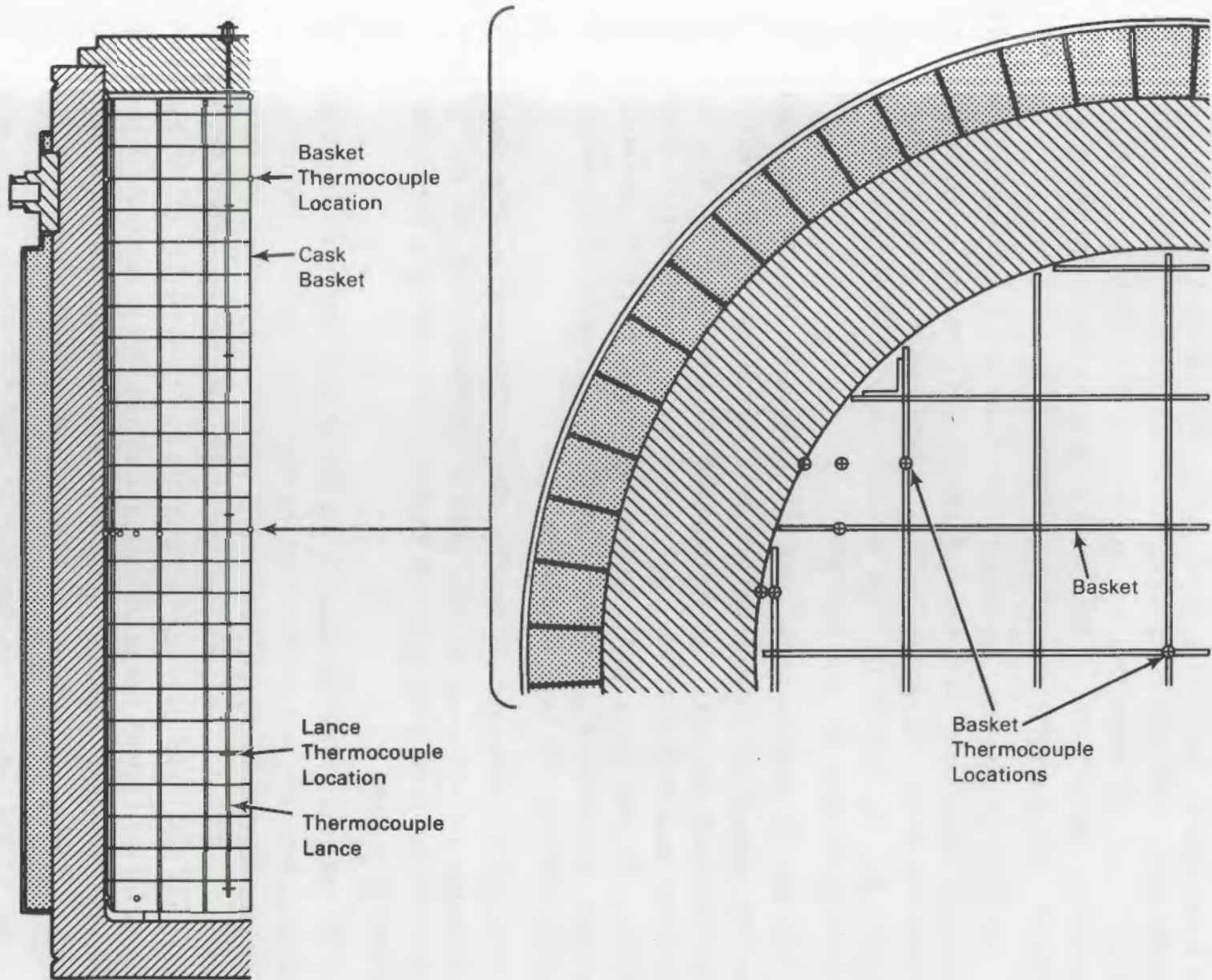


FIGURE 5.24. TN-24P Basket Thermocouple Locations

in a 8-mm-diameter (0.315-in.) tube. Lances were inserted through instrumentation penetrations in the primary test lid and into selected guide tubes of seven fuel assemblies and into two simulated guide tubes attached to the basket. The locations of the lances within the basket and their positions within the fuel assemblies are shown in Figure 5.24.

The selected axial and cross-sectional locations of the lance thermocouples facilitated redundancy, evaluations of temperature symmetry, and determinations of axial and radial temperature profiles in both vertical and horizontal orientations. In addition to these internal temperature measurements, the cask cavity pressure was also recorded.

The exterior surface of the cask was instrumented with 35 iron/constantan Type J thermocouples. Only during horizontal testing were thermocouples placed on the bottom of the cask. The thermocouple patterns on each surface were selected to provide appropriate axial, radial, and circumferential temperature profiles. In addition, a small, self-contained weather station measured the wind speed and direction, atmospheric pressure, air temperature, precipitation, relative humidity, and solar insolation.

Temperature uncertainties for the internal thermocouple lance temperature measurements are $\pm 4^{\circ}\text{C}$, and external temperature measurements are $\pm 4.5^{\circ}\text{C}$ based on the combined uncertainties of the thermocouples, extension wires, and data acquisition system.

The PWR fuel assemblies used in the TN-24P cask performance test were discharged from Virginia Powers Surry Nuclear Power Station. The fuel assemblies were of the Westinghouse 15x15 design and contained 204 fuel rods, 20 control rod guide tubes, and one instrument tube per assembly. Seven grid spacers and upper and lower nozzles maintain the square array of the assembly. The ends of the control rod guide tube are bolted to the upper and lower nozzles to provide structural support. Axial and cross-sectional views of the 15x15 PWR fuel assembly are presented in Figures 5.25 and 5.26, respectively.

The ORIGEN2 computer code was used to predict the decay heat generation rates of the Surry spent fuel assemblies. The results of these calculations for the 24 assemblies used during performance testing are presented in Table 5.9

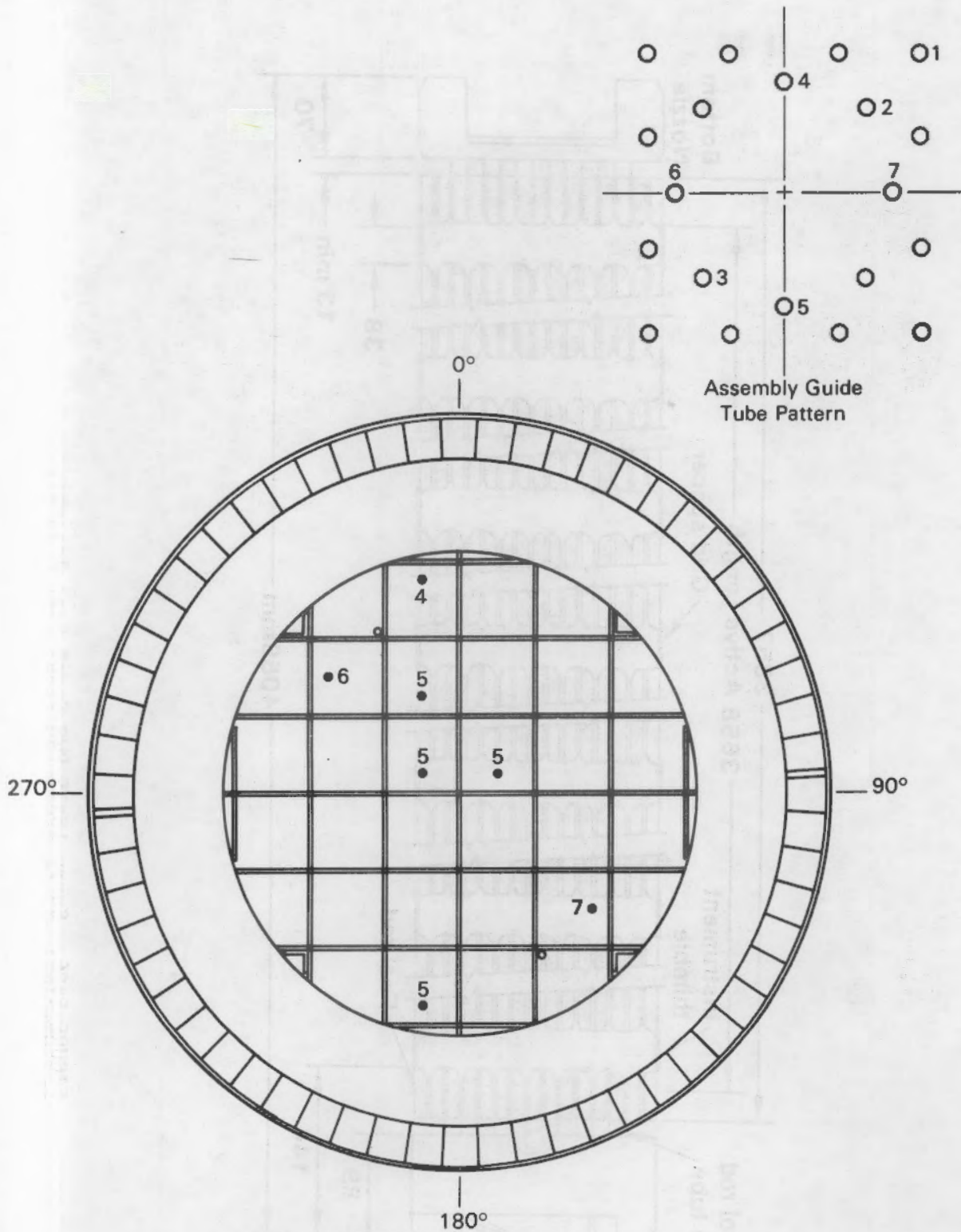


FIGURE 5.25. TN-24P Thermocouple Lance Locations

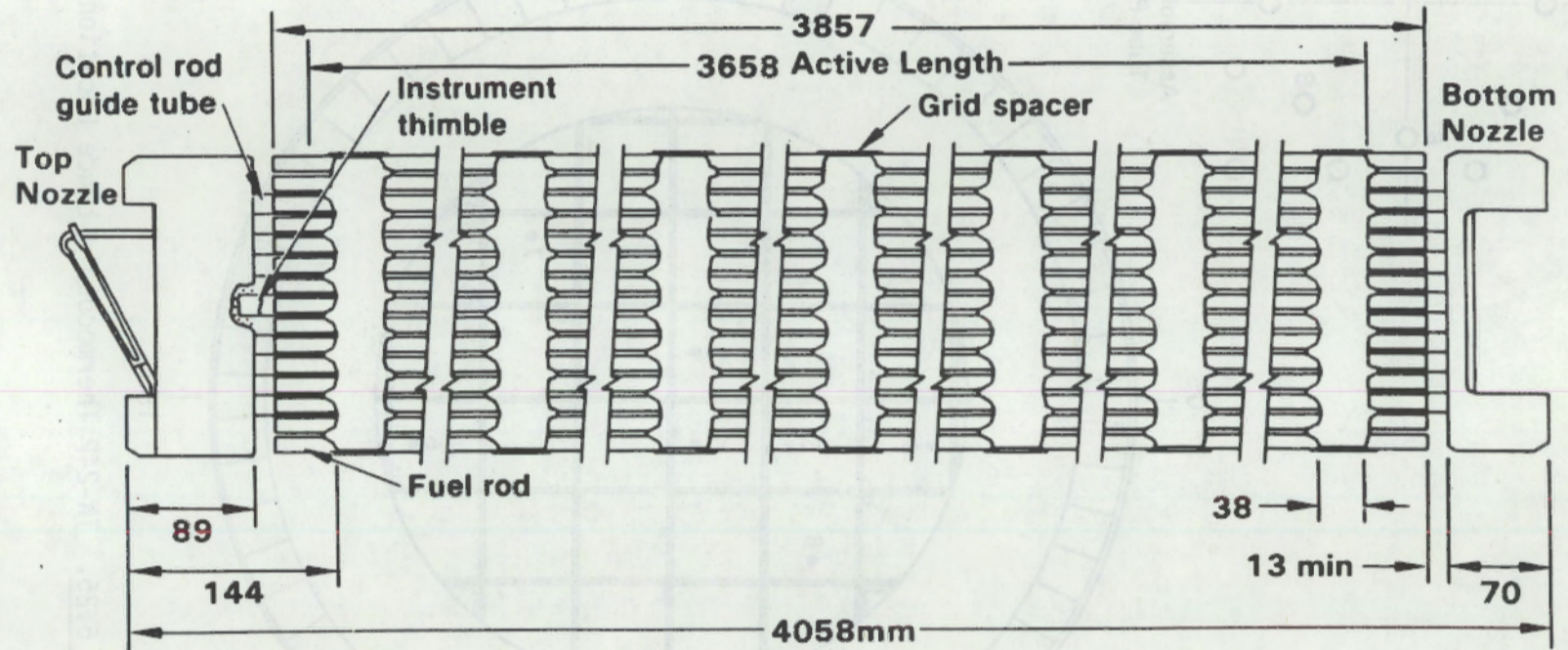


FIGURE 5.26. Surry 15x15 PWR Spent Fuel Assembly

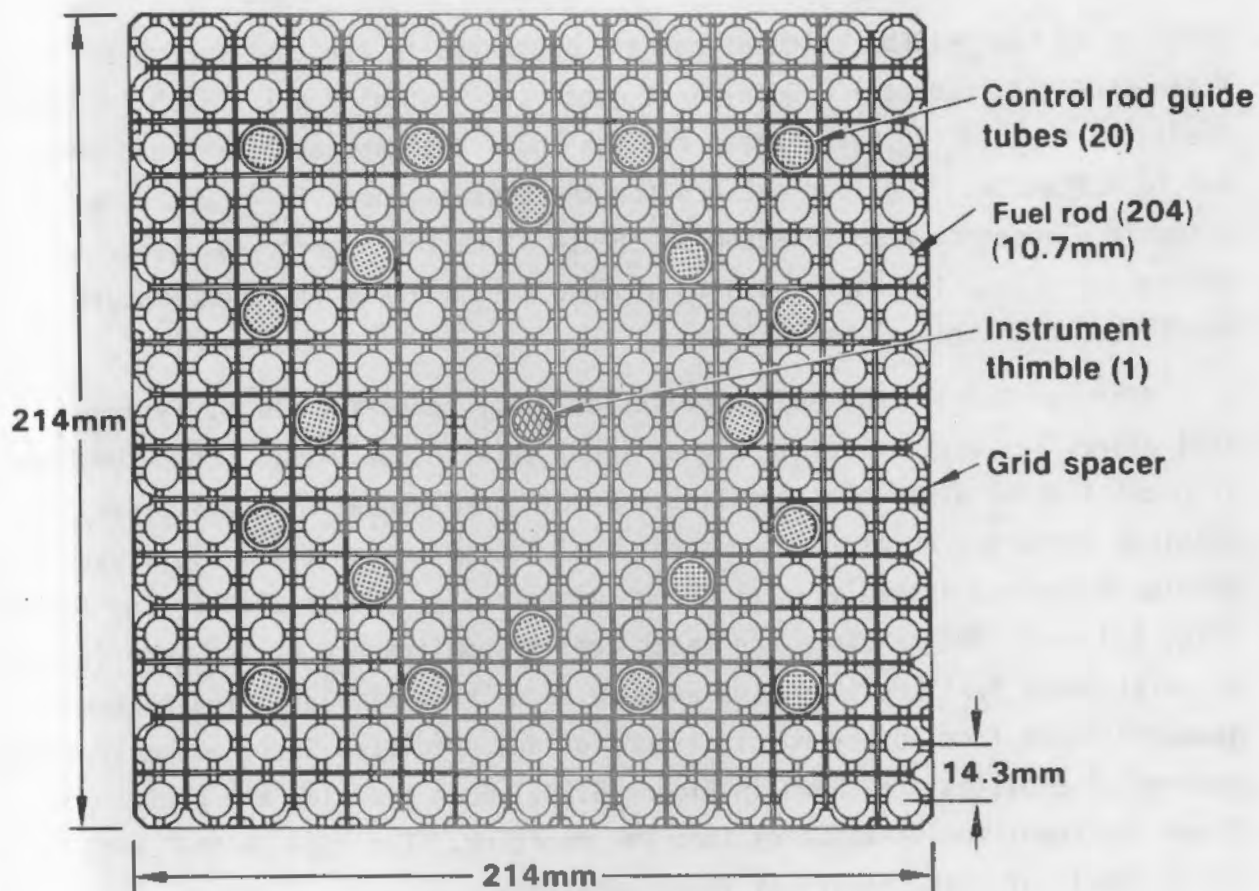


FIGURE 5.27. Surry 15x15 PWR Spent Fuel Assembly Cross Section

TABLE 5.9. Surry PWR Spent Fuel Characteristics

Assembly	Burnup (Gwd/MTU)	Cooling Time (months)	Initial Enrichment (wt%)	Decay Heat Prediction (W)	
				Start 1/14/86	End 2/06/86
W02, W10, W16, W19 W23, W45, W49	29.8	50.3	3.2	845.5	832.3
W01, W17, W21, W38 W44, W46, W52	30.0	50.3	3.2	852.0	839.0
W06, W13, W27, W34	30.5	50.3	3.2	859.0	846.0
V03, V10, V16, V26	30.5	50.3	3.0	870.0	856.5
V18, V22	31.5	50.3	3.0	919.2	905.0

(details of the ORIGEN2 calculations are presented in the test report by McKinnon et al. (1986a)). Decay heat generation rates of all assemblies were predicted to total 20.6 kW; rates for the individual assemblies ranged from 830 to 919 watts. The load pattern for the cask is shown in Figure 5.28. Assembly placements were selected to create a quarter symmetry of heat generation within the basket and to produce a relatively flat temperature profile across the fuel assemblies.

Measured axial decay heat profiles or gamma scans for the Surry spent fuel assemblies were not available as input data to the ORIGEN2 computer code to predict axial decay heat profiles. Axial gamma radiation scans previously obtained on Turkey Point reactor spent fuel assemblies were therefore used to develop a typical assembly axial burnup distribution (Davis 1980). The Turkey Point and Surry PWR reactors and spent fuel assemblies are of the same designs so axial decay heat profiles were assumed to be very similar. The measured gamma activity from Turkey Point assemblies and predicted Surry assembly decay heat axial profiles are shown in Figure 5.29. Both profiles are typical of those for spent fuel assemblies from PWR reactors. The dips in the profiles are a result of grid spacers at those locations.

The TN-24P cask performance test consisted of the six runs indicated in Table 5.10. The test runs involved a fully loaded cask (21 spent fuel assemblies), three backfill media (vacuum, nitrogen, and helium), and two cask orientations (vertical and horizontal).

5.3.2 Computational Model Description

The TN-24P cask was analyzed using two different three-dimensional models. A one-eighth section model was used to investigate the cask thermal performance in a vertical orientation, while a one-half section model was used to analyze the cask when in a horizontal orientation. The smaller, computationally less expensive model was designed for cases in which the cask internals are centered within the cask, an assumption that applied only in the vertical orientation. For the horizontal orientation, previous experience (Wiles et al. 1986) has shown the importance of modeling the basket shift within the cask body and the effect of eccentrically located fuel assemblies within the basket fuel tubes. For this reason, the one-half symmetry model was also developed.

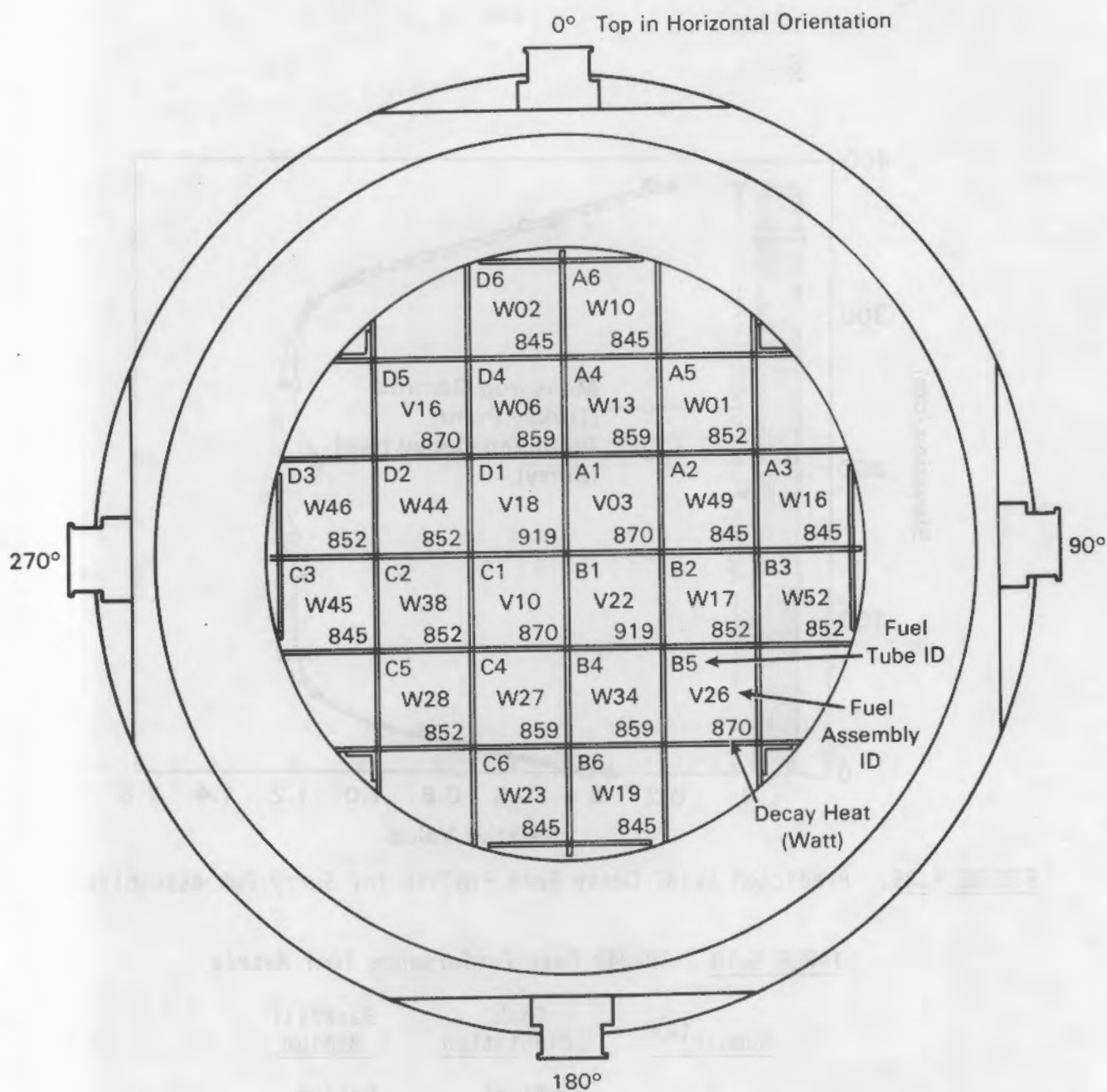


FIGURE 5.28. Spent Fuel Loading Pattern - TN-24P Cask Performance Test

Descriptions of the noding arrangement for the one-eighth sector model are presented below, followed by the one-half symmetry model. Details of the boundary specifications and properties used are then given along with a discussion of the modeling uncertainties.

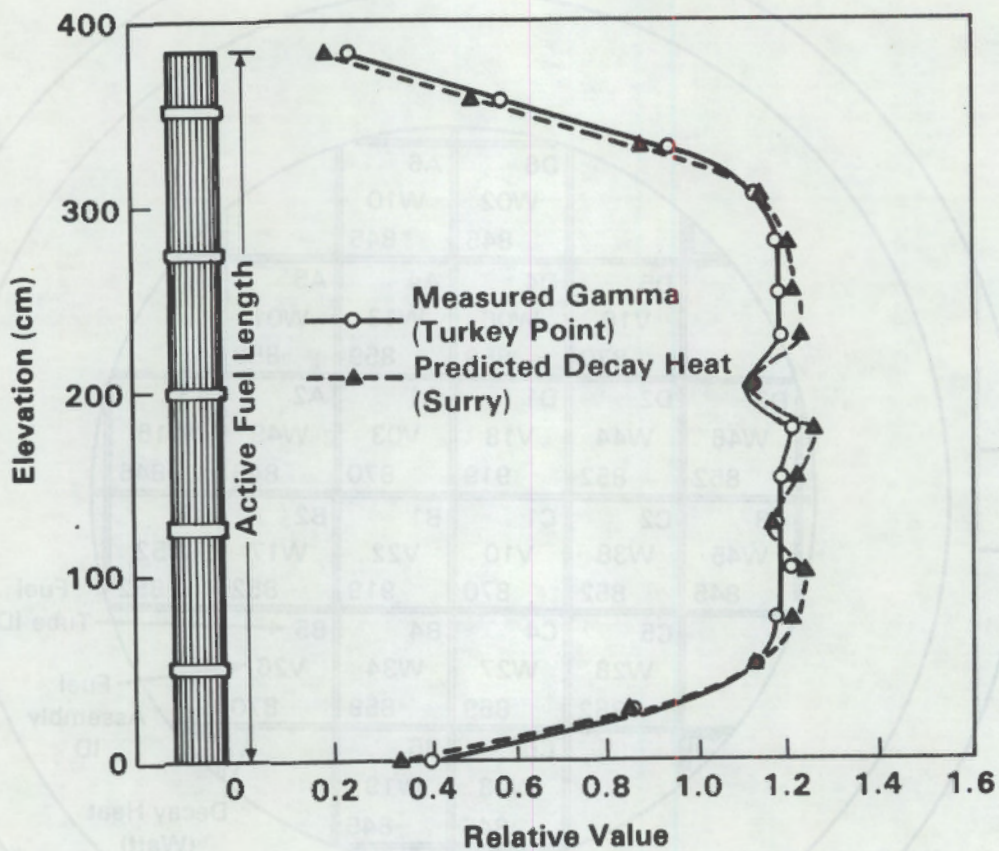


FIGURE 5.29. Predicted Axial Decay Heat Profile for Surry PWR Assemblies

TABLE 5.10. TN-24P Cask Performance Test Matrix

Number (a)	Cask Orientation	Backfill Medium
1	vertical	helium
2	vertical	nitrogen
3	vertical	vacuum
4	horizontal	helium
5	horizontal	nitrogen
6	horizontal	vacuum

(a) All runs were performed with a fully loaded cask (21 assemblies).

5.3.2.1 Nodal Representations

Both the COBRA-SFS one-eighth and one-half section models consisted of 18 uniform axial levels as depicted in Figure 5.30. For the one-eighth section model, each axial level comprised 51 wall nodes, 386 subchannels, and 450 rod nodes. A planar cross section of the one-eighth sector model illustrating the wall noding employed is shown in Figure 5.31.

The wall nodes included 27 basket nodes, 12 cask body nodes, 4 neutron shield nodes, and 8 cask shell nodes. The four outermost shell nodes are zero-thickness nodes that represent the cask surface temperature for the purpose of accurately calculating the contribution of radiation and convection heat transfer to the environment.

One of the lines of symmetry used to define the one-eighth section model runs through two of the basket fuel tubes. Fuel assemblies in these locations were modeled using individual fuel rods for a total of 120 rods. This representation, along with the layout of the 136 fluid subchannels used to describe the flow for the one-half fuel assembly, is shown in Figure 5.32. In the noding of full assemblies, the flexibility of the COBRA-SFS subchannel approach was used to selectively lump the rods and lump the channels to decrease the size of the computational model, as displayed in Figure 5.33. The 225 individual rods were represented by 105 lumped rods and the flow area within the assemblies was modeled by 57 lumped channels. To determine the rod lumping scheme, a simulation of an unlumped assembly was performed to determine the rod temperature distribution. From this simulation, a lumping pattern was then developed. Previous work (Rector, Cuta, and Lombardo, 1986) demonstrated the validity of combining rods with similar surface temperatures to form a single rod surface node. To facilitate data comparisons with thermocouple measurements, thermocouple lance locations were individually modeled as shown in Figure 5.33.

An expanded model was necessary to account for asymmetries in heat transfer paths that occurred when the cask was rotated into a horizontal orientation. The asymmetries resulted from two effects: 1) the unconstrained basket shifting downward to contact the lower inner cask surface, and 2) the fuel assemblies shifting within the basket fuel tubes. The one-half section model that accounts

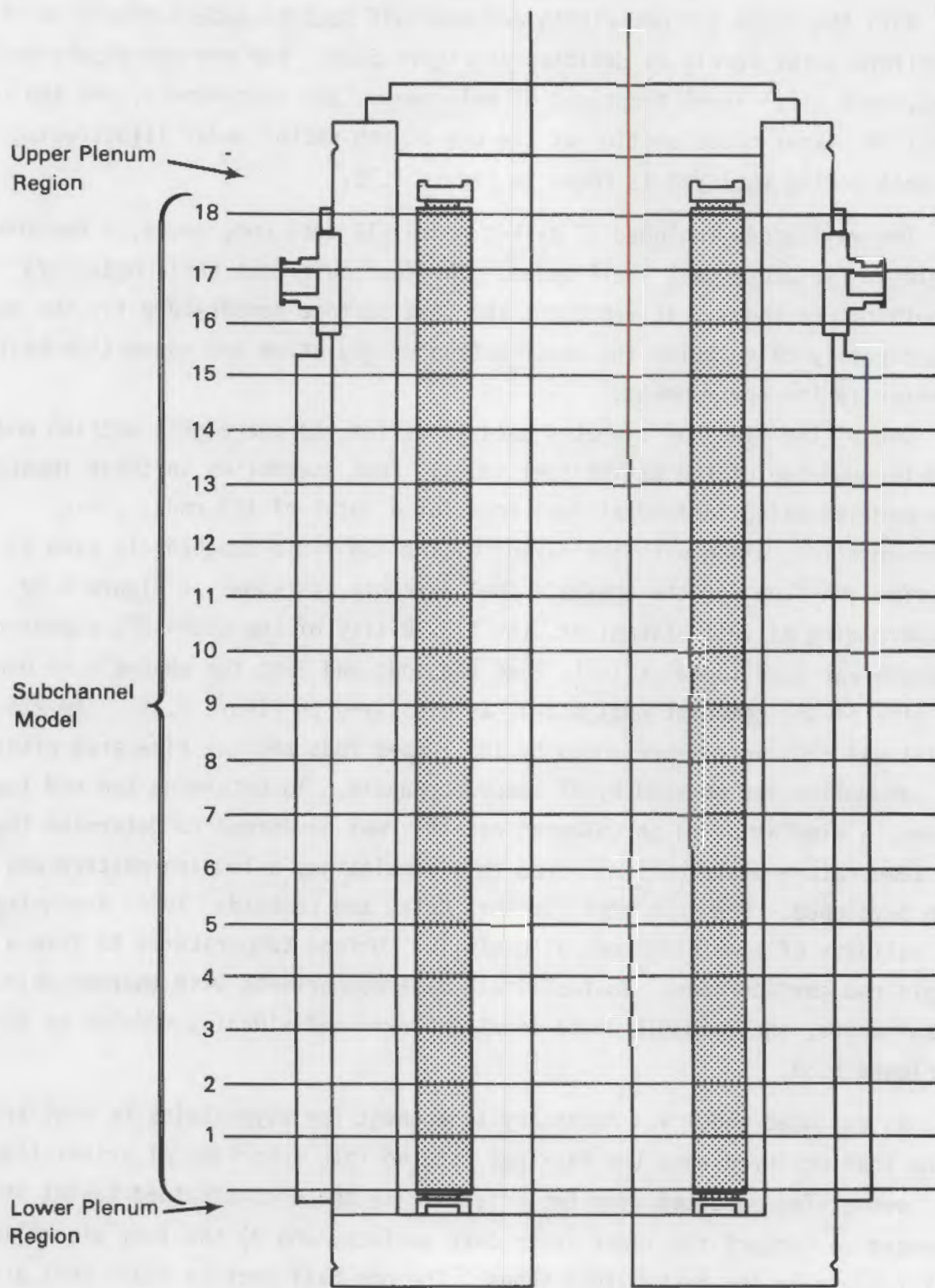


FIGURE 5.30. COBRA-SFS Axial Noding Scheme for the One-Eighth and One-Half Section Models of the TN-24P PWR Cask

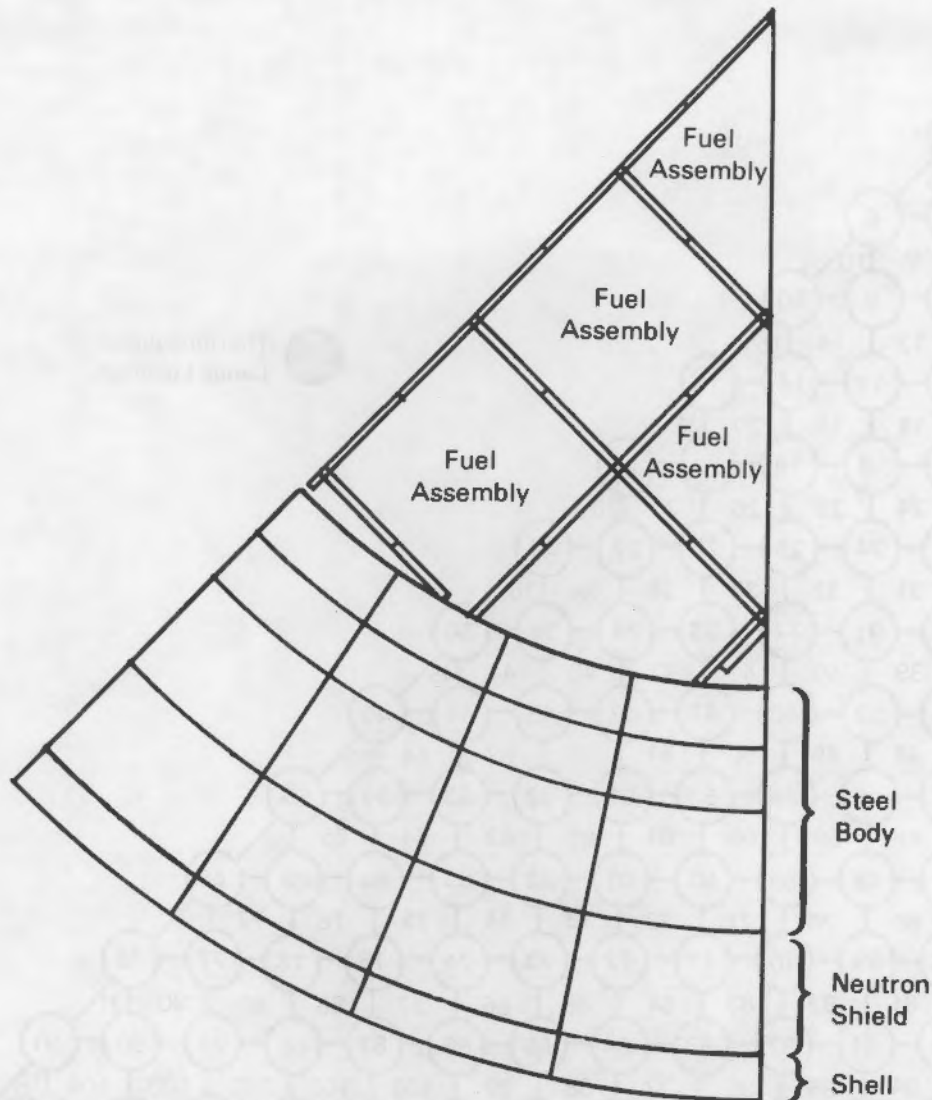


FIGURE 5.31. COBRA-SFS One-Eighth Section Model of the TN-24P PWR Cask Model for the TN-24P Cask Performance Test

for these effects is presented in Figure 5.34. In this model, 191 wall nodes were used at each axial level; 95 of which were basket nodes, 48 were cask body nodes, 16 were neutron shield nodes, and 32 were cask shell wall nodes. All of the fuel assemblies in the one-half section model were represented by the same lumping logic as used in the one-eighth section full fuel assembly representation.

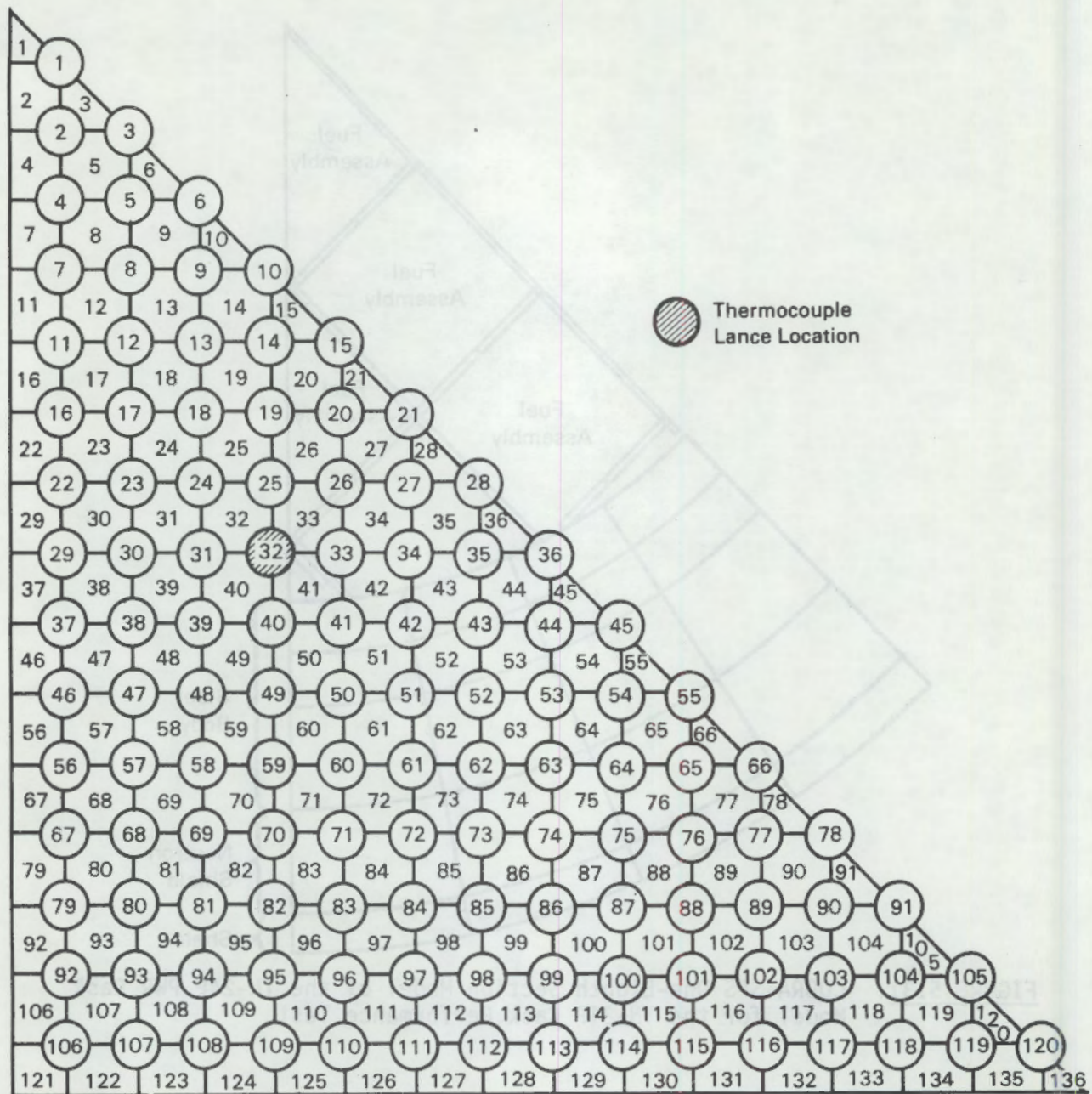
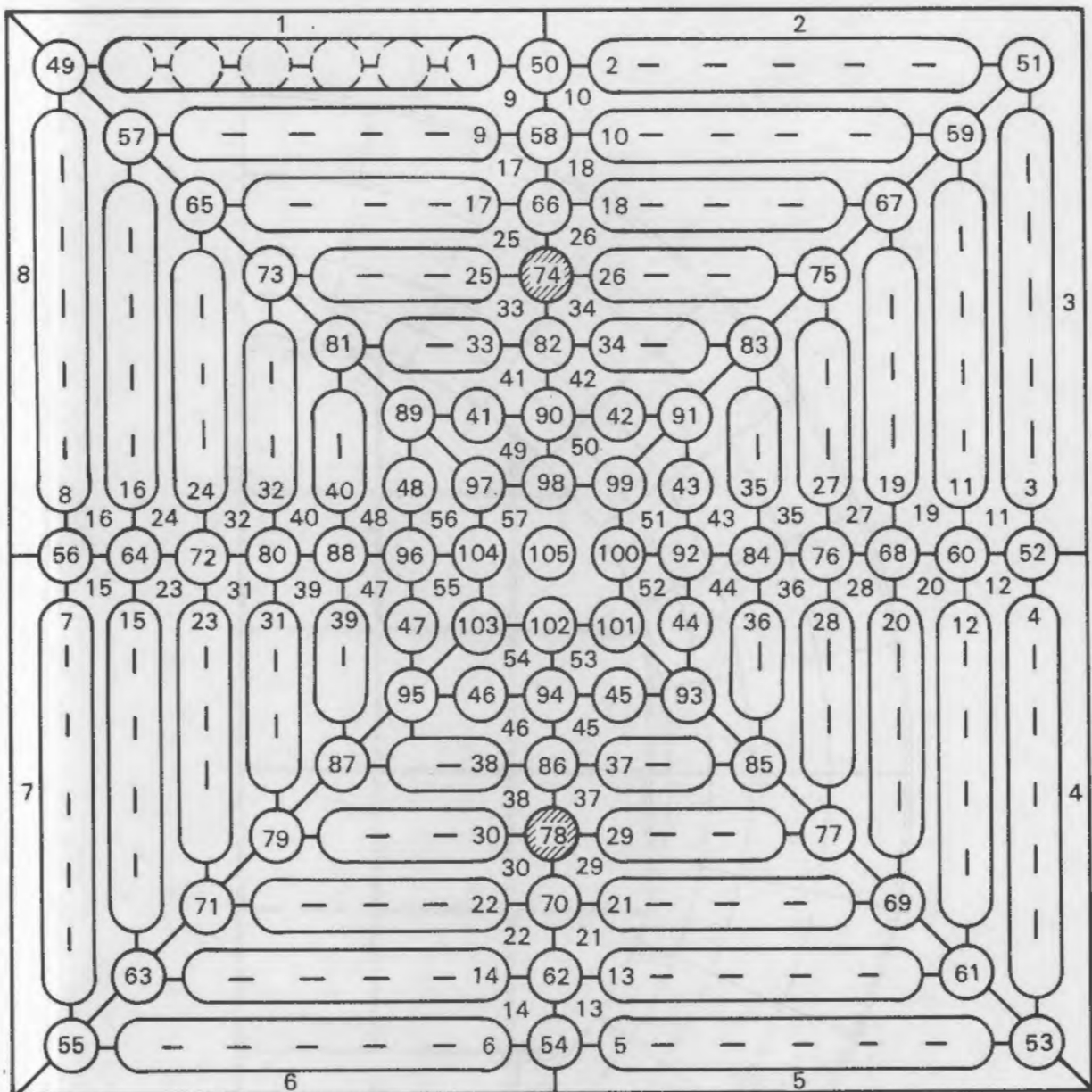


FIGURE 5.32. Half Assembly Subchannel and Rod Noding Scheme for the One-Eighth Section Model of the TN-24P PWR

Conduction heat transfer in the walls was modeled in the radial, circumferential, and axial directions via an input specification of thermal resistances between neighboring nodes. Each thermal resistance can reflect any combination of parallel and/or series resistance paths. An example of such a composite resistance in the TN-24P analyses is the polyethylene resin




 TC Lance Location

FIGURE 5.33. Lumped Rod and Channel Assembly Noding Scheme for the TN-24P PWR Cask

and copper fins, which formed the side neutron shield. In this region, a resistance was calculated that represented the two parallel paths through the shield.

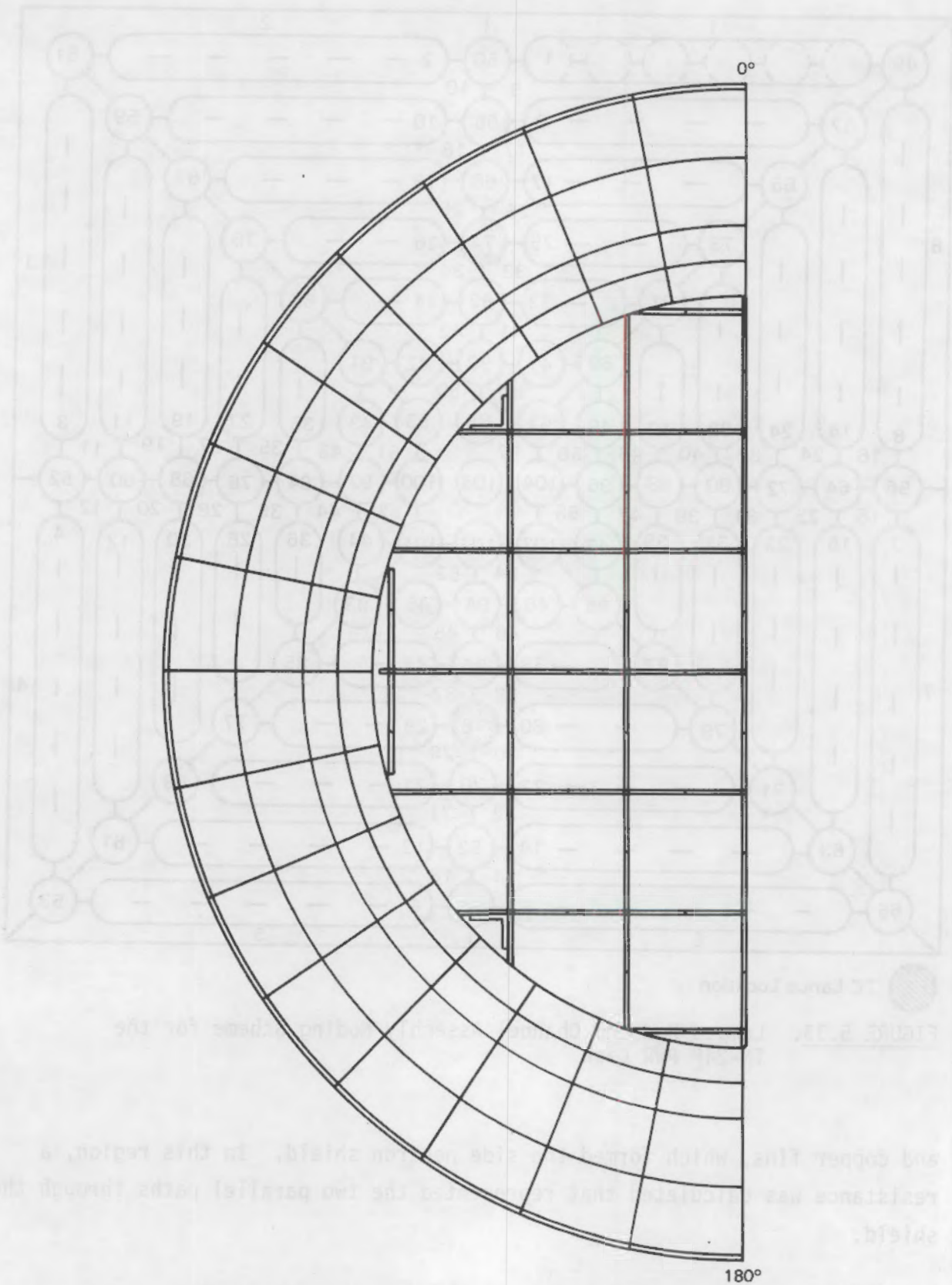


FIGURE 5.34. COBRA-SFS One-Half Section Model of the TN-24P PWR Cask

Axial and radial conduction in the aluminum basket was also accounted for. The dominating resistance in the radial conduction path resulted from the gap between the aluminum basket and the inner cask wall. This resistance was calculated through an iterative procedure in which 1) the average basket temperature was predicted, 2) the expansion of the basket was calculated, and 3) the gap resistance was predicted. Iteration on this term was necessary as the average basket temperature was directly related to the gap resistance.

Radiation heat transfer was treated on an assembly-by-assembly basis. In each enclosure containing a PWR fuel assembly, rod-to-rod, rod-to-wall, and wall-to-wall radiative heat transfers were modeled by specification of graybody exchange factors. The exchange factors for the fuel rods and walls were developed using one-quarter pin surface segments to define the radiation view factors. Radiation exchange in the empty enclosures, which consisted of either basket walls or basket walls and inner cask walls, was determined using wall-to-wall view factors. The COBRA-SFS code used these factors along with appropriate emissivities to calculate the graybody exchange factors.

5.3.2.2 Modeling Parameters, Correlations, and Material Properties

Resistances to flow included surface friction from the rods and walls, and irreversible losses from the grid spacers and assembly inlet and outlet nozzles. Surface friction for all channels was approximated using a friction factor of the form $f = 100/Re$, which was derived for a square rod array with pitch to diameter ratios typical of PWRs. Loss coefficients for the spacers and inlet and exit nozzles had specified values of 1, and 1.5, respectively.

Convective heat transfer from the rod and wall surfaces to the fluid was described using a film coefficient having the form $Nu = 3.66$ (Kays and Crawford 1980). This correlation is the analytical solution of the energy equation for a constant temperature and fully developed temperature and velocity profiles in a circular tube. Fluid-to-fluid conduction between adjacent subchannels was also accounted for.

Heat transfer from the cask surface to the ambient included convection, conduction, and radiation heat transfer. As described earlier for the CASTOR-1C and REA 2023 cask simulations, use of standard correlations to define the convective heat transfer from the casks results in an underpredicted heat

transfer coefficient and, therefore, overpredicted cask surface temperatures. To facilitate the data comparisons presented here, the convective correlations were increased to provide similar predicted and measured cask surface temperatures. For details on the convective correlations employed in the analysis, refer to McKinnon et al. 1986a.

In the vertical orientation cases, the cask was placed on a rail car. The cask bottom boundary condition assumed no natural convection, only conductance through the rail car. Heat transfer from the rail car to the ambient air was specified by a heat transfer coefficient of the form, $Nu = 1.0$, or $h = k/D$, where D was half of the distance between the rail car and the ground and k was the conductivity of nitrogen.

The radiation heat transfer from the top and side outer surfaces to the surrounding environment was a function of surface emissivity and the ambient conditions. The ambient air was assumed to be a black body.

An optional plenum model was used to describe the heat transfer from the recirculating fluid to ambient in the regions immediately above and below the fuel tubes. In the plenum region model, only one-dimensional energy equations are solved. The upper lid was modeled with six nodes; three nodes apiece for the axial and radial directions. For the bottom of the cask, seven nodes were used in the axial direction, four in the radial. The overall heat transfer from the lid and bottom was modeled by specifying the thermal resistance between plenum nodes. Conduction heat transfer between the cask body and lid and the cask body and the bottom is also simulated by the plenum model.

The axial decay heat profile displayed in Figure 5.29 was applied to all of the assemblies. The one-eighth section model incorporated the decay heat rates from quadrant D shown in Figure 5.28. Assembly decay heat rates for the one-half section model were representative of quadrants C and D. A uniform radial decay heat distribution within each fuel assembly was assumed.

The material properties used for the TN-24P model are presented in Table 5.11. All surface emissivities and the greater portion of the solid thermal conductivities were provided by Transnuclear, Inc. The thermal properties of the solids were assumed constant, and properties of fill gases were specified as a function of temperature.

TABLE 5.11. Material Properties for the TN-24P Cask Analysis

<u>Thermal Conductivities (Btu/ft-hr-°F)</u>		<u>Surface Emissivities</u>	
Steel cask body	= 24.0	Fuel rods	= 0.8
Polyethylene resin	= 0.1	Fuel basket	= 0.8
Aluminum basket	= 119.0	Plated cask surfaces	= 0.9
Copper fins	= 218.0	Painted cask surfaces	= 0.9
steel shell	= 24.0	Copper fin surface	= 0.5
Polypropylene	= 0.1		

5.3.2.3 Modeling Uncertainties

The computational model contained a number of uncertainties in cask design and testing information that limited its ability to accurately predict the thermal performance of the TN-24P cask. These uncertainties include the following:

- basket-to-cask-wall gap width
- fuel assembly positioning
- cask boundary heat transfer (convection and conduction)
- decay heat generation rates and axial profiles
- plenum region flow and thermal resistance.

A brief discussion of these uncertainties is presented below.

The aluminum basket was designed to allow thermal expansion in the radial direction; no mechanical connections existed between the inside cask body surface and the basket. To approximate the thermal resistance attributed to the basket-cask gap, an average basket temperature was predicted, a radial expansion calculated, and a new value for the gap determined. This iterative procedure assumed that the basket was originally centered within the cask (for the vertical orientation) and that the basket expanded uniformly.

In the vertical orientation, each fuel assembly was assumed to be centered within the basket fuel tube such that the basket-to-outer rod distance was uniform on all four sides of the fuel assembly, at all axial locations. It is more likely that the assembly is positioned off-center, with varying axial distances to the basket walls.

Natural convection heat transfer from the outside cask surface to the ambient air is difficult to predict accurately. Modifications were made to standard convection correlations to reflect experience gained from previous cask simulations; however, changes to these correlations may be cask-dependent.

The connection between the cask bottom and ambient air was modeled as the sum of two resistances: 1) heat transfer through a simplified model of the rail car, and 2) conduction through stagnant ambient air. This was a simplified approach, with the rail car essentially acting as a fin.

The axial decay heat profile used in the COBRA-SFS analyses was not experimentally determined. Deviations from the true profile may result in substantial differences in predicted and measured temperatures (Rector et al. 1986a).

To account for heat transfer from the lower and upper plenums to the ambient air (through the cask lower and upper lids, respectively), values of the bulk-to-film thermal resistance must be specified. The value of this resistance is expected to be a function of the flow field established within the cask; however, because the flow field in the plenum regions is not calculated, this value is difficult to predict accurately. Furthermore, the gas entering the plenum regions is assumed to be instantaneously mixed and is assumed to be uniform across the cask cross section. In reality, the temperature of the plenum is expected to vary as a function of radial position. The loss coefficients as the fluid flows across the top and bottom of the basket are also difficult to define and were omitted from this analysis. Exclusion of these loss coefficients should result in slightly greater predicted recirculating flows.

5.3.3 Comparisons of Predictions to Data

Axial temperature profiles for the vertical and horizontal helium-filled runs at several positions within the cask are presented in Figures 5.35 and 5.36 respectively. Predicted and measured data are shown as a function of elevation from the cask bottom for four fuel assembly locations (assembly locations D1, D4, D5, and D6 of Figure 5.28), a peripheral basket location (Figure 5.25), the cask surface, and the ambient air. In a comparison of peak temperatures, COBRA-SFS showed excellent agreement with the data, slightly overpredicting the measured peak temperature in both cases by 10°C. Interior cask temperatures were also overpredicted, in part as a result of an overpredicted cask inner wall surface temperature.

In both orientations, good agreement in the shape of the axial profiles was achieved. One interesting trend predicted by COBRA-SFS is the slight shift in the axial profiles for the different cask orientations. This shift is displayed in Figure 5.37, which shows the predicted and measured axial guide tube temperature profiles for the two orientations, along with the ambient temperature. As the cask is rotated from vertical to horizontal, the overall profile is flattened, showing a slight decrease in temperature in the upper elevations, and a slight increase in the lower elevations. It is expected that the modeled shift in basket orientation (to contact the cask wall), the elimination of buoyancy effects, and the removal of the rail car as a heat sink in the horizontal orientation simulations account for the shift in the profiles. It is interesting to note that, with a helium backfill, lower peak temperatures were obtained with the cask in the horizontal orientation, a trend correctly predicted by COBRA-SFS. Again, the success of the COBRA-SFS predictions in the horizontal and vertical orientations displayed above demonstrates the ability of the code to predict the thermal performance of spent fuel storage systems under a wide variety of conditions.

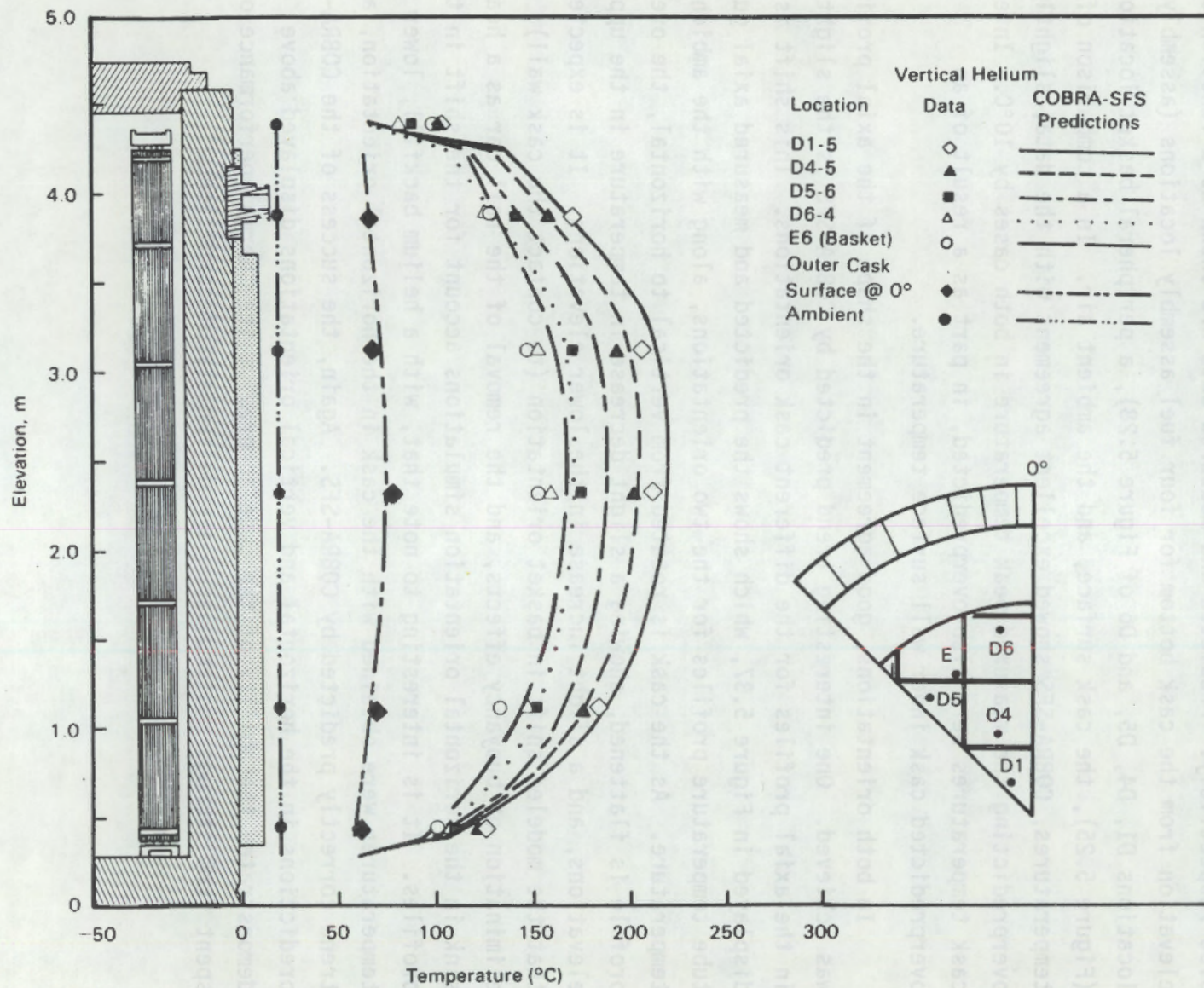


FIGURE 5.35. Comparisons of COBRA-SFS Axial Temperature Profile Predictions with Vertical, Helium TN-24P Test Data

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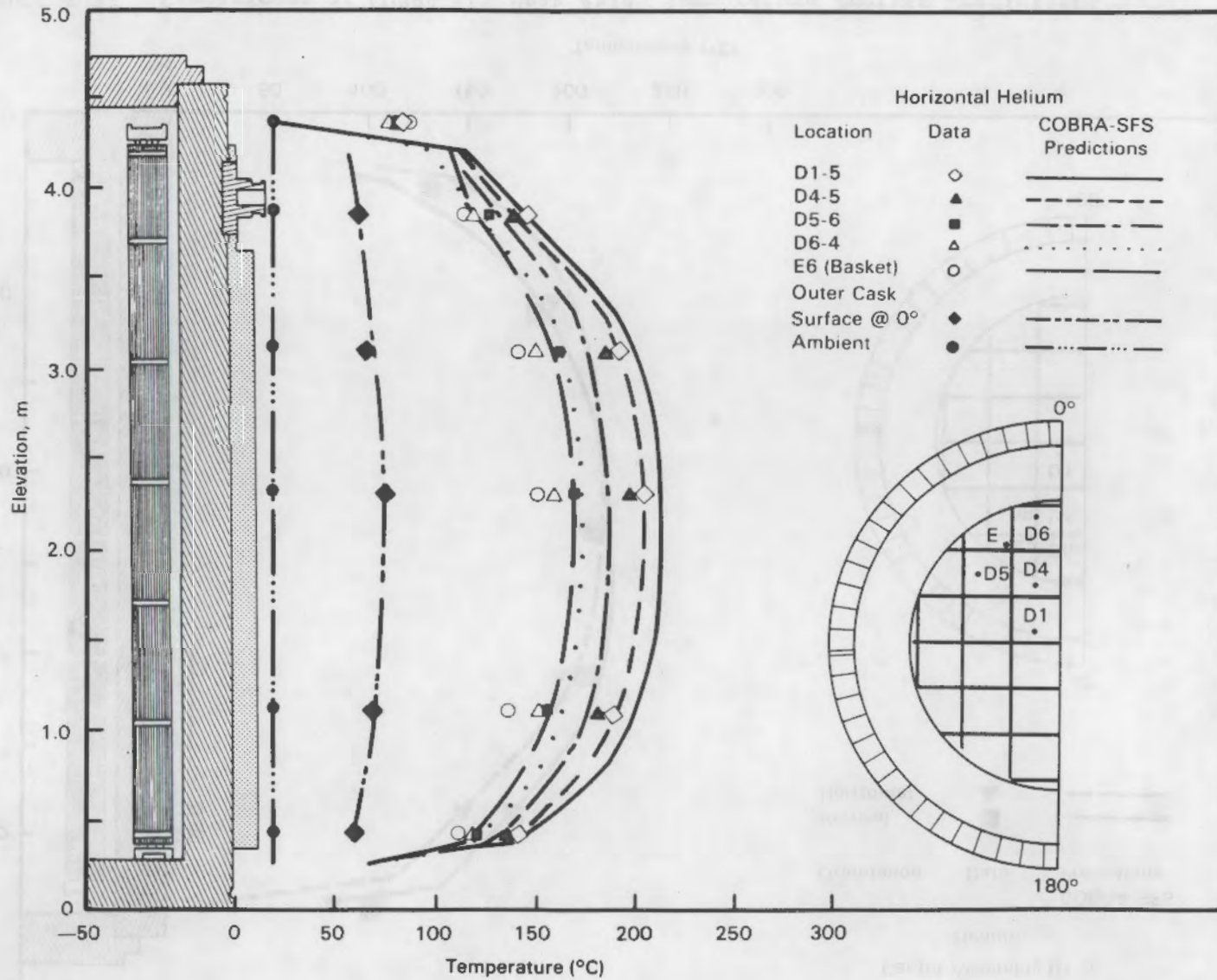


FIGURE 5.36. Comparisons of COBRA-SFS Axial Temperature Profile Predictions with Horizontal, Helium TN-24P Test Data

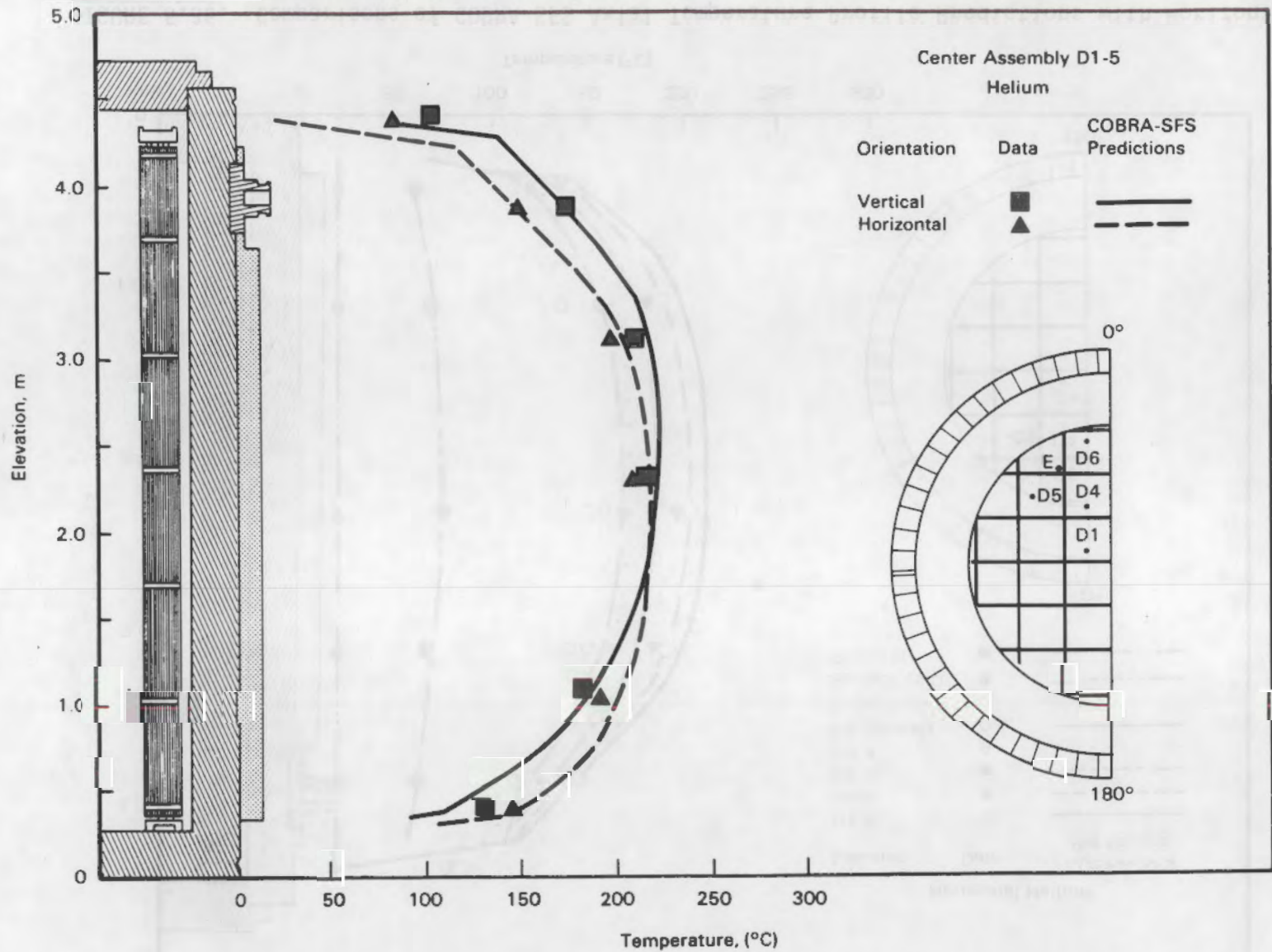


FIGURE 5.37. Comparisons of COBRA-SFS Peak Axial Temperature Profile Predictions with Vertical and Horizontal, Helium, TN-24P Test Data

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APPENDIX A

PWR SINGLE ASSEMBLY SPENT FUEL TEST SIMULATIONS
INPUT, OUTPUT, AND CONVERGENCE LISTS

APPENDIX A

PWR SINGLE ASSEMBLY SPENT FUEL TEST SIMULATIONS
INPUT, OUTPUT, AND CONVERGENCE LISTS

<u>Test Case</u>	<u>Input</u>	<u>Page Number</u> <u>Convergence</u> <u>List</u>	<u>Output</u>
Vertical, helium	A.2	A.3	A.4
Vertical, nitrogen	A.8	A.10	A.10
Vertical, vacuum	A.14	A.16	A.16

-5000

```
1      inhel emad input, validation analyses
prop  7  1
1.      0.      100.0      .0780      1.24      83.33      .0410
2.     200.     340.0      .0970      1.24     119.76      .0533
3.     400.     590.0      .1150      1.24     156.25      .0641
5.     600.     844.0      .1290      1.24     192.31      .0727
10.    800.    1092.0      .1380      1.24     229.36      .0823
15.   1000.   1340.0      .1380      1.24     285.25      .0907
20.   1500.   1580.0      .1380      1.24     357.14      .1130
```

lss304 9.8

```
chan  1  34
153.0  00.0
1  1  29  0  1
1  1  0  0  1
1.0768.7116.4972  2 .141 .563
2.17711.3261.326  3 .141 .563  4 .141 .563
3.0886.6629.6629  5 .141 .563
4.17711.3261.326  5 .141 .563  7 .141 .563
5.17711.3261.326  6 .141 .563  8 .141 .563
6.0768.7116.4972  9 .079 .563
7.15351.423.9943  8 .141 .563  11 .079 .563
8.17711.3261.326  9 .141 .563  12 .141 .563
9.15351.423.9943  10 .079 .563  13 .141 .563
10.0768.7116.4972  14 .141 .563
11.15351.423.9943  12 .141 .563  16 .141 .563
12.15351.423.9943  13 .079 .563  17 .079 .563
13.15351.423.9943  14 .141 .563  18 .079 .563
14.17711.3261.326  15 .141 .563  19 .141 .563
15.0768.7116.4972  20 .079 .563
16.17711.3261.326  17 .141 .563  22 .141 .563
17.15351.423.9943  18 .079 .563  23 .141 .563
18.15351.423.9943  19 .141 .563  24 .141 .563
19.17711.3261.326  20 .141 .563  25 .141 .563
20.15351.423.9943  21 .079 .563  26 .141 .563
21.0768.7116.4972  27 .141 .563
22.17711.3261.326  23 .141 .563  29 .141 1.68
23.17711.3261.326  24 .141 .563  29 .141 1.59
24.17711.3261.326  25 .141 .563  29 .141 1.55
25.17711.3261.326  26 .141 .563  29 .141 1.47
26.17711.3261.326  27 .141 .563  29 .141 1.36
27.17711.3261.326  28 .141 .563  29 .141 1.24
28.0886.6629.6629  29 .141 1.07
```

2 299.47010.015.203

```
rods  1  1  2  1
1  1  36  0
2 36 .422 0.0  1 .125
1 36 .422 1.0  1 .25  2 .25
1 34 .422 1.0  1 .125  2 .25  3 .125
1 33 .422 1.0  2 .25  4 .25
1 32 .422 1.0  2 .25  3 .25  4 .25  5 .25
1 31 .422 1.0  3 .125  5 .25  6 .125
1 30 .422 1.0  4 .25  7 .25
1 29 .422 1.0  4 .25  5 .25  7 .25  8 .25
1 28 .422 1.0  5 .25  6 .25  8 .25  9 .25
2 27 .422 0.0  6 .125  9 .25  10 .125
2 26 .422 0.0  7 .25  11 .25
1 25 .422 1.0  7 .25  8 .25  11 .25  12 .25
1 24 .422 1.0  8 .25  9 .25  12 .25  13 .25
```

```

1 23 .422 1.0 9 .25 10 .25 13 .25 14 .25
1 22 .422 1.0 10 .125 14 .25 15 .125
1 21 .422 1.0 11 .25 16 .25
1 20 .422 1.0 11 .25 12 .25 16 .25 17 .25
2 19 .422 0.0 12 .25 13 .25 17 .25 18 .25
1 18 .422 1.0 13 .25 14 .25 18 .25 19 .25
1 17 .422 1.0 14 .25 15 .25 19 .25 20 .25
2 16 .422 0.0 15 .125 20 .25 21 .125
1 15 .422 1.0 16 .25 22 .25
1 14 .422 1.0 16 .25 17 .25 22 .25 23 .25
1 13 .422 1.0 17 .25 18 .25 23 .25 24 .25
1 12 .422 1.0 18 .25 19 .25 24 .25 25 .25
1 11 .422 1.0 19 .25 20 .25 25 .25 26 .25
1 10 .422 1.0 20 .25 21 .25 26 .25 27 .25
1 9 .422 1.0 21 .125 27 .25 28 .125
1 8 .422 1.0 22 .25 29 .25
1 7 .422 1.0 22 .25 23 .25 29 .50
1 6 .422 1.0 23 .25 24 .25 29 .50
1 5 .422 1.0 24 .25 25 .25 29 .50
1 4 .422 1.0 25 .25 26 .25 29 .50
1 3 .422 1.0 26 .25 27 .25 29 .50
1 2 .422 1.0 27 .25 28 .25 29 .50
1 1 .422 1.0 28 .125 29 .375
2.8.0717 685.36699.540.0779 409.0243 10.422 0
2.8.0717 685.36699.540.0779 409.0243 10.422 0
slab 0 1 1
1 1 0.0
1 13.05 5.203
1 1 1 29 1

radg 1 1 0
1 1 1 1
heat 2 0 1
3.66 3.66
1000. 1000.

1.0
drag 2 0
100. -1.0 100. -1.0
64. -1.0 64. -1.0
bdry 1 1 1 0
1 0.01 1.0
1 7 .0209 4.0902263 8.3157315 5.5412319 5.7647302 0.9922241 7
1.0239.6
1 15.498 1 0.0
1 1.0 1 1.0 1

calc 0
0 .1
15
oper 1 3 1
14.7 230. .00005 .00230 230. .005 0.0
12
0. 0.0580 80.1176 1.05.2353 1.13.3529 1.13.4709 1.13
.5882 1.13.7059 1.13.8235 1.00.9411 .319.9412 0. 1.0 0.
outp 1
endd

```

```

data from iterative solution using the recirculation module
time = 0.0000 dt = ***** implicit dt = 0.0000 explicit dt = 8.6760 mode = 0

```


iteration no.	sweep no.	peak clad				total flow (lbm/s)	pressure drop(psi)	error			
		temp(f)	fluid	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	371.4	31	35	1	-0.324e-07	0.0004003	24.3023	11.4450	0.0053	0.0022
	2	371.0	30	35	1			0.9801	11.4450	0.0477	0.0019
2	1	392.7	25	35	1	-0.1080e-07	0.0000293	0.1714	1.0040	0.0177	0.0024
	2	407.5	20	35	1			0.0449	1.0040	0.0100	0.0014
3	1	415.9	20	35	1	0.010e-00	0.0000278	0.0246	1.4570	0.0034	0.0000
	2	420.2	20	35	1			0.0100	1.4570	0.0043	0.0002
4	1	422.1	20	35	1	-0.774e-07	0.0000276	0.0042	1.1090	0.0009	0.0003
	2	423.1	20	35	1			0.0020	1.1090	0.0042	0.0000
5	1	423.0	20	35	1	-0.214e-07	0.0000276	0.0010	0.6090	0.0007	0.0002
	2	423.0	20	35	1			0.0010	0.6090	0.0023	0.0000
6	1	423.9	20	35	1	-0.000e-00	0.0000276	0.0004	0.3370	0.0007	0.0001
	2	423.9	20	35	1			0.0004	0.3370	0.0014	0.0000
7	1	424.0	20	35	1	-0.472e-00	0.0000276	0.0001	0.0730	0.0009	0.0001
	2	424.0	20	35	1			0.0002	0.0730	0.0011	0.0000
8	1	424.0	20	35	1	-0.145e-00	0.0000276	-0.0001	0.0292	0.0010	0.0000
	2	424.0	20	35	1			0.0002	0.0292	0.0011	0.0000
9	1	424.0	20	35	1	0.209e-00	0.0000276	-0.0001	0.0101	0.0010	0.0000
	2	424.0	20	35	1			0.0002	0.0101	0.0010	0.0000
10	1	424.0	20	35	1	0.070e-00	0.0000276	-0.0001	0.0030	0.0010	0.0000
	2	424.0	20	35	1			0.0002	0.0030	0.0010	0.0000

side boundary temperature summary time = 0.0000 seconds
boundary slab node no. 1

axial zone (inches)	(1)	(2)	(
0.0 - 4.5	210.27	210.27	
4.5 - 9.0	236.02	230.01	
9.0 - 13.5	263.70	253.75	
13.5 - 18.0	280.74	260.72	
18.0 - 22.5	273.40	273.40	
22.5 - 27.0	200.23	200.21	
27.0 - 31.5	200.97	200.95	
31.5 - 36.0	293.71	293.09	
36.0 - 40.5	300.40	300.44	
40.5 - 45.0	307.20	307.10	
45.0 - 49.5	313.94	313.92	
49.5 - 54.0	315.92	315.90	
54.0 - 58.5	310.44	310.42	

58.5 - 63.0	318.96	318.94
63.0 - 67.5	317.49	317.46
67.5 - 72.0	318.01	317.99
72.0 - 76.5	318.53	318.51
76.5 - 81.0	319.05	319.03
81.0 - 85.5	319.29	319.27
85.5 - 90.0	318.99	318.97
90.0 - 94.5	314.89	314.67
94.5 - 99.0	312.38	312.38
99.0 - 103.5	310.08	310.06
103.5 - 108.0	307.78	307.76
108.0 - 112.5	305.47	305.45
112.5 - 117.0	303.17	303.15
117.0 - 121.5	298.12	298.10
121.5 - 126.0	290.32	290.30
126.0 - 130.5	282.53	282.51
130.5 - 135.0	274.73	274.71
135.0 - 139.5	266.93	266.92
139.5 - 144.0	259.13	259.12
144.0 - 148.5	251.33	251.33
148.5 - 153.0	243.53	243.53

calculated rod temperatures at time = 0.0000 seconds

rod no. 18

assembly 1 (fuel type 2 - cylinder)

rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.387)

				* fuel temperatures(f.)		
				*		
axial zone	heat flux	type	hsurf	* fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2)	*		*
0.0 - 4.5	0.0000	2	10.1	235.4	235.4	
4.5 - 9.0	0.0000	2	10.5	278.4	278.2	
9.0 - 13.5	0.0000	2	10.8	311.9	311.7	
13.5 - 18.0	0.0000	2	11.0	332.4	332.2	
18.0 - 22.5	0.0000	2	11.1	343.8	343.6	
22.5 - 27.0	0.0000	2	11.2	351.4	351.2	
27.0 - 31.5	0.0000	2	11.2	358.6	358.3	
31.5 - 36.0	0.0000	2	11.3	365.4	365.2	
36.0 - 40.5	0.0000	2	11.4	371.0	371.0	
40.5 - 45.0	0.0000	2	11.4	377.0	377.4	
45.0 - 49.5	0.0000	2	11.5	383.2	383.0	
49.5 - 54.0	0.0000	2	11.5	385.2	385.0	
54.0 - 58.5	0.0000	2	11.5	385.8	385.6	
58.5 - 63.0	0.0000	2	11.5	386.2	386.1	
63.0 - 67.5	0.0000	2	11.5	386.7	386.5	
67.5 - 72.0	0.0000	2	11.5	387.1	387.0	
72.0 - 76.5	0.0000	2	11.5	387.0	387.4	
76.5 - 81.0	0.0000	2	11.5	388.0	387.8	
81.0 - 85.5	0.0000	2	11.5	388.1	388.0	
85.5 - 90.0	0.0000	2	11.5	388.3	388.2	
90.0 - 94.5	0.0000	2	11.5	384.4	384.2	
94.5 - 99.0	0.0000	2	11.5	382.4	382.3	
99.0 - 103.5	0.0000	2	11.4	380.4	380.3	
103.5 - 108.0	0.0000	2	11.4	378.5	378.3	
108.0 - 112.5	0.0000	2	11.4	375.6	375.5	
112.5 - 117.0	0.0000	2	11.4	371.8	371.7	
117.0 - 121.5	0.0000	2	11.3	365.7	365.5	

121.5 - 126.0	0.0000	2	11.2	357.1	357.0
126.0 - 130.5	0.0000	2	11.1	344.6	344.5
130.5 - 135.0	0.0000	2	10.9	327.7	327.6
135.0 - 139.5	0.0000	2	10.8	309.6	309.5
139.5 - 144.0	0.0000	2	10.6	290.3	290.2
144.0 - 148.5	0.0000	2	10.3	256.0	256.0
148.5 - 153.0	0.0000	2	10.2	244.3	244.3

calculated rod temperatures at time = 0.0000 seconds

rod no. 27

assembly 1

(fuel type 2 - cylinder)

rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.367)

						* fuel temperatures(f.)		
						*		
axial zone	heat flux	type	hsurf	fluid	clad			
(in.)	(abtu/hr-ft ²)		(b/h-f-ft ²)					
0.0 - 4.5	0.0000	2	10.1	240.0	240.0			
4.5 - 9.0	0.0000	2	10.6	290.2	290.1			
9.0 - 13.5	0.0000	2	11.0	320.5	320.4			
13.5 - 18.0	0.0000	2	11.2	351.6	351.5			
18.0 - 22.5	0.0000	2	11.3	364.6	364.4			
22.5 - 27.0	0.0000	2	11.4	372.5	372.4			
27.0 - 31.5	0.0000	2	11.4	379.7	379.6			
31.5 - 36.0	0.0000	2	11.5	386.7	386.6			
36.0 - 40.5	0.0000	2	11.5	393.1	393.0			
40.5 - 45.0	0.0000	2	11.6	398.8	398.7			
45.0 - 49.5	0.0000	2	11.6	404.2	404.1			
49.5 - 54.0	0.0000	2	11.7	406.2	406.1			
54.0 - 58.5	0.0000	2	11.7	406.8	406.7			
58.5 - 63.0	0.0000	2	11.7	407.3	407.2			
63.0 - 67.5	0.0000	2	11.7	407.7	407.6			
67.5 - 72.0	0.0000	2	11.7	408.1	408.0			
72.0 - 76.5	0.0000	2	11.7	408.6	408.5			
76.5 - 81.0	0.0000	2	11.7	409.0	408.9			
81.0 - 85.5	0.0000	2	11.7	409.1	409.0			
85.5 - 90.0	0.0000	2	11.7	407.4	407.4			
90.0 - 94.5	0.0000	2	11.7	405.8	405.5			
94.5 - 99.0	0.0000	2	11.6	403.7	403.6			
99.0 - 103.5	0.0000	2	11.6	401.8	401.7			
103.5 - 108.0	0.0000	2	11.6	399.9	399.8			
108.0 - 112.5	0.0000	2	11.6	396.9	396.9			
112.5 - 117.0	0.0000	2	11.5	392.7	392.6			
117.0 - 121.5	0.0000	2	11.5	386.3	386.2			
121.5 - 126.0	0.0000	2	11.4	377.5	377.5			
126.0 - 130.5	0.0000	2	11.3	363.0	363.7			
130.5 - 135.0	0.0000	2	11.1	344.3	344.2			
135.0 - 139.5	0.0000	2	10.9	323.1	323.1			
139.5 - 144.0	0.0000	2	10.7	300.5	300.5			
144.0 - 148.5	0.0000	2	10.3	258.3	258.3			
148.5 - 153.0	0.0000	2	10.2	244.7	244.7			

calculated rod temperatures at time = 0.0000 seconds

rod no. 36

assembly 1

(fuel type 2 - cylinder)

rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.367)

* fuel temperatures(f.)

axial zone (in.)	heat flux (mbtu/hr-ft ²)	type	hsurf (b/h-f-ft ²)	fluid	clad
0.0 - 4.5	0.0000	2	10.2	243.2	243.1
4.5 - 9.0	0.0000	2	10.7	298.4	298.3
9.0 - 13.5	0.0000	2	11.1	348.8	339.8
13.5 - 18.0	0.0000	2	11.3	364.8	364.7
18.0 - 22.5	0.0000	2	11.4	378.8	378.7
22.5 - 27.0	0.0000	2	11.5	387.8	388.9
27.0 - 31.5	0.0000	2	11.8	394.3	394.2
31.5 - 36.0	0.0000	2	11.8	401.5	401.3
36.0 - 40.5	0.0000	2	11.7	407.8	407.7
40.5 - 45.0	0.0000	2	11.7	413.4	413.2
45.0 - 49.5	0.0000	2	11.8	418.7	418.5
49.5 - 54.0	0.0000	2	11.8	420.7	420.6
54.0 - 58.5	0.0000	2	11.8	421.4	421.3
58.5 - 63.0	0.0000	2	11.8	421.8	421.7
63.0 - 67.5	0.0000	2	11.8	422.3	422.1
67.5 - 72.0	0.0000	2	11.8	422.7	422.6
72.0 - 76.5	0.0000	2	11.8	423.1	423.0
76.5 - 81.0	0.0000	2	11.8	423.5	423.4
81.0 - 85.5	0.0000	2	11.8	423.7	423.5
85.5 - 90.0	0.0000	2	11.8	422.1	422.0
90.0 - 94.5	0.0000	2	11.8	420.3	420.2
94.5 - 99.0	0.0000	2	11.8	418.4	418.3
99.0 - 103.5	0.0000	2	11.7	418.6	418.5
103.5 - 108.0	0.0000	2	11.7	414.7	414.6
108.0 - 112.5	0.0000	2	11.7	411.7	411.6
112.5 - 117.0	0.0000	2	11.7	407.2	407.1
117.0 - 121.5	0.0000	2	11.8	400.6	400.5
121.5 - 126.0	0.0000	2	11.5	391.7	391.6
126.0 - 130.5	0.0000	2	11.4	377.1	377.0
130.5 - 135.0	0.0000	2	11.2	355.9	355.8
135.0 - 139.5	0.0000	2	11.0	332.7	332.7
139.5 - 144.0	0.0000	2	10.8	307.9	307.8
144.0 - 148.5	0.0000	2	10.3	268.1	268.0
148.5 - 153.0	0.0000	2	10.2	244.9	244.9

+5000

```
1 nitrogen emad input, validation analyses
prop 11 1
1. 100. 100.9 .0154 .240 14.08 .0463
2. 200. 157.9 .0174 .241 16.67 .0518
3. 300. 182.1 .0193 .243 19.23 .0580
4. 400. 206.5 .0212 .245 21.74 .0630
5. 500. 231.1 .0231 .247 24.27 .0680
6. 600. 256.0 .0250 .250 26.81 .0720
7. 700. 281.1 .0268 .253 29.33 .0770
8. 800. 306.7 .0286 .256 31.85 .0810
10. 900. 332.5 .0303 .259 34.36 .0850
15. 1000. 358.6 .0319 .262 36.90 .0889
20. 2000. 617.2 .0471 .286 62.11 .1242
lss304 .11 486. 9.8
chan 1 34
153.0 00.0
1 1 29 0 1
1 1 0 0 1
1 0760.7116.4972 2 .141 .563
2 17711.3261.326 3 .141 .563 4 .141 .563
3 0806.6629.6629 5 .141 .563
4 17711.3261.326 5 .141 .563 7 .141 .563
5 17711.3261.326 6 .141 .563 8 .141 .563
6 0760.7116.4972 9 .079 .563
7 15351.423.9943 8 .141 .563 11 .079 .563
8 17711.3261.326 9 .141 .563 12 .141 .563
9 15351.423.9943 10 .079 .563 13 .141 .563
10 0760.7116.4972 14 .141 .563
11 15351.423.9943 12 .141 .563 16 .141 .563
12 15351.423.9943 13 .079 .563 17 .079 .563
13 15351.423.9943 14 .141 .563 18 .079 .563
14 17711.3261.326 15 .141 .563 19 .141 .563
15 0760.7116.4972 20 .079 .563
16 17711.3261.326 17 .141 .563 22 .141 .563
17 15351.423.9943 18 .079 .563 23 .141 .563
18 15351.423.9943 19 .141 .563 24 .141 .563
19 17711.3261.326 20 .141 .563 25 .141 .563
20 15351.423.9943 21 .079 .563 26 .141 .563
21 0760.7116.4972 27 .141 .563
22 17711.3261.326 23 .141 .563 29 .141 1.00
23 17711.3261.326 24 .141 .563 29 .141 1.59
24 17711.3261.326 25 .141 .563 29 .141 1.55
25 17711.3261.326 26 .141 .563 29 .141 1.47
26 17711.3261.326 27 .141 .563 29 .141 1.36
27 17711.3261.326 28 .141 .563 29 .141 1.24
28 0806.6629.6629 29 .141 1.07
2 299.47010.015.203

rods 1 1 2 1
1 1 36 0
2 36 .422 0.0 1 .125
1 35 .422 1.0 1 .25 2 .25
1 34 .422 1.0 1 .125 2 .25 3 .125
1 33 .422 1.0 2 .25 4 .25
1 32 .422 1.0 2 .25 3 .25 4 .25 5 .25
1 31 .422 1.0 3 .125 5 .25 6 .125
1 30 .422 1.0 4 .25 7 .25
1 29 .422 1.0 4 .25 5 .25 7 .25 8 .25
1 28 .422 1.0 5 .25 6 .25 8 .25 9 .25
```

```

2 27 .422 0.0 6 .125 9 .25 10 .125
2 26 .422 0.0 7 .25 11 .25
1 25 .422 1.0 7 .25 8 .25 11 .25 12 .25
1 24 .422 1.0 8 .25 9 .25 12 .25 13 .25
1 23 .422 1.0 9 .25 10 .25 13 .25 14 .25
1 22 .422 1.0 10 .125 14 .25 15 .125
1 21 .422 1.0 11 .25 16 .25
1 20 .422 1.0 11 .25 12 .25 16 .25 17 .25
2 19 .422 0.0 12 .25 13 .25 17 .25 18 .25
1 18 .422 1.0 13 .25 14 .25 18 .25 19 .25
1 17 .422 1.0 14 .25 15 .25 19 .25 20 .25
2 16 .422 0.0 15 .125 20 .25 21 .125
1 15 .422 1.0 16 .25 22 .25
1 14 .422 1.0 16 .25 17 .25 22 .25 23 .25
1 13 .422 1.0 17 .25 18 .25 23 .25 24 .25
1 12 .422 1.0 18 .25 19 .25 24 .25 25 .25
1 11 .422 1.0 19 .25 20 .25 25 .25 26 .25
1 10 .422 1.0 20 .25 21 .25 26 .25 27 .25
1 9 .422 1.0 21 .125 27 .25 28 .125
1 8 .422 1.0 22 .25 29 .25
1 7 .422 1.0 22 .25 23 .25 29 .50
1 6 .422 1.0 23 .25 24 .25 29 .50
1 5 .422 1.0 24 .25 25 .25 29 .50
1 4 .422 1.0 25 .25 26 .25 29 .50
1 3 .422 1.0 26 .25 27 .25 29 .50
1 2 .422 1.0 27 .25 28 .25 29 .50
1 1 .422 1.0 28 .125 29 .375
2.0 .0717 685 .36699.540 .0779 400 .0243 10 .422 0
2.0 .0717 685 .36699.540 .0779 400 .0243 10 .422 0
slab 0 1 1
1 1 0.0
1 13.05 5.203
1 1 1 29 1

radg 1 1 0
1 1 1 1
heat 2 0 1
3.68 3.68
1000. 1000.
1.0
drag 2 0
100. -1.0 100. -1.0
64. -1.0 64. -1.0
bdry 1 1 1 0
1 0.01 1.0
1 7 .0205.4.0902262.1.3157313.0.5412321.4.7647319.2.9922281.0
1.0200.5
1 15.498 1 0.0
1 1.0 1 1.0 1
calc 1
0 1
15
oper 1 3 1
14.7 230. 00005 00230 230. 005 0.0
12
0. 0.0500 00.1176 1.05.2353 1.13.3529 1.13.4709 1.13
.5002 1.13.7059 1.13.0235 1.00.9411 .319.9412 0. 1.0 0.
outp 1
endd

```


data from iterative solution using the recirculation module

time = 0.0000 dt = ***** implicit dt = 0.0000 explicit dt = 0.8966 mode = 0

iteration no.	sweep no.	peak clad				total flow (lbm/s)	pressure drop(psi)	error			
		temp(f)	fluid	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	482.3	27	35	1	0.318e-11	0.0044829	91.5772	1.1814	0.0006	0.0318
	2	482.6	26	35	1			0.2795	1.1814	0.0734	0.0303
2	1	483.4	25	35	1	0.129e-11	0.0043283	0.1305	1.3044	0.0185	0.0188
	2	488.4	25	35	1			0.0131	1.3044	0.0006	0.0193
3	1	487.1	25	35	1	0.587e-12	0.0043249	0.0181	2.3611	0.0055	0.0017
	2	488.4	24	35	1			0.0033	2.3611	0.0042	0.0024
4	1	488.7	24	35	1	0.169e-12	0.0043248	0.0051	2.2438	0.0023	0.0012
	2	489.3	23	35	1			0.0013	2.2438	0.0023	0.0010
5	1	489.5	23	35	1	0.834e-13	0.0043249	0.0020	0.7570	0.0008	0.0006
	2	489.8	23	35	1			0.0007	0.7570	0.0010	0.0004
6	1	489.8	23	35	1	0.188e-13	0.0043250	0.0008	0.6934	0.0004	0.0003
	2	489.9	22	36	1			0.0005	0.6934	0.0004	0.0002
7	1	490.0	22	35	1	-0.122e-13	0.0043251	0.0002	0.5455	0.0004	0.0002
	2	490.0	22	35	1			0.0005	0.5455	0.0004	0.0001
8	1	490.0	22	35	1	-0.190e-13	0.0043251	0.0000	0.3601	0.0003	0.0002
	2	490.0	22	35	1			0.0004	0.3601	0.0004	0.0001
9	1	490.1	22	35	1	-0.161e-13	0.0043251	-0.0001	0.2017	0.0003	0.0001
	2	490.1	22	35	1			0.0004	0.2017	0.0003	0.0001
10	1	490.1	22	35	1	-0.888e-14	0.0043251	-0.0001	0.1039	0.0003	0.0001
	2	490.1	22	35	1			0.0004	0.1039	0.0003	0.0001
11	1	490.1	22	35	1	-0.844e-14	0.0043252	-0.0001	0.0534	0.0003	0.0001
	2	490.1	22	35	1			0.0004	0.0534	0.0003	0.0001
12	1	490.1	22	35	1	-0.121e-14	0.0043252	-0.0001	0.0291	0.0003	0.0001
	2	490.1	22	35	1			0.0004	0.0291	0.0003	0.0001
13	1	490.1	22	35	1	-0.252e-15	0.0043252	-0.0001	0.0167	0.0003	0.0001
	2	490.1	22	35	1			0.0004	0.0167	0.0003	0.0001
14	1	490.1	22	35	1	-0.100e-14	0.0043252	-0.0001	0.0101	0.0003	0.0001
	2	490.1	22	35	1			0.0004	0.0101	0.0003	0.0001
15	1	490.1	22	35	1	0.531e-15	0.0043252	-0.0001	0.0064	0.0003	0.0001
	2	490.1	22	35	1			0.0004	0.0064	0.0003	0.0001

side boundary temperature summary time = 0.0000 seconds
 boundary slab node no. 1

axial zone (inches)	(1)	(2)	(
0.0 - 4.5	214.65	214.64	
4.5 - 9.0	233.14	233.13	
9.0 - 13.5	251.63	251.62	
13.5 - 18.0	264.99	264.98	
18.0 - 22.5	271.63	271.61	
22.5 - 27.0	278.27	278.25	
27.0 - 31.5	284.91	284.89	
31.5 - 36.0	291.55	291.53	
36.0 - 40.5	298.19	298.17	
40.5 - 45.0	304.83	304.81	
45.0 - 49.5	311.47	311.45	
49.5 - 54.0	313.86	313.84	
54.0 - 58.5	314.96	314.94	
58.5 - 63.0	316.06	316.03	
63.0 - 67.5	317.15	317.13	
67.5 - 72.0	318.24	318.22	
72.0 - 76.5	319.34	319.32	
76.5 - 81.0	320.43	320.41	
81.0 - 85.5	321.39	321.37	
85.5 - 90.0	321.10	321.08	
90.0 - 94.5	320.61	320.79	
94.5 - 99.0	320.52	320.50	
99.0 - 103.5	320.23	320.21	
103.5 - 108.0	319.94	319.92	
108.0 - 112.5	319.65	319.63	
112.5 - 117.0	319.36	319.34	
117.0 - 121.5	318.06	318.78	
121.5 - 126.0	311.96	311.95	
126.0 - 130.5	307.13	307.11	
130.5 - 135.0	302.29	302.28	
135.0 - 139.5	297.45	297.44	
139.5 - 144.0	292.62	292.61	
144.0 - 148.5	287.78	287.77	
148.5 - 153.0	282.94	282.94	

calculated rod temperatures at time = 0.0000 seconds

rod no. 18

assembly 1

(fuel type 2 - cylinder)

rod o.d. - 0.422 (in.)

zone-(fuel dia.(in.)) - 1-(0.387)

			* fuel temperatures(f.)		
			*		
axial zone	heat flux	type	hsurf	* fluid	clad
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2) *		
0.0 - 4.5	0.0000	2	1.9	268.6	268.1
4.5 - 9.0	0.0000	2	1.9	293.2	293.7
9.0 - 13.5	0.0000	2	2.0	323.0	323.6
13.5 - 18.0	0.0000	2	2.0	347.7	348.1
18.0 - 22.5	0.0000	2	2.1	366.1	366.2
22.5 - 27.0	0.0000	2	2.1	379.4	379.3
27.0 - 31.5	0.0000	2	2.1	390.8	389.8
31.5 - 36.0	0.0000	2	2.1	399.0	398.7
36.0 - 40.5	0.0000	2	2.2	406.4	406.1
40.5 - 45.0	0.0000	2	2.2	412.4	412.1
45.0 - 49.5	0.0000	2	2.2	417.8	417.2
49.5 - 54.0	0.0000	2	2.2	420.8	420.4

54.0 - 58.5	0.0000	2	2.2	422.9	422.4
58.5 - 63.0	0.0000	2	2.2	424.4	423.8
63.0 - 67.5	0.0000	2	2.2	425.6	425.0
67.5 - 72.0	0.0000	2	2.2	426.6	426.0
72.0 - 76.5	0.0000	2	2.2	427.4	426.9
76.5 - 81.0	0.0000	2	2.2	428.2	427.6
81.0 - 85.5	0.0000	2	2.2	428.8	428.2
85.5 - 90.0	0.0000	2	2.2	428.9	428.3
90.0 - 94.5	0.0000	2	2.2	428.8	428.2
94.5 - 99.0	0.0000	2	2.2	428.6	428.0
99.0 - 103.5	0.0000	2	2.2	428.2	427.6
103.5 - 108.0	0.0000	2	2.2	427.7	427.1
108.0 - 112.5	0.0000	2	2.2	426.3	425.7
112.5 - 117.0	0.0000	2	2.2	423.8	423.1
117.0 - 121.5	0.0000	2	2.2	419.8	419.1
121.5 - 126.0	0.0000	2	2.2	414.2	413.4
126.0 - 130.5	0.0000	2	2.1	405.2	404.4
130.5 - 135.0	0.0000	2	2.1	392.2	391.2
135.0 - 139.5	0.0000	2	2.1	377.0	376.1
139.5 - 144.0	0.0000	2	2.1	360.8	359.9
144.0 - 148.5	0.0000	2	2.0	335.0	334.5
148.5 - 153.0	0.0000	2	2.0	323.5	323.0

calculated rod temperatures at time = 0.0000 seconds

rod no. 27

assembly 1 (fuel type 2 - cylinder)

rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.387)

						* fuel temperatures(f.)	
						*	
axial zone	heat flux	type	hsurf	* fluid	clad		
(in.)	(mbtu/hr-ft ²)		(b/h-f-ft ²) *				
0.0 - 4.5	0.0000	2	1.9	276.7	276.7		
4.5 - 9.0	0.0000	2	1.9	300.9	302.2		
9.0 - 13.5	0.0000	2	2.0	333.5	335.2		
13.5 - 18.0	0.0000	2	2.1	363.5	365.0		
18.0 - 22.5	0.0000	2	2.1	387.8	388.9		
22.5 - 27.0	0.0000	2	2.1	405.7	406.4		
27.0 - 31.5	0.0000	2	2.2	419.4	419.8		
31.5 - 36.0	0.0000	2	2.2	430.4	430.7		
36.0 - 40.5	0.0000	2	2.2	439.2	439.3		
40.5 - 45.0	0.0000	2	2.2	446.1	446.1		
45.0 - 49.5	0.0000	2	2.2	451.7	451.6		
49.5 - 54.0	0.0000	2	2.2	455.6	455.5		
54.0 - 58.5	0.0000	2	2.3	458.3	458.1		
58.5 - 63.0	0.0000	2	2.3	460.2	459.9		
63.0 - 67.5	0.0000	2	2.3	461.8	461.3		
67.5 - 72.0	0.0000	2	2.3	462.8	462.4		
72.0 - 76.5	0.0000	2	2.3	463.7	463.4		
76.5 - 81.0	0.0000	2	2.3	464.5	464.1		
81.0 - 85.5	0.0000	2	2.3	465.1	464.7		
85.5 - 90.0	0.0000	2	2.3	465.4	465.0		
90.0 - 94.5	0.0000	2	2.3	465.5	465.1		
94.5 - 99.0	0.0000	2	2.3	465.4	465.0		
99.0 - 103.5	0.0000	2	2.3	465.1	464.7		
103.5 - 108.0	0.0000	2	2.3	464.7	464.3		
108.0 - 112.5	0.0000	2	2.3	463.5	463.0		
112.5 - 117.0	0.0000	2	2.3	461.0	460.4		

117.0 - 121.5	0.0000	2	2.2	457.1	456.5
121.5 - 126.0	0.0000	2	2.2	451.9	451.2
126.0 - 130.5	0.0000	2	2.2	443.0	442.1
130.5 - 135.0	0.0000	2	2.2	429.0	427.8
135.0 - 139.5	0.0000	2	2.2	411.8	410.4
139.5 - 144.0	0.0000	2	2.1	392.5	391.1
144.0 - 148.5	0.0000	2	2.1	361.9	360.0
148.5 - 153.0	0.0000	2	2.0	342.6	341.3

calculated rod temperatures at time = 0.0000 seconds

rod no. 36

assembly 1

(fuel type 2 - cylinder)

rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.387)

						* fuel temperatures(f.)	
						*	
axial zone	heat flux	type	hsurf	* fluid	clad		
(in.)	(mbtu/hr-ft ²)		(b/h-f-ft ²)	*			
0.0 - 4.5	0.0000	2	1.9	280.5	280.0		
4.5 - 9.0	0.0000	2	2.0	304.2	305.9		
9.0 - 13.5	0.0000	2	2.0	337.6	340.0		
13.5 - 18.0	0.0000	2	2.1	370.6	373.0		
18.0 - 22.5	0.0000	2	2.1	399.0	400.9		
22.5 - 27.0	0.0000	2	2.2	420.5	421.8		
27.0 - 31.5	0.0000	2	2.2	436.9	437.8		
31.5 - 36.0	0.0000	2	2.2	449.8	450.3		
36.0 - 40.5	0.0000	2	2.3	459.0	460.1		
40.5 - 45.0	0.0000	2	2.3	467.4	467.6		
45.0 - 49.5	0.0000	2	2.3	473.5	473.5		
49.5 - 54.0	0.0000	2	2.3	478.0	477.9		
54.0 - 58.5	0.0000	2	2.3	481.2	481.0		
58.5 - 63.0	0.0000	2	2.3	483.4	483.1		
63.0 - 67.5	0.0000	2	2.3	485.1	484.7		
67.5 - 72.0	0.0000	2	2.3	486.3	486.9		
72.0 - 76.5	0.0000	2	2.3	487.3	486.9		
76.5 - 81.0	0.0000	2	2.3	488.1	487.7		
81.0 - 85.5	0.0000	2	2.3	488.0	488.4		
85.5 - 90.0	0.0000	2	2.3	489.2	488.7		
90.0 - 94.5	0.0000	2	2.3	489.4	488.9		
94.5 - 99.0	0.0000	2	2.3	489.4	488.9		
99.0 - 103.5	0.0000	2	2.3	489.2	488.7		
103.5 - 108.0	0.0000	2	2.3	488.9	488.4		
108.0 - 112.5	0.0000	2	2.3	487.8	487.2		
112.5 - 117.0	0.0000	2	2.3	485.4	484.7		
117.0 - 121.5	0.0000	2	2.3	481.7	480.9		
121.5 - 126.0	0.0000	2	2.3	476.0	475.9		
126.0 - 130.5	0.0000	2	2.3	468.1	466.9		
130.5 - 135.0	0.0000	2	2.2	453.9	452.4		
135.0 - 139.5	0.0000	2	2.2	438.0	434.2		
139.5 - 144.0	0.0000	2	2.2	415.3	413.3		
144.0 - 148.5	0.0000	2	2.1	382.7	379.9		
148.5 - 153.0	0.0000	2	2.1	359.0	356.9		

*5000

1 vacuum emad input, validation analyses

prop	11	1					
	1.	100.	100.9	.0154	.240	14.08	.0463
	2.	200.	157.9	.0174	.241	16.67	.0518
	3.	300.	182.1	.0193	.243	19.23	.0580
	4.	400.	206.5	.0212	.245	21.74	.0630
	5.	500.	231.1	.0231	.247	24.27	.0680
	6.	600.	256.0	.0250	.250	26.81	.0720
	7.	700.	281.1	.0260	.253	29.33	.0770
	8.	800.	306.7	.0260	.256	31.85	.0810
	10.	900.	332.5	.0303	.259	34.30	.0850
	15.	1000.	358.6	.0319	.262	36.90	.0889
	20.	2000.	617.2	.0471	.286	62.11	.1242

1ss304 .11 400. 9.8

chan 1 34

153.0 90.0

1 1 29 0 1

1 1 0 0 1

1.	0768.7116.4972	2.	.141.563		
2.	17711.3261.326	3.	.141.563	4.	.141.563
3.	0806.0829.0829	5.	.141.563		
4.	17711.3261.326	5.	.141.563	7.	.141.563
5.	17711.3261.326	8.	.141.563	8.	.141.563
6.	0768.7116.4972	9.	.079.563		
7.	15351.423.9943	8.	.141.563	11.	.079.563
8.	17711.3261.326	9.	.141.563	12.	.141.563
9.	15351.423.9943	10.	.079.563	13.	.141.563
10.	0768.7116.4972	14.	.141.563		
11.	15351.423.9943	12.	.141.563	16.	.141.563
12.	15351.423.9943	13.	.079.563	17.	.079.563
13.	15351.423.9943	14.	.141.563	18.	.079.563
14.	17711.3261.326	15.	.141.563	19.	.141.563
15.	0768.7116.4972	20.	.079.563		
16.	17711.3261.326	17.	.141.563	22.	.141.563
17.	15351.423.9943	18.	.079.563	23.	.141.563
18.	15351.423.9943	19.	.141.563	24.	.141.563
19.	17711.3261.326	20.	.141.563	25.	.141.563
20.	15351.423.9943	21.	.079.563	26.	.141.563
21.	0768.7116.4972	27.	.141.563		
22.	17711.3261.326	23.	.141.563	29.	.141.1.68
23.	17711.3261.326	24.	.141.563	29.	.141.1.59
24.	17711.3261.326	25.	.141.563	29.	.141.1.55
25.	17711.3261.326	26.	.141.563	29.	.141.1.47
26.	17711.3261.326	27.	.141.563	29.	.141.1.36
27.	17711.3261.326	28.	.141.563	29.	.141.1.24
28.	0806.0829.0829	29.	.141.1.07		

2 299.47010.015.203

rods 1 1 2 1

1 1 36 0

2	36	.422	0.0	1	.125						
1	35	.422	1.0	1	.25	2	.25				
1	34	.422	1.0	1	.125	2	.25	3	.125		
1	33	.422	1.0	2	.25	4	.25				
1	32	.422	1.0	2	.25	3	.25	4	.25	5	.25
1	31	.422	1.0	3	.125	5	.25	8	.125		
1	30	.422	1.0	4	.25	7	.25				
1	29	.422	1.0	4	.25	5	.25	7	.25	8	.25
1	28	.422	1.0	5	.25	6	.25	8	.25	9	.25

```

2 27 .422 0.0 8 .125 9 .25 10 .125
2 28 .422 0.0 7 .25 11 .25
1 25 .422 1.0 7 .25 8 .25 11 .25 12 .25
1 24 .422 1.0 8 .25 9 .25 12 .25 13 .25
1 23 .422 1.0 9 .25 10 .25 13 .25 14 .25
1 22 .422 1.0 10 .125 14 .25 15 .125
1 21 .422 1.0 11 .25 16 .25
1 20 .422 1.0 11 .25 12 .25 16 .25 17 .25
2 19 .422 0.0 12 .25 13 .25 17 .25 18 .25
1 18 .422 1.0 13 .25 14 .25 18 .25 19 .25
1 17 .422 1.0 14 .25 15 .25 19 .25 20 .25
2 16 .422 0.0 15 .125 20 .25 21 .125
1 15 .422 1.0 16 .25 22 .25
1 14 .422 1.0 16 .25 17 .25 22 .25 23 .25
1 13 .422 1.0 17 .25 18 .25 23 .25 24 .25
1 12 .422 1.0 18 .25 19 .25 24 .25 25 .25
1 11 .422 1.0 19 .25 20 .25 25 .25 26 .25
1 10 .422 1.0 20 .25 21 .25 25 .25 27 .25
1 9 .422 1.0 21 .125 27 .25 28 .125
1 8 .422 1.0 22 .25 29 .25
1 7 .422 1.0 22 .25 23 .25 29 .50
1 6 .422 1.0 23 .25 24 .25 29 .50
1 5 .422 1.0 24 .25 25 .25 29 .50
1 4 .422 1.0 25 .25 26 .25 29 .50
1 3 .422 1.0 26 .25 27 .25 29 .50
1 2 .422 1.0 27 .25 28 .25 29 .50
1 1 .422 1.0 28 .125 29 .375
2.8.0717 685.36899.540.0779 409.0243 10.422 0
2.8.0717 685.36899.540.0779 409.0243 10.422 0
slab 0 1 1
1 1 0.0
1 13.05 5.203
1 1 1 29 1

radg 1 1 0
1 1 1 1
heat 2 0 1
1.00 1.00
1000. 1000.
1.0
drag 2 0
100. -1.0 100. -1.0
64. -1.0 64. -1.0
bdry 1 1 1 0
1 0.01 1.0
1 7 .0207 9.0902262.0 3157316.3 5412318.1 7647301.7 9922230.5
1.0235.3
1 15.498 1 0.0
1 1.0 1 1.0 1
calc 1
.0 .1
15
oper 1 3 1
14.7 230. .00005 .00230 230. .005 0.0
. 12
0. 0.0508 00.1176 1.05.2353 1.13.3529 1.13.4709 1.13
.5002 1.13.7059 1.13.8235 1.00.9411 .319.9412 0. 1.0 0.
outp 1
endd

```


data from iterative solution using the recirculation module

time = 0.0000 dt = ***** implicit dt = 0.0000 explicit dt = ***** mode = 0

iteration no.	sweep no.	peak clad				total flow (lbm/s)	pressure drop(psi)	error			
		temp(f)	fluid	rod	aaa.			total energy	flow	fluid energy	rod energy
1	1	492.0	25	35	1	0.317e-11	-0.0000260	18.2264	4.5391	0.0138	0.0122
	2	492.2	25	35	1			0.2451	4.5391	0.1110	0.0110
2	1	502.2	20	35	1	0.160e-11	0.0000000	0.0129	0.9980	0.0260	0.0144
	2	503.7	20	35	1			0.0001	0.9980	0.0110	0.0031
3	1	505.0	20	35	1	0.710e-12	0.0000000	0.0011	0.9973	0.0071	0.0019
	2	505.0	20	35	1			0.0004	0.9973	0.0043	0.0011
4	1	505.9	20	35	1	0.102e-12	0.0000000	-0.0009	0.9942	0.0025	0.0007
	2	505.0	20	35	1			0.0001	0.9942	0.0024	0.0004
5	1	500.0	20	35	1	-0.000e-13	0.0000000	0.0000	0.3335	0.0013	0.0002
	2	500.1	19	35	1			0.0000	0.3335	0.0020	0.0001
6	1	500.1	20	35	1	-0.114e-12	0.0000000	0.0000	0.0990	0.0015	0.0001
	2	500.1	19	35	1			0.0000	0.0990	0.0018	0.0001
7	1	500.1	20	35	1	-0.900e-13	0.0000000	0.0000	0.0290	0.0015	0.0001
	2	500.1	19	35	1			0.0000	0.0290	0.0017	0.0000
8	1	500.1	20	35	1	-0.522e-13	0.0000000	0.0000	0.0007	0.0015	0.0001
	2	500.1	19	35	1			0.0000	0.0007	0.0017	0.0001

cobra-sfs code results

case 1 vacuum enad input, validation analyses

date 06/11/07 time 10:38:37

side boundary temperature summary time = 0.0000 seconds
 boundary slab node no. 1

axial zone (inches)	(1)	(2)	(3)
0.0 - 4.5	216.72	216.72	
4.5 - 9.0	234.37	234.30	
9.0 - 13.5	252.02	252.00	
13.5 - 18.0	265.09	265.07	
18.0 - 22.5	272.17	272.15	
22.5 - 27.0	279.25	279.23	
27.0 - 31.5	280.33	280.31	
31.5 - 36.0	293.42	293.40	
36.0 - 40.5	300.50	300.40	
40.5 - 45.0	307.50	307.50	

45.0 - 49.5	314.86	314.84
49.5 - 54.0	316.50	316.48
54.0 - 58.5	316.74	316.71
58.5 - 63.0	316.97	316.95
63.0 - 67.5	317.20	317.18
67.5 - 72.0	317.44	317.42
72.0 - 76.5	317.67	317.65
76.5 - 81.0	317.91	317.89
81.0 - 85.5	317.91	317.89
85.5 - 90.0	315.75	315.73
90.0 - 94.5	313.59	313.57
94.5 - 99.0	311.43	311.41
99.0 - 103.5	309.27	309.25
103.5 - 108.0	307.12	307.10
108.0 - 112.5	304.96	304.94
112.5 - 117.0	302.80	302.78
117.0 - 121.5	297.63	297.61
121.5 - 126.0	289.46	289.44
126.0 - 130.5	281.29	281.27
130.5 - 135.0	273.11	273.10
135.0 - 139.5	264.94	264.93
139.5 - 144.0	256.77	256.76
144.0 - 148.5	248.59	248.59
148.5 - 153.0	240.42	240.42

calculated rod temperatures at time = 0.0000 seconds
 rod no. 16
 assembly 1 (fuel type 2 - cylinder)
 Rod o.d. = 0.422 (in.) zone-(fuel dia.(in.)) = 1-(0.387)

* fuel temperatures(f.)						
*						
axial zone	heat flux	type	hsurf	fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2) *			
0.0 - 4.5	0.0000	2	0.5	253.0	252.8	
4.5 - 9.0	0.0000	2	0.5	325.1	324.7	
9.0 - 13.5	0.0000	2	0.6	368.1	367.6	
13.5 - 18.0	0.0000	2	0.6	389.8	389.2	
18.0 - 22.5	0.0000	2	0.6	401.5	400.9	
22.5 - 27.0	0.0000	2	0.6	407.9	407.3	
27.0 - 31.5	0.0000	2	0.6	414.3	413.7	
31.5 - 36.0	0.0000	2	0.6	420.6	420.0	
36.0 - 40.5	0.0000	2	0.6	426.1	425.5	
40.5 - 45.0	0.0000	2	0.6	430.7	430.1	
45.0 - 49.5	0.0000	2	0.6	435.3	434.7	
49.5 - 54.0	0.0000	2	0.6	436.6	436.0	
54.0 - 58.5	0.0000	2	0.6	436.7	436.1	
58.5 - 63.0	0.0000	2	0.6	436.9	436.3	
63.0 - 67.5	0.0000	2	0.6	437.0	436.4	
67.5 - 72.0	0.0000	2	0.6	437.2	436.6	
72.0 - 76.5	0.0000	2	0.6	437.3	436.7	
76.5 - 81.0	0.0000	2	0.6	437.5	436.9	
81.0 - 85.5	0.0000	2	0.6	437.5	436.9	
85.5 - 90.0	0.0000	2	0.6	438.1	435.5	
90.0 - 94.5	0.0000	2	0.6	434.7	434.0	
94.5 - 99.0	0.0000	2	0.6	433.2	432.6	
99.0 - 103.5	0.0000	2	0.6	431.8	431.2	
103.5 - 108.0	0.0000	2	0.6	430.4	429.8	

100.0 - 112.5	0.0000	2	0.6	427.8	426.9
112.5 - 117.0	0.0000	2	0.6	423.2	422.8
117.0 - 121.5	0.0000	2	0.6	416.8	416.2
121.5 - 126.0	0.0000	2	0.6	408.4	407.8
126.0 - 130.5	0.0000	2	0.6	393.1	392.5
130.5 - 135.0	0.0000	2	0.6	369.6	369.1
135.0 - 139.5	0.0000	2	0.6	344.3	343.8
139.5 - 144.0	0.0000	2	0.5	316.8	316.2
144.0 - 148.5	0.0000	2	0.5	248.8	248.8
148.5 - 153.0	0.0000	2	0.5	248.4	248.4

calculated rod temperatures at time = 0.0000 seconds

rod no. 27

assembly 1 (fuel type 2 - cylinder)

rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.367)

* fuel temperatures(f.)						
*						
axial zone	heat flux	type	hsurf	fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-F-ft2)			
0.0 - 4.5	0.0000	2	0.5	267.3	267.2	
4.5 - 9.0	0.0000	2	0.6	357.0	356.9	
9.0 - 13.5	0.0000	2	0.6	407.4	407.2	
13.5 - 18.0	0.0000	2	0.6	431.5	431.3	
18.0 - 22.5	0.0000	2	0.6	444.8	444.3	
22.5 - 27.0	0.0000	2	0.6	450.9	450.6	
27.0 - 31.5	0.0000	2	0.6	457.2	456.9	
31.5 - 36.0	0.0000	2	0.6	463.5	463.2	
36.0 - 40.5	0.0000	2	0.6	468.6	468.4	
40.5 - 45.0	0.0000	2	0.6	472.7	472.4	
45.0 - 49.5	0.0000	2	0.6	476.7	476.5	
49.5 - 54.0	0.0000	2	0.6	477.8	477.5	
54.0 - 58.5	0.0000	2	0.6	478.0	477.7	
58.5 - 63.0	0.0000	2	0.6	478.1	477.8	
63.0 - 67.5	0.0000	2	0.6	478.2	477.9	
67.5 - 72.0	0.0000	2	0.6	478.4	478.1	
72.0 - 76.5	0.0000	2	0.6	478.5	478.2	
76.5 - 81.0	0.0000	2	0.6	478.6	478.4	
81.0 - 85.5	0.0000	2	0.6	478.6	478.4	
85.5 - 90.0	0.0000	2	0.6	477.4	477.1	
90.0 - 94.5	0.0000	2	0.6	476.1	475.8	
94.5 - 99.0	0.0000	2	0.6	474.9	474.6	
99.0 - 103.5	0.0000	2	0.6	473.7	473.4	
103.5 - 108.0	0.0000	2	0.6	472.4	472.1	
108.0 - 112.5	0.0000	2	0.6	469.3	469.1	
112.5 - 117.0	0.0000	2	0.6	464.4	464.1	
117.0 - 121.5	0.0000	2	0.6	457.6	457.3	
121.5 - 126.0	0.0000	2	0.6	449.0	448.7	
126.0 - 130.5	0.0000	2	0.6	431.6	431.3	
130.5 - 135.0	0.0000	2	0.6	403.7	403.4	
135.0 - 139.5	0.0000	2	0.6	373.1	372.9	
139.5 - 144.0	0.0000	2	0.6	339.2	339.0	
144.0 - 148.5	0.0000	2	0.5	248.9	248.9	
148.5 - 153.0	0.0000	2	0.5	248.5	248.5	

calculated rod temperatures at time = 0.0000 seconds

rod no. 36

assembly 1 (fuel type 2 - cylinder)
 Ørod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.367)

				* fuel temperatures(f.)		
				*		
axial zone	heat flux	type	hsurf	*	fluid	clad
(in.)	(mbtu/hr-ft ²)		(b/h-f-ft ²)	*		
0.0 - 4.5	0.0000	2	0.5		276.9	276.8
4.5 - 9.0	0.0000	2	0.6		377.7	377.5
9.0 - 13.5	0.0000	2	0.6		432.4	432.1
13.5 - 18.0	0.0000	2	0.6		458.1	457.7
18.0 - 22.5	0.0000	2	0.6		471.9	471.5
22.5 - 27.0	0.0000	2	0.6		478.2	477.9
27.0 - 31.5	0.0000	2	0.6		484.5	484.1
31.5 - 36.0	0.0000	2	0.6		490.8	490.4
36.0 - 40.5	0.0000	2	0.6		495.7	495.4
40.5 - 45.0	0.0000	2	0.6		499.4	499.1
45.0 - 49.5	0.0000	2	0.6		503.2	502.8
49.5 - 54.0	0.0000	2	0.6		504.2	503.8
54.0 - 58.5	0.0000	2	0.6		504.3	504.0
58.5 - 63.0	0.0000	2	0.6		504.5	504.1
63.0 - 67.5	0.0000	2	0.6		504.6	504.2
67.5 - 72.0	0.0000	2	0.6		504.7	504.3
72.0 - 76.5	0.0000	2	0.6		504.9	504.5
76.5 - 81.0	0.0000	2	0.6		505.0	504.6
81.0 - 85.5	0.0000	2	0.6		505.0	504.6
85.5 - 90.0	0.0000	2	0.6		503.8	503.4
90.0 - 94.5	0.0000	2	0.6		502.7	502.3
94.5 - 99.0	0.0000	2	0.6		501.5	501.1
99.0 - 103.5	0.0000	2	0.6		500.4	500.0
103.5 - 108.0	0.0000	2	0.6		499.2	498.8
108.0 - 112.5	0.0000	2	0.6		498.0	495.6
112.5 - 117.0	0.0000	2	0.6		498.7	498.3
117.0 - 121.5	0.0000	2	0.6		483.7	483.3
121.5 - 126.0	0.0000	2	0.6		474.9	474.5
126.0 - 130.5	0.0000	2	0.6		455.3	455.9
130.5 - 135.0	0.0000	2	0.6		425.7	425.4
135.0 - 139.5	0.0000	2	0.6		392.0	391.7
139.5 - 144.0	0.0000	2	0.6		354.2	353.9
144.0 - 148.5	0.0000	2	0.5		249.1	249.0
148.5 - 153.0	0.0000	2	0.5		240.5	240.5

APPENDIX B

ELECTRICALLY HEATED PWR SINGLE ASSEMBLY SPENT FUEL TEST SIMULATIONS
INPUT, OUTPUT, AND CONVERGENCE LISTS

APPENDIX B

ELECTRICALLY HEATED PWR SINGLE ASSEMBLY SPENT FUEL TEST SIMULATIONS
INPUT, OUTPUT, AND CONVERGENCE LISTS

<u>Test Case</u>	<u>Input</u>	<u>Page Number Convergence List</u>	<u>Output</u>
Vertical, nitrogen	B.2	B.14	B.15
Inclined, nitrogen	B.18	B.30	B.31
Horizontal, nitrogen	B.34	B.46	A.46

.8000

```
1 1 agns vertical nitrogen full-load validation analyses
prop 11 2
1. 100. 133.9 .0154 .240 14.08 .0463
2. 200. 157.9 .0174 .241 18.67 .0518
3. 300. 182.1 .0193 .243 19.23 .0580
4. 400. 206.5 .0212 .245 21.74 .0630
5. 500. 231.1 .0231 .247 24.27 .0680
6. 600. 256.0 .0250 .250 26.81 .0720
7. 700. 281.1 .0268 .253 29.33 .0770
8. 800. 306.7 .0286 .256 31.85 .0810
10. 900. 332.5 .0303 .259 34.36 .0850
15. 1000. 358.6 .0319 .262 36.90 .0889
20. 2000. 617.2 .0471 .286 62.11 .1242
1 can 13.
2steel 100.
chan 2 24
165.3 0.0
1 1 256 0
1 1 0 0 1
1. 21091.321.3299 2.2855.530 17.2855.530
2. 21861.241.6597 3.2855.581 18.161.433
3. 21861.241.6597 4.2855.581 19.161.433
4. 21861.241.6597 5.2855.581 20.161.433
5. 21861.241.6597 6.2855.581 21.161.433
6. 21861.241.6597 7.2855.581 22.161.433
7. 21861.241.6597 8.2855.581 23.161.433
8. 21861.241.6597 9.2855.581 24.161.433
9. 21861.241.6597 10.2855.581 25.161.433
10. 21861.241.6597 11.2855.581 26.161.433
11. 21861.241.6597 12.2855.581 27.161.433
12. 21861.241.6597 13.2855.581 28.161.433
13. 21861.241.6597 14.2855.581 29.161.433
14. 21861.241.6597 15.2855.581 30.161.433
15. 21861.241.6597 16.2855.581 31.161.433
16. 21091.321.3299 32.2855.530
17. 21861.241.6597 18.161.581 33.2855.433
18. 1991.3201.320 19.161.581 34.161.581
19. 1991.3201.320 20.161.581 35.161.581
20. 1991.3201.320 21.161.581 36.161.581
21. 1991.3201.320 22.161.581 37.161.581
22. 1991.3201.320 23.161.581 38.161.581
23. 1991.3201.320 24.161.581 39.161.581
24. 1991.3201.320 25.161.581 40.161.581
25. 1991.3201.320 26.161.581 41.161.581
26. 1991.3201.320 27.161.581 42.161.581
27. 1991.3201.320 28.161.581 43.161.581
28. 1991.3201.320 29.161.581 44.161.581
29. 1991.3201.320 30.161.581 45.161.581
30. 1991.3201.320 31.161.581 46.161.581
31. 1991.3201.320 32.161.433 47.161.581
32. 21861.241.6597 48.2855.581
33. 21861.241.6597 34.161.581 49.2855.433
34. 1991.3201.320 35.161.581 50.161.581
35. 18461.3821.382 36.121.581 51.121.581
36. 18461.3821.382 37.161.581 52.121.581
37. 1991.3201.320 38.161.581 53.161.581
38. 1991.3201.320 39.161.581 54.161.581
39. 1991.3201.320 40.161.581 55.161.581
40. 1991.3201.320 41.161.581 56.161.581
```


41	.1991.3201.320	42	.161.581	57	.161.581
42	.1991.3201.320	43	.161.581	58	.161.581
43	.1991.3201.320	44	.161.581	59	.161.581
44	.1991.3201.320	45	.161.581	60	.161.581
45	.18461.3821.382	46	.121.581	61	.121.581
46	.18461.3821.382	47	.161.581	62	.121.581
47	.1991.3201.320	48	.161.433	63	.161.581
48	.21861.241.6597	64	.2855.581		
49	.21861.241.6597	50	.161.581	65	.2855.433
50	.1991.3201.320	51	.181.581	66	.161.581
51	.18461.3821.382	52	.121.581	67	.161.581
52	.18461.3821.382	53	.161.581	68	.161.581
53	.1991.3201.320	54	.161.581	69	.161.581
54	.1991.3201.320	55	.161.581	70	.161.581
55	.1991.3201.320	56	.161.581	71	.161.581
56	.1991.3201.320	57	.161.581	72	.161.581
57	.1991.3201.320	58	.161.581	73	.161.581
58	.1991.3201.320	59	.161.581	74	.161.581
59	.1991.3201.320	60	.161.581	75	.161.581
60	.1991.3201.320	61	.161.581	76	.161.581
61	.18461.3821.382	62	.121.581	77	.161.581
62	.18461.3821.382	63	.161.581	78	.161.581
63	.1991.3201.320	64	.161.433	79	.161.581
64	.21861.241.6597	68	.2855.581		
65	.21861.241.6597	66	.161.581	81	.2855.433
66	.1991.3201.320	67	.161.581	82	.161.581
67	.1991.3201.320	68	.161.581	83	.161.581
68	.1991.3201.320	69	.161.581	84	.161.581
69	.18461.3821.382	70	.121.581	85	.121.581
70	.18461.3821.382	71	.161.581	86	.121.581
71	.1991.3201.320	72	.161.581	87	.161.581
72	.1991.3201.320	73	.161.581	88	.161.581
73	.1991.3201.320	74	.161.581	89	.161.581
74	.1991.3201.320	75	.161.581	90	.161.581
75	.18461.3821.382	76	.121.581	91	.121.581
76	.18461.3821.382	77	.161.581	92	.121.581
77	.1991.3201.320	78	.161.581	93	.161.581
78	.1991.3201.320	79	.161.581	94	.161.581
79	.18461.3821.382	80	.121.433	95	.121.581
80	.20421.304.7226	96	.2455.581		
81	.21861.241.6597	82	.161.581	97	.2855.433
82	.1991.3201.320	83	.161.581	98	.161.581
83	.1991.3201.320	84	.161.581	99	.161.581
84	.1991.3201.320	85	.161.581	100	.161.581
85	.18461.3821.382	86	.121.581	101	.161.581
86	.18461.3821.382	87	.161.581	102	.161.581
87	.1991.3201.320	88	.161.581	103	.161.581
88	.1991.3201.320	89	.161.581	104	.161.581
89	.1991.3201.320	90	.161.581	105	.161.581
90	.1991.3201.320	91	.161.581	106	.161.581
91	.18461.3821.382	92	.121.581	107	.161.581
92	.18461.3821.382	93	.161.581	108	.161.581
93	.1991.3201.320	94	.161.581	109	.161.581
94	.1991.3201.320	95	.161.581	110	.161.581
95	.18461.3821.382	96	.121.433	111	.161.581
96	.20421.304.7226	112	.2455.581		
97	.21861.241.6597	98	.161.581	113	.2855.433
98	.1991.3201.320	99	.161.581	114	.161.581
99	.1991.3201.320	100	.161.581	115	.161.581
100	.1991.3201.320	101	.161.581	116	.161.581

101	1991	3201	320	102	161	581	117	161	581
102	1991	3201	320	103	161	581	118	161	581
103	1991	3201	320	104	161	581	119	161	581
104	1991	3201	320	105	161	581	120	161	581
105	1991	3201	320	106	161	581	121	161	581
106	1991	3201	320	107	161	581	122	161	581
107	1991	3201	320	108	161	581	123	161	581
108	1991	3201	320	109	161	581	124	161	581
109	1991	3201	320	110	161	581	125	161	581
110	1991	3201	320	111	161	581	126	161	581
111	1991	3201	320	112	161	433	127	161	581
112	21061	241	6597	120	2855	581			
113	21061	241	6597	114	161	581	129	2855	433
114	1991	3201	320	115	161	581	130	161	581
115	1991	3201	320	116	161	581	131	161	581
116	1991	3201	320	117	161	581	132	161	581
117	1991	3201	320	118	161	581	133	161	581
118	1991	3201	320	119	161	581	134	161	581
119	1991	3201	320	120	161	581	135	161	581
120	18461	3821	382	121	121	581	136	121	581
121	18461	3821	382	122	161	581	137	121	581
122	1991	3201	320	123	161	581	138	161	581
123	1991	3201	320	124	161	581	139	161	581
124	1991	3201	320	125	161	581	140	161	581
125	1991	3201	320	126	161	581	141	161	581
126	1991	3201	320	127	161	581	142	161	581
127	1991	3201	320	128	161	433	143	161	581
128	21061	241	6597	144	2855	581			
129	21061	241	6597	130	161	581	145	2855	433
130	1991	3201	320	131	161	581	146	161	581
131	1991	3201	320	132	161	581	147	161	581
132	1991	3201	320	133	161	581	148	161	581
133	1991	3201	320	134	161	581	149	161	581
134	1991	3201	320	135	161	581	150	161	581
135	1991	3201	320	136	161	581	151	161	581
136	18461	3821	382	137	121	581	152	161	581
137	18461	3821	382	138	161	581	153	161	581
138	1991	3201	320	139	161	581	154	161	581
139	1991	3201	320	140	161	581	155	161	581
140	1991	3201	320	141	161	581	156	161	581
141	1991	3201	320	142	161	581	157	161	581
142	1991	3201	320	143	161	581	158	161	581
143	1991	3201	320	144	161	433	159	161	581
144	21061	241	6597	160	2855	581			
145	21061	241	6597	146	161	581	161	2855	433
146	1991	3201	320	147	161	581	162	161	581
147	1991	3201	320	148	161	581	163	161	581
148	1991	3201	320	149	161	581	164	161	581
149	1991	3201	320	150	161	581	165	161	581
150	1991	3201	320	151	161	581	166	161	581
151	1991	3201	320	152	161	581	167	161	581
152	1991	3201	320	153	161	581	168	161	581
153	1991	3201	320	154	161	581	169	161	581
154	1991	3201	320	155	161	581	170	161	581
155	1991	3201	320	156	161	581	171	161	581
156	1991	3201	320	157	161	581	172	161	581
157	1991	3201	320	158	161	581	173	161	581
158	1991	3201	320	159	161	581	174	161	581
159	1991	3201	320	160	161	433	175	161	581
160	21061	241	6597	176	2855	581			

161.21861.241.6597	162	.161	.581	177.2855	.433
162.1991.3281.328	163	.161	.581	178	.161 .581
163.1991.3281.328	164	.161	.581	179	.161 .581
164.1991.3281.328	165	.161	.581	180	.161 .581
165.18461.3821.382	166	.121	.581	181	.121 .581
166.18461.3821.382	167	.161	.581	182	.121 .581
167.1991.3281.328	168	.161	.581	183	.161 .581
168.1991.3281.328	169	.161	.581	184	.161 .581
169.1991.3281.328	170	.161	.581	185	.161 .581
170.1991.3281.328	171	.161	.581	186	.161 .581
171.18461.3821.382	172	.121	.581	187	.121 .581
172.18461.3821.382	173	.161	.581	188	.121 .581
173.1991.3281.328	174	.161	.581	189	.161 .581
174.1991.3281.328	175	.161	.581	190	.161 .581
175.18461.3821.382	176	.121	.433	191	.161 .581
176.28421.384.7226	192	.2455	.581		
177.21861.241.6597	178	.161	.581	193.2855	.433
178.1991.3281.328	179	.161	.581	194	.161 .581
179.1991.3281.328	180	.161	.581	195	.161 .581
180.1991.3281.328	181	.161	.581	196	.161 .581
181.18461.3821.382	182	.121	.581	197	.161 .581
182.18461.3821.382	183	.161	.581	198	.161 .581
183.1991.3281.328	184	.161	.581	199	.161 .581
184.1991.3281.328	185	.161	.581	200	.161 .581
185.1991.3281.328	186	.161	.581	201	.161 .581
186.1991.3281.328	187	.161	.581	202	.161 .581
187.18461.3821.382	188	.121	.581	203	.161 .581
188.18461.3821.382	189	.161	.581	204	.161 .581
189.1991.3281.328	190	.161	.581	205	.161 .581
190.1991.3281.328	191	.161	.581	206	.161 .581
191.18461.3821.382	192	.121	.433	207	.161 .581
192.28421.384.7226	208	.2455	.581		
193.21861.241.6597	194	.161	.581	209.2855	.433
194.1991.3281.328	195	.161	.581	210	.161 .581
195.18461.3821.382	196	.121	.581	211	.121 .581
196.18461.3821.382	197	.161	.581	212	.121 .581
197.1991.3281.328	198	.161	.581	213	.161 .581
198.1991.3281.328	199	.161	.581	214	.161 .581
199.1991.3281.328	200	.161	.581	215	.161 .581
200.1991.3281.328	201	.161	.581	216	.161 .581
201.1991.3281.328	202	.161	.581	217	.161 .581
202.1991.3281.328	203	.161	.581	218	.161 .581
203.1991.3281.328	204	.161	.581	219	.161 .581
204.1991.3281.328	205	.161	.581	220	.161 .581
205.18461.3821.382	206	.121	.581	221	.121 .581
206.18461.3821.382	207	.161	.581	222	.121 .581
207.1991.3281.328	208	.161	.433	223	.161 .581
208.21861.241.6597	224	.2855	.581		
209.21861.241.6597	210	.161	.581	225.2855	.433
210.1991.3281.328	211	.161	.581	226	.161 .581
211.18461.3821.382	212	.121	.581	227	.161 .581
212.18461.3821.382	213	.161	.581	228	.161 .581
213.19901.3281.328	214	.161	.581	229	.161 .581
214.19901.3281.328	215	.161	.581	230	.161 .581
215.19901.3281.328	216	.161	.581	231	.161 .581
216.19901.3281.328	217	.161	.581	232	.161 .581
217.19901.3281.328	218	.161	.581	233	.161 .581
218.19901.3281.328	219	.161	.581	234	.161 .581
219.19901.3281.328	220	.161	.581	235	.161 .581
220.19901.3281.328	221	.161	.581	236	.161 .581

221.18481.3821.382	222.121.581	237.161.581								
222.18481.3821.382	223.161.581	238.161.581								
223.1991.3281.328	224.161.433	239.161.581								
224.21861.241.8597	240.2855.581									
225.21861.241.8597	226.161.581	241.2855.538								
226.1991.3281.328	227.161.581	242.161.433								
227.1991.3281.328	228.161.581	243.161.433								
228.1991.3281.328	229.161.581	244.161.433								
229.1991.3281.328	230.161.581	245.161.433								
230.1991.3281.328	231.161.581	246.161.433								
231.1991.3281.328	232.161.581	247.161.433								
232.1991.3281.328	233.161.581	248.161.433								
233.1991.3281.328	234.161.581	249.161.433								
234.1991.3281.328	236.161.581	250.161.433								
235.1991.3281.328	236.161.581	251.161.433								
236.1991.3281.328	237.161.581	252.161.433								
237.1991.3281.328	238.161.581	253.161.433								
238.1991.3281.328	239.161.581	254.161.433								
239.1991.3281.328	240.161.433	255.161.433								
240.21861.241.8597	256.2855.538									
241.21861.321.3299	242.2855.538									
242.21861.241.8597	243.2855.581									
243.21861.241.8597	244.2855.581									
244.21861.241.8597	245.2855.581									
245.21861.241.8597	246.2855.581									
246.21861.241.8597	247.2855.581									
247.21861.241.8597	248.2855.581									
248.21861.241.8597	249.2855.581									
249.21861.241.8597	250.2855.581									
250.21861.241.8597	251.2855.581									
251.21861.241.8597	252.2855.581									
252.21861.241.8597	253.2855.581									
253.21861.241.8597	254.2855.581									
254.21861.241.8597	255.2855.581									
255.21861.241.8597	256.2855.538									
256.21861.321.3299										
2	2	18								
0	1	0	0	1						
2	18.1584.888	0.	21.588	5.44	82.121	5.44	96.188	2.83		
2	28.1584.888	0.	32.121	5.44	106.188	2.83				
2	38.1584.888	0.	41.588	5.44	116.188	2.83				
2	48.1584.888	0.	52.121	5.44	126.188	2.83				
2	58.1584.888	0.	61.588	5.44	136.188	2.83				
2	68.1584.888	0.	72.121	5.44	146.188	2.83				
2	78.1584.888	0.	81.588	5.44	156.188	2.83				
2	88.1584.888	0.	166.188	2.83						
2	918.928.872	0.	102.583	4.13						
2	1018.928.872	0.								
2	1118.928.872	0.	122.583	4.13						
2	1218.928.872	0.								
2	1318.928.872	0.	142.583	4.13						
2	1418.928.872	0.								
2	1518.928.872	0.	162.583	4.13						
2	1618.928.872	0.								
rods	1	1	1	0	0	1				
1	1	225								
1	.42	1.	1	.25	2	.25	17	.25	18	.25
2	.42	1.	2	.25	3	.25	18	.25	19	.25
3	.42	1.	3	.25	4	.25	19	.25	20	.25

4	.42	1.	4	.25	5	.25	20	.25	21	.25
5	.42	1.	5	.25	6	.25	21	.25	22	.25
6	.42	1.	6	.25	7	.25	22	.25	23	.25
7	.42	1.	7	.25	8	.25	23	.25	24	.25
8	.42	1.	8	.25	9	.25	24	.25	25	.25
9	.42	1.	9	.25	10	.25	25	.25	26	.25
10	.42	1.	10	.25	11	.25	26	.25	27	.25
11	.42	1.	11	.25	12	.25	27	.25	28	.25
12	.42	1.	12	.25	13	.25	28	.25	29	.25
13	.42	1.	13	.25	14	.25	29	.25	30	.25
14	.42	1.	14	.25	15	.25	30	.25	31	.25
15	.42	1.	15	.25	16	.25	31	.25	32	.25
16	.42	1.	17	.25	18	.25	33	.25	34	.25
17	.42	1.	18	.26	19	.26	34	.25	35	.25
18	.42	1.	19	.25	20	.25	35	.25	36	.25
19	.42	1.	20	.25	21	.25	36	.25	37	.25
20	.42	1.	21	.25	22	.25	37	.25	38	.25
21	.42	1.	22	.25	23	.25	38	.25	39	.25
22	.42	1.	23	.25	24	.26	39	.25	40	.25
23	.42	1.	24	.25	25	.25	40	.25	41	.25
24	.42	1.	25	.25	26	.25	41	.25	42	.25
25	.42	1.	26	.25	27	.25	42	.25	43	.25
26	.42	1.	27	.25	28	.25	43	.25	44	.25
27	.42	1.	28	.25	29	.25	44	.25	45	.25
28	.42	1.	29	.25	30	.25	45	.25	46	.25
29	.42	1.	30	.25	31	.25	46	.25	47	.25
30	.42	1.	31	.25	32	.26	47	.25	48	.25
31	.42	1.	33	.26	34	.25	49	.25	50	.25
32	.42	1.	34	.25	35	.25	50	.25	51	.25
33	0.42	0.	35	.25	36	.25	51	.25	52	.25
34	.42	1.	36	.25	37	.25	52	.25	53	.25
35	.42	1.	37	.25	38	.25	53	.25	54	.25
36	.42	1.	38	.25	39	.25	54	.25	55	.25
37	.42	1.	39	.25	40	.25	55	.25	56	.25
38	.42	1.	40	.25	41	.25	56	.25	57	.25
39	.42	1.	41	.25	42	.25	57	.25	58	.25
40	.42	1.	42	.25	43	.25	58	.25	59	.25
41	.42	1.	43	.25	44	.25	59	.25	60	.25
42	.42	1.	44	.25	45	.25	60	.25	61	.25
43	0.42	0.	45	.25	46	.25	61	.25	62	.25
44	.42	1.	46	.25	47	.25	62	.25	63	.25
45	.42	1.	47	.25	48	.25	63	.25	64	.25
46	.42	1.	49	.25	50	.25	65	.25	66	.25
47	.42	1.	50	.25	51	.25	66	.25	67	.25
48	.42	1.	51	.25	52	.25	67	.25	68	.25
49	.42	1.	52	.25	53	.25	68	.25	69	.25
50	.42	1.	53	.25	54	.25	69	.25	70	.25
51	.42	1.	54	.25	55	.25	70	.25	71	.25
52	.42	1.	55	.25	56	.25	71	.25	72	.25
53	.42	1.	56	.25	57	.25	72	.25	73	.25
54	.42	1.	57	.25	58	.25	73	.25	74	.25
55	.42	1.	58	.25	59	.25	74	.25	75	.25
56	.42	1.	59	.25	60	.25	75	.25	76	.25
57	.42	1.	60	.25	61	.25	76	.25	77	.25
58	.42	1.	61	.25	62	.25	77	.25	78	.25
59	.42	1.	62	.25	63	.25	78	.25	79	.25
60	.42	1.	63	.25	64	.25	79	.25	80	.25
61	.42	0.	65	.25	66	.25	81	.25	82	.25
62	.42	1.	66	.25	67	.25	82	.25	83	.25
63	.42	1.	67	.25	68	.25	83	.25	84	.25

64	.42	1.	68	.25	69	.25	84	.25	85	.25
65	0.42	0.	69	.25	70	.25	85	.25	86	.25
66	.42	1.	70	.25	71	.25	86	.25	87	.25
67	.42	1.	71	.25	72	.25	87	.25	88	.25
68	.42	1.	72	.25	73	.25	88	.25	89	.25
69	.42	1.	73	.25	74	.25	89	.25	90	.25
70	.42	1.	74	.25	75	.25	90	.25	91	.25
71	0.42	0.	75	.25	76	.25	91	.25	92	.25
72	.42	1.	76	.25	77	.25	92	.25	93	.25
73	.42	1.	77	.25	78	.25	93	.25	94	.25
74	.42	1.	78	.25	79	.25	94	.25	95	.25
75	0.42	0.	79	.25	80	.25	95	.25	96	.25
76	.42	1.	81	.25	82	.25	97	.25	98	.25
77	.42	1.	82	.25	83	.25	98	.25	99	.25
78	.42	1.	83	.25	84	.25	99	.25	100	.25
79	.42	1.	84	.25	85	.25	100	.25	101	.25
80	.42	1.	85	.25	86	.25	101	.25	102	.25
81	.42	1.	86	.25	87	.25	102	.25	103	.25
82	.42	1.	87	.25	88	.25	103	.25	104	.25
83	.42	1.	88	.25	89	.25	104	.25	105	.25
84	.42	1.	89	.25	90	.25	105	.25	106	.25
85	.42	1.	90	.25	91	.25	106	.25	107	.25
86	.42	1.	91	.25	92	.25	107	.25	108	.25
87	.42	1.	92	.25	93	.25	108	.25	109	.25
88	.42	1.	93	.25	94	.25	109	.25	110	.25
89	.42	1.	94	.25	95	.25	110	.25	111	.25
90	.42	1.	95	.25	96	.25	111	.25	112	.25
91	.42	1.	97	.25	98	.25	113	.25	114	.25
92	.42	0.	98	.25	99	.25	114	.25	115	.25
93	.42	1.	99	.25	100	.25	115	.25	116	.25
94	.42	1.	100	.25	101	.25	116	.25	117	.25
95	.42	1.	101	.25	102	.25	117	.25	118	.25
96	.42	1.	102	.25	103	.25	118	.25	119	.25
97	.42	1.	103	.25	104	.25	119	.25	120	.25
98	.42	1.	104	.25	105	.25	120	.25	121	.25
99	.42	1.	105	.25	106	.25	121	.25	122	.25
100	.42	1.	106	.25	107	.25	122	.25	123	.25
101	.42	1.	107	.25	108	.25	123	.25	124	.25
102	.42	1.	108	.25	109	.25	124	.25	125	.25
103	.42	1.	109	.25	110	.25	125	.25	126	.25
104	.42	0.	110	.25	111	.25	126	.25	127	.25
105	.42	1.	111	.25	112	.25	127	.25	128	.25
106	.42	1.	113	.25	114	.25	129	.25	130	.25
107	.42	1.	114	.25	115	.25	130	.25	131	.25
108	.42	1.	115	.25	116	.25	131	.25	132	.25
109	.42	1.	116	.25	117	.25	132	.25	133	.25
110	.42	1.	117	.25	118	.25	133	.25	134	.25
111	.42	1.	118	.25	119	.25	134	.25	135	.25
112	.42	1.	119	.25	120	.25	135	.25	136	.25
113	0.42	0.	120	.25	121	.25	136	.25	137	.25
114	.42	1.	121	.25	122	.25	137	.25	138	.25
115	.42	1.	122	.25	123	.25	138	.25	139	.25
116	.42	1.	123	.25	124	.25	139	.25	140	.25
117	.42	1.	124	.25	125	.25	140	.25	141	.25
118	.42	1.	125	.25	126	.25	141	.25	142	.25
119	.42	1.	126	.25	127	.25	142	.25	143	.25
120	.42	1.	127	.25	128	.25	143	.25	144	.25
121	.42	1.	129	.25	130	.25	145	.25	146	.25
122	.42	1.	130	.25	131	.25	146	.25	147	.25
123	.42	1.	131	.25	132	.25	147	.25	148	.25

124	.42	1.	132	.25	133	.25	148	.25	149	.25
125	.42	1.	133	.25	134	.25	149	.25	150	.25
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127	.42	1.	135	.25	138	.25	151	.25	152	.25
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132	.42	1.	140	.25	141	.25	156	.25	157	.25
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134	.42	1.	142	.25	143	.25	158	.25	159	.25
135	.42	1.	143	.25	144	.25	159	.25	160	.25
136	.42	1.	145	.25	146	.25	161	.25	162	.25
137	.42	1.	146	.25	147	.25	162	.25	163	.25
138	.42	1.	147	.25	148	.25	163	.25	164	.25
139	.42	1.	148	.25	149	.25	164	.25	165	.25
140	.42	1.	149	.25	150	.25	165	.25	166	.25
141	.42	1.	150	.25	151	.25	166	.25	167	.25
142	.42	1.	151	.25	152	.25	167	.25	168	.25
143	.42	1.	152	.25	153	.25	168	.25	169	.25
144	.42	1.	153	.25	154	.25	169	.25	170	.25
145	.42	1.	154	.25	155	.25	170	.25	171	.25
146	.42	1.	155	.25	156	.25	171	.25	172	.25
147	.42	1.	156	.25	157	.25	172	.25	173	.25
148	.42	1.	157	.25	158	.25	173	.25	174	.25
149	.42	1.	158	.25	159	.25	174	.25	175	.25
150	.42	1.	159	.25	160	.25	175	.25	176	.25
151	.42	0.	161	.25	162	.25	177	.25	178	.25
152	.42	1.	162	.25	163	.25	178	.25	179	.25
153	.42	1.	163	.25	164	.25	179	.25	180	.25
154	.42	1.	164	.25	165	.25	180	.25	181	.25
155	0.42	0.	165	.25	166	.25	181	.25	182	.25
156	.42	1.	166	.25	167	.25	182	.25	183	.25
157	.42	1.	167	.25	168	.25	183	.25	184	.25
158	.42	1.	168	.25	169	.25	184	.25	185	.25
159	.42	1.	169	.25	170	.25	185	.25	186	.25
160	.42	1.	170	.25	171	.25	186	.25	187	.25
161	0.42	0.	171	.25	172	.25	187	.25	188	.25
162	.42	1.	172	.25	173	.25	188	.25	189	.25
163	.42	1.	173	.25	174	.25	189	.25	190	.25
164	.42	1.	174	.25	175	.25	190	.25	191	.25
165	0.42	0.	175	.25	176	.25	191	.25	192	.25
166	.42	1.	177	.25	178	.25	193	.25	194	.25
167	.42	1.	178	.25	179	.25	194	.25	195	.25
168	.42	1.	179	.25	180	.25	195	.25	196	.25
169	.42	1.	180	.25	181	.25	196	.25	197	.25
170	.42	1.	181	.25	182	.25	197	.25	198	.25
171	.42	1.	182	.25	183	.25	198	.25	199	.25
172	.42	1.	183	.25	184	.25	199	.25	200	.25
173	.42	1.	184	.25	185	.25	200	.25	201	.25
174	.42	1.	185	.25	186	.25	201	.25	202	.25
175	.42	1.	186	.25	187	.25	202	.25	203	.25
176	.42	1.	187	.25	188	.25	203	.25	204	.25
177	.42	1.	188	.25	189	.25	204	.25	205	.25
178	.42	1.	189	.25	190	.25	205	.25	206	.25
179	.42	1.	190	.25	191	.25	206	.25	207	.25
180	.42	1.	191	.25	192	.25	207	.25	208	.25
181	.42	1.	193	.25	194	.25	209	.25	210	.25
182	.42	1.	194	.25	195	.25	210	.25	211	.25
183	0.42	0.	195	.25	196	.25	211	.25	212	.25

184	.42	1.	196	.25	197	.25	212	.25	213	.25
185	.42	1.	197	.25	198	.25	213	.25	214	.25
186	.42	1.	198	.25	199	.25	214	.25	215	.25
187	.42	1.	199	.25	200	.25	215	.25	216	.25
188	.42	1.	200	.25	201	.25	216	.25	217	.25
189	.42	1.	201	.25	202	.25	217	.25	218	.25
190	.42	1.	202	.25	203	.25	218	.25	219	.25
191	.42	1.	203	.25	204	.25	219	.25	220	.25
192	.42	1.	204	.25	205	.25	220	.25	221	.25
193	.42	0.	205	.25	206	.25	221	.25	222	.25
194	.42	1.	206	.25	207	.25	222	.25	223	.25
195	.42	1.	207	.25	208	.25	223	.25	224	.25
196	.42	1.	209	.25	210	.25	225	.25	226	.25
197	.42	1.	210	.25	211	.25	226	.25	227	.25
198	.42	1.	211	.25	212	.25	227	.25	228	.25
199	.42	1.	212	.25	213	.25	228	.25	229	.25
200	.42	1.	213	.25	214	.25	229	.25	230	.25
201	.42	1.	214	.25	215	.25	230	.25	231	.25
202	.42	1.	215	.25	216	.25	231	.25	232	.25
203	.42	1.	216	.25	217	.25	232	.25	233	.25
204	.42	1.	217	.25	218	.25	233	.25	234	.25
205	.42	1.	218	.25	219	.25	234	.25	235	.25
206	.42	1.	219	.25	220	.25	235	.25	236	.25
207	.42	1.	220	.25	221	.25	236	.25	237	.25
208	.42	1.	221	.25	222	.25	237	.25	238	.25
209	.42	1.	222	.25	223	.25	238	.25	239	.25
210	.42	1.	223	.25	224	.25	239	.25	240	.25
211	.42	1.	225	.25	226	.25	241	.25	242	.25
212	.42	1.	226	.25	227	.25	242	.25	243	.25
213	.42	1.	227	.25	228	.25	243	.25	244	.25
214	.42	1.	228	.25	229	.25	244	.25	245	.25
215	.42	1.	229	.25	230	.25	245	.25	246	.25
216	.42	1.	230	.25	231	.25	246	.25	247	.25
217	.42	1.	231	.25	232	.25	247	.25	248	.25
218	.42	1.	232	.25	233	.25	248	.25	249	.25
219	.42	1.	233	.25	234	.25	249	.25	250	.25
220	.42	1.	234	.25	235	.25	250	.25	251	.25
221	.42	1.	235	.25	236	.25	251	.25	252	.25
222	.42	1.	236	.25	237	.25	252	.25	253	.25
223	.42	1.	237	.25	238	.25	253	.25	254	.25
224	.42	1.	238	.25	239	.25	254	.25	255	.25
225	.42	1.	239	.25	240	.25	255	.25	256	.25
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3.0	.059	.655	.350	10.	0.1	409.	.0251000.	.420		
slab	2	3	16							
1					3078.					
2					989.					
1	1	.95			2	2	1	8	1	
2	1	.95			1	3	1			
3	1	.95			1	4	1			
4	1	.95			1	5	1			
5	1	.95			1	6	1			
6	1	.95			1	7	1			
7	1	.95			1	8	1			
8	1	.95								
9	2	1.74			2	10	2	16	2	
10	2	1.74			1	11	2			
11	2	1.74			1	12	2			
12	2	1.74			1	13	2			
13	2	1.74			1	14	2			

14	2	1.74			1	15	2							
15	2	1.74			1	16	2							
16	2	1.74												
1		34.20		.5581										
2		12.145		4.614		989.								
3		8130		6.684										
1	9	1	1	1	1	2	1	1	3	1	1	4	1	
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			2	1	2									
2	9	1	9	1	1	10	1	1	11	1	1	12	1	
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			2	2	2									
3	9	1	16	1	1	32	1	1	48	1	1	64	1	
			1	86	1	1	96	1	1	112	1	1	128	1
			2	3	2									
4	9	1	144	1	1	180	1	1	176	1	1	192	1	
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			2	4	2									
5	9	1	249	1	1	250	1	1	251	1	1	249	1	
			1	253	1	1	254	1	1	255	1	1	256	1
			2	5	2									
6	9	1	241	1	1	242	1	1	243	1	1	244	1	
			1	245	1	1	246	1	1	247	1	1	248	1
			2	6	2									
7	9	1	129	1	1	145	1	1	161	1	1	177	1	
			1	193	1	1	209	1	1	225	1	1	241	1
			2	7	2									
8	9	1	1	1	1	17	1	1	33	1	1	49	1	
			1	85	1	1	81	1	1	97	1	1	113	1
			2	8	2									
9	1	2	09	3										
10	1	2	10	3										
11	1	2	11	3										
12	1	2	12	3										
13	1	2	13	3										
14	1	2	14	3										
15	1	2	15	3										
16	1	2	16	3										

radg	2	1	1											
1	16													
14.614	.25	1.0016	2.0	3.0	4.0	5.0	6.0							
		7.0	8.0	9.6808	10.2656	11.8085	12.0							
		13.0	14.0	15.0	16.0435									
24.614	.25	1.0	2.0016	3.0	4.0	5.0	6.0							
		7.0	8.0	9.2656	10.6808	11.8435	12.0							
		13.0	14.0	15.0	16.0085									
34.614	.25	1.0	2.0	3.0016	4.0	5.0	6.0							
		7.0	8.0	9.0	10.0435	11.6808	12.2656							
		13.0085	14.0	15.0	16.0									
44.614	.25	1.0	2.0	3.0	4.0016	5.0	6.0							
		7.0	8.0	9.0	10.0085	11.2656	12.6808							
		13.0435	14.0	15.0	16.0									
54.614	.25	1.0	2.0	3.0	4.0	5.0016	6.0							
		7.0	8.0	9.0	10.0	11.0	12.0435							
		13.6808	14.2656	15.0085	16.0									
64.614	.25	1.0	2.0	3.0	4.0	5.0	6.0016							
		7.0	8.0	9.0	10.0	11.0	12.0085							
		13.2656	14.6808	15.0435	16.0									
74.614	.25	1.0	2.0	3.0	4.0	5.0	6.0							

			7.0016	8.0	9.0085	10.0	11.0	12.0		
			13.0	14.0435	15.6000	16.2656				
84.614	.25		1.0	2.0	3.0	4.0	5.0	6.0		
			7.0	8.0016	9.0435	10.0	11.0	12.0		
			13.0	14.0085	15.2656	16.6000				
96.684	.6		1.4700	2.1833	3.0	4.0	5.0	6.0		
			7.0059	8.03	9.0271	10.0734	11.0037	12.0		
			13.0	14.0134	15.0037	16.0695				
108.684	.8		1.1833	2.4700	3.0300	4.0059	5.0	6.0		
			7.0	8.0	9.0734	10.0271	11.0095	12.0037		
			13.0134	14.0	15.0	16.0037				
116.684	.6		1.0059	2.03	3.47	4.1833	5.0	6.0		
			7.0	8.0	9.0637	10.0095	11.0271	12.0734		
			13.0037	14.0	15.0	16.0134				
128.684	.8		1.0	2.0	3.1833	4.47	5.03	6.0059		
			7.0	8.0	9.0000	10.0637	11.0734	12.0271		
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136.684	.6		1.0	2.0	3.0059	4.0300	5.47	6.1833		
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146.684	.8		1.0	2.0	3.0	4.0	5.1833	6.4700		
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			13.0734	14.0271	15.0095	16.0037				
156.684	.6		1.0	2.0	3.0	4.0	5.0059	6.03		
			7.47	8.1833	9.0637	10.0	11.0	12.0134		
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166.684	.6		1.03	2.0059	3.0	4.0	5.0	6.0		
			7.1833	8.4700	9.0695	10.0037	11.0134	12.0		
			13.0	14.0037	15.0734	16.0271				
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2	-1	16	1	2	3	4	5	6	7	8
			9	10	11	12				
			13	14	15	16				
heat	1	0	1							
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1.0	1.0									
drag	2	2								
100	-1.0				100	-1.0	.05			
100	-1.0				100	-1.0	50.			
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7	1	17	.066	1.155	1.276	4.393	1.454	4.699	4.	
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7	32	33	.066	1.155	1.276	4.393	1.454	4.699	4.	
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7	48	49	.066	1.155	1.276	4.393	1.454	4.699	4.	
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7	96	97	.066	1.155	1.276	4.393	1.454	4.699	4.	
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7	144	145	.066	1.155	1.276	4.393	1.454	4.699	4.	
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```

outp 1101
 endd

data from iterative solution using the recirculation module
 time = 0.0000 dt = ***** implicit dt = 0.0000 explicit dt = 3.2688 mode = 0

iteration no.	sweep no.	peak clad				total flow (lbs/a)	pressure drop(psi)	error			
		temp(f)	fluid	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	519.7	24	128	1	0.498e-10	0.0048675	13.5006	1.3823	0.0462	0.0118
	2	522.2	24	128	1			-0.0252	1.3823	0.0256	0.0046
2	1	526.0	24	128	1	0.216e-10	0.0047013	-0.0557	3.1935	0.0557	0.0038
	2	536.3	23	128	1			0.0120	3.1935	0.0256	0.0049
3	1	538.2	24	128	1	0.894e-12	0.0047092	0.0444	1.4453	0.0052	0.0013
	2	543.9	23	128	1			0.0203	1.4453	0.0229	0.0013
4	1	544.9	22	128	1	-0.245e-10	0.0047134	-0.0187	1.1330	0.0028	0.0004
	2	548.3	22	128	1			0.0149	1.1330	0.0183	0.0008
5	1	548.9	22	128	1	-0.674e-10	0.0047165	0.0233	1.1794	0.0018	0.0002
	2	550.0	21	128	1			0.0108	1.1794	0.0119	0.0005
6	1	550.9	21	128	1	-0.189e-09	0.0047193	0.0125	1.0867	0.0024	0.0001
	2	551.7	21	128	1			0.0075	1.0867	0.0048	0.0002
7	1	551.0	21	128	1	-0.935e-10	0.0047215	-0.0036	1.1215	0.0025	0.0001
	2	552.1	21	128	1			0.0058	1.1215	0.0049	0.0001
8	1	552.2	21	128	1	-0.467e-10	0.0047232	0.0038	1.1085	0.0024	0.0001
	2	552.2	21	128	1			0.0053	1.1085	0.0034	0.0001
9	1	552.2	21	128	1	-0.102e-10	0.0047245	0.0017	1.0738	0.0024	0.0001
	2	552.2	21	128	1			0.0051	1.0738	0.0034	0.0001
10	1	552.2	21	128	1	0.760e-11	0.0047255	0.0041	0.9731	0.0023	0.0001
	2	552.0	21	128	1			0.0053	0.9731	0.0029	0.0001
11	1	552.0	21	128	1	0.125e-10	0.0047264	0.0015	0.9550	0.0022	0.0001
	2	551.9	21	128	1			0.0055	0.9550	0.0022	0.0001
12	1	551.9	21	128	1	0.112e-10	0.0047271	0.0019	0.9279	0.0021	0.0001
	2	551.7	21	128	1			0.0058	0.9279	0.0018	0.0001
13	1	551.7	21	128	1	0.027e-11	0.0047277	0.0050	0.8909	0.0021	0.0001
	2	551.8	21	128	1			0.0082	0.8909	0.0016	0.0001
14	1	551.6	21	128	1	0.551e-11	0.0047282	0.0029	0.8216	0.0020	0.0001
	2	551.5	21	128	1			0.0064	0.8216	0.0017	0.0001
15	1	551.5	22	128	1	0.345e-11	0.0047287	0.0033	0.5836	0.0020	0.0001
	2	551.4	22	128	1			0.0086	0.5836	0.0016	0.0001
16	1	551.4	22	128	1	0.208e-11	0.0047291	0.0048	0.4248	0.0020	0.0001
	2	551.4	22	128	1			0.0067	0.4248	0.0019	0.0001

17	1	551.4	22	128	1	0.119e-11	0.0047294	0.0040	0.3177	0.0020	0.0001
	2	551.3	22	128	1			0.0009	0.3177	0.0020	0.0001
18	1	551.3	22	128	1	0.618e-12	0.0047297	0.0041	0.2446	0.0020	0.0001
	2	551.3	22	128	1			0.0009	0.2446	0.0020	0.0001
19	1	551.3	22	128	1	0.202e-12	0.0047300	0.0045	0.1937	0.0020	0.0001
	2	551.3	22	128	1			0.0070	0.1937	0.0020	0.0001
20	1	551.3	22	128	1	0.371e-13	0.0047302	0.0044	0.1574	0.0020	0.0001
	2	551.3	22	128	1			0.0070	0.1574	0.0020	0.0001

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 - 6.9	168.01	168.79	168.78	168.78	168.77	168.00	165.03	166.04	168.34	168.34
6.9 - 13.8	197.03	197.02	197.05	197.06	197.90	197.87	197.09	197.00	213.24	213.24
13.8 - 20.7	228.21	228.22	228.30	226.31	226.33	226.27	226.27	226.28	247.75	247.75
20.7 - 27.5	263.48	263.55	263.54	263.50	263.50	263.51	263.31	263.20	272.05	272.05
27.5 - 34.4	296.77	296.89	296.84	296.00	296.87	296.00	296.51	296.45	290.41	290.41
34.4 - 41.3	325.37	325.51	325.43	325.46	325.46	325.39	325.00	325.01	305.67	305.67
41.3 - 48.2	349.43	349.56	349.47	349.50	349.51	349.44	349.12	349.06	317.51	317.51
48.2 - 55.1	369.46	369.59	369.48	369.53	369.54	369.47	369.15	369.09	327.12	327.12
55.1 - 62.0	385.70	385.00	385.77	385.03	385.05	385.00	385.47	385.41	334.03	334.03
62.0 - 68.9	399.14	399.24	399.11	399.18	399.20	399.15	398.83	398.70	339.90	339.90
68.9 - 75.8	409.92	410.01	409.87	409.95	409.98	409.94	409.01	409.55	345.09	345.09
75.8 - 82.6	410.01	410.09	417.93	418.02	418.06	410.02	417.70	417.03	347.21	347.21
82.6 - 89.5	424.10	424.25	424.09	424.18	424.22	424.19	423.87	423.00	348.09	348.09
89.5 - 96.4	428.72	428.79	428.02	428.72	428.76	428.74	428.41	428.34	349.95	349.95
96.4 -103.3	431.05	431.71	431.53	431.04	431.09	431.00	431.34	431.27	349.10	349.10
103.3 -110.2	433.56	433.62	433.44	433.54	433.60	433.50	433.25	433.18	348.23	348.23
110.2 -117.1	434.73	434.79	434.00	434.71	434.76	434.74	434.42	434.34	347.35	347.35
117.1 -124.0	435.22	435.27	435.00	435.19	435.25	435.23	434.90	434.83	346.12	346.12
124.0 -130.9	435.00	435.13	434.94	435.05	435.11	435.09	434.76	434.69	344.72	344.72
130.9 -137.7	434.01	434.07	433.87	433.90	434.04	434.03	433.70	433.62	341.07	341.07
137.7 -144.6	431.02	431.00	431.00	431.79	431.05	431.04	431.50	431.43	337.57	337.57
144.6 -151.5	427.97	428.02	427.02	427.93	427.99	427.98	427.64	427.56	331.37	331.37
151.5 -158.4	420.50	420.54	420.34	420.46	420.51	420.50	420.17	420.10	323.32	323.32
158.4 -165.3	401.78	401.79	401.00	401.77	401.78	401.77	401.03	401.00	314.29	314.29

side boundary temperature summary time = 0.0000 seconds
boundary slab node no. 9

axial zone (inches)	(1)	(2)
0.0 - 6.9	168.34	167.77
6.9 - 13.8	213.24	213.35

13.8 - 20.7	247.75	247.00
20.7 - 27.5	272.05	272.11
27.5 - 34.4	290.41	290.43
34.4 - 41.3	305.67	305.89
41.3 - 48.2	317.51	317.50
48.2 - 55.1	327.12	327.10
55.1 - 62.0	334.03	333.99
62.0 - 68.9	339.98	339.92
68.9 - 75.8	345.09	345.05
75.8 - 82.6	347.21	347.13
82.6 - 89.5	348.09	348.00
89.5 - 96.4	349.95	349.00
96.4 - 103.3	349.10	349.01
103.3 - 110.2	348.23	348.13
110.2 - 117.1	347.35	347.25
117.1 - 124.0	346.12	346.01
124.0 - 130.9	344.72	344.64
130.9 - 137.7	341.07	341.79
137.7 - 144.6	337.57	337.48
144.6 - 151.5	331.37	331.29
151.5 - 158.4	323.32	323.23
158.4 - 165.3	314.29	314.10

calculated rod temperatures at time = 0.0000 seconds

rod no. 1

assembly 1 (fuel type 1 - cylinder)

rod o.d. - 0.420 (in.) zone-(fuel dia.(in.)) - 1-(0.350)

			* fuel temperatures(f.)		
			*		
axial zone	heat flux	type	hsurf	* fluid	clad
(in.)	(mbtu/hr-ft ²)		(b/h-f-ft ²)	*	*
0.0 - 8.9	0.0000	1	1.1	171.4	171.7
8.9 - 13.8	0.0000	1	1.1	189.7	189.6
13.8 - 20.7	0.0000	1	1.2	213.3	212.1
20.7 - 27.5	0.0000	1	1.2	258.0	260.3
27.5 - 34.4	0.0000	1	1.3	297.0	305.1
34.4 - 41.3	0.0000	1	1.3	329.6	338.4
41.3 - 48.2	0.0000	1	1.3	357.3	360.0
48.2 - 55.1	0.0000	1	1.4	380.5	390.0
55.1 - 62.0	0.0000	1	1.4	399.0	410.2
62.0 - 68.9	0.0000	1	1.4	415.2	426.2
68.9 - 75.8	0.0000	1	1.4	427.0	439.3
75.8 - 82.6	0.0000	1	1.4	437.6	449.3
82.6 - 89.5	0.0000	1	1.5	445.1	457.1
89.5 - 96.4	0.0000	1	1.5	450.7	463.0
96.4 - 103.3	0.0000	1	1.5	454.7	467.1
103.3 - 110.2	0.0000	1	1.5	457.3	470.0
110.2 - 117.1	0.0000	1	1.5	459.1	471.9
117.1 - 124.0	0.0000	1	1.5	460.1	473.0
124.0 - 130.9	0.0000	1	1.5	460.4	473.4
130.9 - 137.7	0.0000	1	1.5	459.9	473.0
137.7 - 144.6	0.0000	1	1.5	458.3	471.6
144.6 - 151.5	0.0000	1	1.5	455.4	468.8
151.5 - 158.4	0.0000	1	1.5	449.8	463.5
158.4 - 165.3	0.0000	1	1.4	423.5	429.4

calculated rod temperatures at time = 0.0000 seconds
 rod no. 128
 assembly 1 (fuel type 1 - cylinder)
 Rod o.d. - 0.428 (in.) zone-(fuel dia.(in.)) - 1-(0.350)

				* fuel temperatures(f.)		
				*		
axial zone	heat flux	type	hsurf	* fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2) *			
0.0 - 6.9	0.0000	1	1.3	179.3	179.3	
6.9 - 13.8	0.0000	1	1.3	179.9	180.0	
13.8 - 20.7	0.0000	1	1.3	183.5	184.0	
20.7 - 27.5	0.0000	1	1.4	237.0	247.5	
27.5 - 34.4	0.0000	1	1.5	290.9	300.0	
34.4 - 41.3	0.0000	1	1.5	339.6	347.7	
41.3 - 48.2	0.0000	1	1.6	382.3	389.4	
48.2 - 55.1	0.0000	1	1.7	418.4	424.5	
55.1 - 62.0	0.0000	1	1.7	448.3	453.5	
62.0 - 68.9	0.0000	1	1.7	472.5	477.0	
68.9 - 75.8	0.0000	1	1.8	492.0	495.8	
75.8 - 82.6	0.0000	1	1.8	507.4	510.7	
82.6 - 89.5	0.0000	1	1.8	519.4	522.2	
89.5 - 96.4	0.0000	1	1.8	520.7	531.1	
96.4 - 103.3	0.0000	1	1.8	535.7	537.0	
103.3 - 110.2	0.0000	1	1.8	540.0	542.0	
110.2 - 117.1	0.0000	1	1.8	544.0	546.3	
117.1 - 124.0	0.0000	1	1.8	547.2	548.0	
124.0 - 130.9	0.0000	1	1.8	548.9	550.4	
130.9 - 137.7	0.0000	1	1.8	549.8	551.3	
137.7 - 144.6	0.0000	1	1.8	550.0	551.3	
144.6 - 151.5	0.0000	1	1.8	549.2	550.5	
151.5 - 158.4	0.0000	1	1.8	547.3	548.4	
158.4 - 165.3	0.0000	1	1.8	500.0	502.2	

-8000

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1 1 agns inclined nitrogen full-load validation analyses
prop 11 2
1. 100. 133.9 .0154 .240 14.00 .0463
2. 200. 157.9 .0174 .241 16.87 .0510
3. 300. 182.1 .0193 .243 19.23 .0560
4. 400. 206.5 .0212 .245 21.74 .0630
5. 500. 231.1 .0231 .247 24.27 .0680
6. 600. 256.0 .0250 .250 26.81 .0720
7. 700. 281.1 .0268 .253 29.33 .0770
8. 800. 306.7 .0286 .256 31.85 .0810
10. 900. 332.5 .0303 .259 34.36 .0850
15. 1000. 358.6 .0319 .262 36.90 .0889
20. 2000. 617.2 .0471 .286 62.11 .1242
1 can 13.
2steel 100.
chan 2 24
165.3 65.0
1 1 250 0
1 1 0 0 1
1.21091.321.3299 2.2855 .530 17.2855 .530
2.21061.241.6597 3.2855 .581 18.161 .433
3.21061.241.6597 4.2855 .581 19.161 .433
4.21061.241.6597 5.2855 .581 20.161 .433
5.21061.241.6597 6.2855 .581 21.161 .433
6.21061.241.6597 7.2855 .581 22.161 .433
7.21061.241.6597 8.2855 .581 23.161 .433
8.21061.241.6597 9.2855 .581 24.161 .433
9.21061.241.6597 10.2855 .581 25.161 .433
10.21061.241.6597 11.2855 .581 26.161 .433
11.21061.241.6597 12.2855 .581 27.161 .433
12.21061.241.6597 13.2855 .581 28.161 .433
13.21061.241.6597 14.2855 .581 29.161 .433
14.21061.241.6597 15.2855 .581 30.161 .433
15.21061.241.6597 16.2855 .581 31.161 .433
16.21091.321.3299 32.2855 .530
17.21061.241.6597 18.161 .581 33.2855 .433
18.1991.3201.320 19.161 .581 34.161 .581
19.1991.3201.320 20.161 .581 35.161 .581
20.1991.3201.320 21.161 .581 36.161 .581
21.1991.3201.320 22.161 .581 37.161 .581
22.1991.3201.320 23.161 .581 38.161 .581
23.1991.3201.320 24.161 .581 39.161 .581
24.1991.3201.320 25.161 .581 40.161 .581
25.1991.3201.320 26.161 .581 41.161 .581
26.1991.3201.320 27.161 .581 42.161 .581
27.1991.3201.320 28.161 .581 43.161 .581
28.1991.3201.320 29.161 .581 44.161 .581
29.1991.3201.320 30.161 .581 45.161 .581
30.1991.3201.320 31.161 .581 46.161 .581
31.1991.3201.320 32.161 .433 47.161 .581
32.21061.241.6597 48.2855 .581
33.21061.241.6597 34.161 .581 49.2855 .433
34.1991.3201.320 35.161 .581 50.161 .581
35.18461.3821.382 36.121 .581 51.121 .581
36.18461.3821.382 37.181 .581 52.121 .581
37.1991.3201.320 38.161 .581 53.161 .581
38.1991.3201.320 39.161 .581 54.161 .581
39.1991.3201.320 40.161 .581 55.161 .581
40.1991.3201.320 41.161 .581 56.161 .581
```


41	.1991.3201.320	42	.161.581	57	.161.581
42	.1991.3201.320	43	.161.581	58	.161.581
43	.1991.3201.320	44	.161.581	59	.161.581
44	.1991.3201.320	45	.161.581	60	.161.581
45	.18461.3821.382	46	.121.581	61	.121.581
46	.18461.3821.382	47	.161.581	62	.121.581
47	.1991.3201.320	48	.161.433	63	.161.581
48	.21861.241.6597	64	.2855.581		
49	.21861.241.6597	50	.161.581	65	.2855.433
50	.1991.3201.320	51	.161.581	66	.161.581
51	.18461.3821.382	52	.121.581	67	.161.581
52	.18461.3821.382	53	.161.581	68	.161.581
53	.1991.3201.320	54	.161.581	69	.161.581
54	.1991.3201.320	55	.161.581	70	.161.581
55	.1991.3201.320	56	.161.581	71	.161.581
56	.1991.3201.320	57	.161.581	72	.161.581
57	.1991.3201.320	58	.161.581	73	.161.581
58	.1991.3201.320	59	.161.581	74	.161.581
59	.1991.3201.320	60	.161.581	75	.161.581
60	.1991.3201.320	61	.161.581	76	.161.581
61	.18461.3821.382	62	.121.581	77	.161.581
62	.18461.3821.382	63	.161.581	78	.161.581
63	.1991.3201.320	64	.161.433	79	.161.581
64	.21861.241.6597	80	.2855.581		
65	.21861.241.6597	66	.161.581	61	.2855.433
66	.1991.3201.320	67	.161.581	82	.161.581
67	.1991.3201.320	68	.161.581	83	.161.581
68	.1991.3201.320	69	.161.581	84	.161.581
69	.18461.3821.382	70	.121.581	85	.121.581
70	.18461.3821.382	71	.161.581	86	.121.581
71	.1991.3201.320	72	.161.581	87	.161.581
72	.1991.3201.320	73	.161.581	88	.161.581
73	.1991.3201.320	74	.161.581	89	.161.581
74	.1991.3201.320	75	.161.581	90	.161.581
75	.18461.3821.382	76	.121.581	91	.121.581
76	.18461.3821.382	77	.161.581	92	.121.581
77	.1991.3201.320	78	.161.581	93	.161.581
78	.1991.3201.320	79	.161.581	94	.161.581
79	.18461.3821.382	80	.121.433	95	.121.581
80	.20421.304.7226	96	.2455.581		
81	.21861.241.6597	82	.161.581	97	.2855.433
82	.1991.3201.320	83	.161.581	98	.161.581
83	.1991.3201.320	84	.161.581	99	.161.581
84	.1991.3201.320	85	.161.581	100	.161.581
85	.18461.3821.382	86	.121.581	101	.161.581
86	.18461.3821.382	87	.161.581	102	.161.581
87	.1991.3201.320	88	.161.581	103	.161.581
88	.1991.3201.320	89	.161.581	104	.161.581
89	.1991.3201.320	90	.161.581	105	.161.581
90	.1991.3201.320	91	.161.581	106	.161.581
91	.18461.3821.382	92	.121.581	107	.161.581
92	.18461.3821.382	93	.161.581	108	.161.581
93	.1991.3201.320	94	.161.581	109	.161.581
94	.1991.3201.320	95	.161.581	110	.161.581
95	.18461.3821.382	96	.121.433	111	.161.581
96	.20421.304.7226	112	.2455.581		
97	.21861.241.6597	98	.161.581	113	.2855.433
98	.1991.3201.320	99	.161.581	114	.161.581
99	.1991.3201.320	100	.161.581	115	.161.581
100	.1991.3201.320	101	.161.581	116	.161.581

101	.1991.3201.320	102	.161	.581	117	.161	.581
102	.1991.3201.320	103	.161	.581	118	.161	.581
103	.1991.3201.320	104	.161	.581	119	.161	.581
104	.1991.3201.320	105	.161	.581	120	.161	.581
105	.1991.3201.320	106	.161	.581	121	.161	.581
106	.1991.3201.320	107	.161	.581	122	.161	.581
107	.1991.3201.320	108	.161	.581	123	.161	.581
108	.1991.3201.320	109	.161	.581	124	.161	.581
109	.1991.3201.320	110	.161	.581	125	.161	.581
110	.1991.3201.320	111	.161	.581	126	.161	.581
111	.1991.3201.320	112	.161	.433	127	.161	.581
112	.21061.241.6597	120	.2055	.581			
113	.21061.241.6597	114	.161	.581	129	.2055	.433
114	.1991.3201.320	115	.161	.581	130	.161	.581
115	.1991.3201.320	116	.161	.581	131	.161	.581
116	.1991.3201.320	117	.161	.581	132	.161	.581
117	.1991.3201.320	118	.161	.581	133	.161	.581
118	.1991.3201.320	119	.161	.581	134	.161	.581
119	.1991.3201.320	120	.161	.581	135	.161	.581
120	.18461.3021.302	121	.121	.601	136	.121	.581
121	.18461.3021.302	122	.161	.581	137	.121	.581
122	.1991.3201.320	123	.161	.581	138	.161	.581
123	.1991.3201.320	124	.161	.581	139	.161	.581
124	.1991.3201.320	125	.161	.581	140	.161	.581
125	.1991.3201.320	126	.161	.581	141	.161	.581
126	.1991.3201.320	127	.161	.581	142	.161	.581
127	.1991.3201.320	128	.161	.433	143	.161	.581
128	.21061.241.6597	144	.2055	.581			
129	.21061.241.6597	130	.161	.581	145	.2055	.433
130	.1991.3201.320	131	.161	.581	146	.161	.581
131	.1991.3201.320	132	.161	.581	147	.161	.581
132	.1991.3201.320	133	.161	.581	148	.161	.581
133	.1991.3201.320	134	.161	.581	149	.161	.581
134	.1991.3201.320	135	.161	.581	150	.161	.581
135	.1991.3201.320	136	.161	.581	151	.161	.581
136	.18461.3021.302	137	.121	.581	152	.161	.581
137	.18461.3021.302	138	.161	.581	153	.161	.581
138	.1991.3201.320	139	.161	.581	154	.161	.581
139	.1991.3201.320	140	.161	.581	155	.161	.581
140	.1991.3201.320	141	.161	.581	156	.161	.581
141	.1991.3201.320	142	.161	.581	157	.161	.581
142	.1991.3201.320	143	.161	.581	158	.161	.581
143	.1991.3201.320	144	.161	.433	159	.161	.581
144	.21061.241.6597	160	.2055	.581			
145	.21061.241.6597	146	.161	.581	161	.2055	.433
146	.1991.3201.320	147	.161	.581	162	.161	.581
147	.1991.3201.320	148	.161	.581	163	.161	.581
148	.1991.3201.320	149	.161	.581	164	.161	.581
149	.1991.3201.320	150	.161	.581	165	.161	.581
150	.1991.3201.320	151	.161	.581	166	.161	.581
151	.1991.3201.320	152	.161	.581	167	.161	.581
152	.1991.3201.320	153	.161	.581	168	.161	.581
153	.1991.3201.320	154	.161	.581	169	.161	.581
154	.1991.3201.320	155	.161	.581	170	.161	.581
155	.1991.3201.320	156	.161	.581	171	.161	.581
156	.1991.3201.320	157	.161	.581	172	.161	.581
157	.1991.3201.320	158	.161	.581	173	.161	.581
158	.1991.3201.320	159	.161	.581	174	.161	.581
159	.1991.3201.320	160	.161	.433	175	.161	.581
160	.21061.241.6597	176	.2055	.581			

161.21861.241.6597 162 .161 .581 177.2855 .433
162 .1991.3201.320 163 .161 .581 178 .161 .581
163 .1991.3201.320 164 .161 .581 179 .161 .581
164 .1991.3201.320 165 .161 .581 180 .161 .581
165 .18461.3821.382 166 .121 .581 181 .121 .581
166 .18461.3821.382 167 .161 .581 182 .121 .581
167 .1991.3201.320 168 .161 .581 183 .161 .581
168 .1991.3201.320 169 .161 .581 184 .161 .581
169 .1991.3201.320 170 .161 .581 185 .161 .581
170 .1991.3201.320 171 .161 .581 186 .161 .581
171 .18461.3821.382 172 .121 .581 187 .121 .581
172 .18461.3821.382 173 .161 .581 188 .121 .581
173 .1991.3201.320 174 .161 .581 189 .161 .581
174 .1991.3201.320 175 .161 .581 190 .161 .581
175 .18461.3821.382 176 .121 .433 191 .161 .581
176 .28421.384.7226 192.2455 .581
177.21861.241.6597 178 .161 .581 193.2855 .433
178 .1991.3201.320 179 .161 .581 194 .161 .581
179 .1991.3201.320 180 .161 .581 195 .161 .581
180 .1991.3201.320 181 .161 .581 196 .161 .581
181 .18461.3821.382 182 .121 .581 197 .161 .581
182 .18461.3821.382 183 .161 .581 198 .161 .581
183 .1991.3201.320 184 .161 .581 199 .161 .581
184 .1991.3201.320 185 .161 .581 200 .161 .581
185 .1991.3201.320 186 .161 .581 201 .161 .581
186 .1991.3201.320 187 .161 .581 202 .161 .581
187 .18461.3821.382 188 .121 .581 203 .161 .581
188 .18461.3821.382 189 .161 .581 204 .161 .581
189 .1991.3201.320 190 .161 .581 205 .161 .581
190 .1991.3201.320 191 .161 .581 206 .161 .581
191 .18461.3821.382 192 .121 .433 207 .161 .581
192 .28421.384.7226 208.2455 .581
193.21861.241.6597 194 .161 .581 209.2855 .433
194 .1991.3201.320 195 .161 .581 210 .161 .581
195 .18461.3821.382 196 .121 .581 211 .121 .581
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197 .1991.3201.320 198 .161 .581 213 .161 .581
198 .1991.3201.320 199 .161 .581 214 .161 .581
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200 .1991.3201.320 201 .161 .581 216 .161 .581
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205 .18461.3821.382 206 .121 .581 221 .121 .581
206 .18461.3821.382 207 .161 .581 222 .121 .581
207 .1991.3201.320 208 .161 .433 223 .161 .581
208.21861.241.6597 224.2855 .581
209.21861.241.6597 210 .161 .581 225.2855 .433
210 .1991.3201.320 211 .161 .581 226 .161 .581
211 .18461.3821.382 212 .121 .581 227 .161 .581
212 .18461.3821.382 213 .161 .581 228 .161 .581
213 .19901.3201.320 214 .161 .581 229 .161 .581
214 .19901.3201.320 215 .161 .581 230 .161 .581
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219 .19901.3201.320 220 .161 .581 235 .161 .581
220 .19901.3201.320 221 .161 .581 236 .161 .581

221.18461.3821.382 222 .121 .581 237 .161 .581
 222.18461.3821.382 223 .161 .581 238 .161 .581
 223 .1991.3201.320 224 .161 .433 239 .161 .581
 224.21861.241.6597 240 2855 .581
 225.21861.241.6597 226 .161 .581 241 2855 .538
 226.19901.3201.320 227 .161 .581 242 .161 .433
 227.19901.3201.320 228 .161 .581 243 .161 .433
 228.19901.3201.320 229 .161 .581 244 .161 .433
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 231.19901.3201.320 232 .161 .581 247 .161 .433
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 234.19901.3201.320 235 .161 .581 250 .161 .433
 235.19901.3201.320 236 .161 .581 251 .161 .433
 236.19901.3201.320 237 .161 .581 252 .161 .433
 237.19901.3201.320 238 .161 .581 253 .161 .433
 238.19901.3201.320 239 .161 .581 254 .161 .433
 239.19901.3201.320 240 .161 .433 255 .161 .433
 240.21861.241.6597 256 2855 .538
 241.21801.321.3299 242 2855 .538
 242.21861.241.6597 243 2855 .581
 243.21861.241.6597 244 2855 .581
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 255.21861.241.6597 256 2855 .538
 256.21801.321.3299

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2 18.1584.688 0. 21.500 5.44 82.121 5.44 96.188 2.83
 2 28.1584.688 0. 32.121 5.44 106.188 2.83
 2 38.1584.688 0. 41.500 5.44 116.188 2.83
 2 48.1584.688 0. 52.121 5.44 126.188 2.83
 2 58.1584.688 0. 61.500 5.44 136.188 2.83
 2 68.1584.688 0. 72.121 5.44 146.188 2.83
 2 78.1584.688 0. 81.500 5.44 156.188 2.83
 2 88.1584.688 0. 106.188 2.83
 2 910.926.872 0. 102.583 4.13
 2 1010.926.872 0.
 2 1110.926.872 0. 122.583 4.13
 2 1210.926.872 0.
 2 1310.926.872 0. 142.583 4.13
 2 1410.926.872 0.
 2 1510.926.872 0. 162.583 4.13
 2 1610.926.872 0.

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1 .42 1. 1 .25 2 .25 17 .25 18 .25
 2 .42 1. 2 .25 3 .25 18 .25 19 .25
 3 .42 1. 3 .25 4 .25 19 .25 20 .25

4	.42	1.	4	.25	5	.25	20	.25	21	.25
5	.42	1.	5	.25	6	.25	21	.25	22	.25
6	.42	1.	6	.25	7	.25	22	.25	23	.25
7	.42	1.	7	.25	8	.25	23	.25	24	.25
8	.42	1.	8	.25	9	.25	24	.25	25	.25
9	.42	1.	9	.25	10	.25	25	.25	26	.25
10	.42	1.	10	.25	11	.25	26	.25	27	.25
11	.42	1.	11	.25	12	.25	27	.25	28	.25
12	.42	1.	12	.25	13	.25	28	.25	29	.25
13	.42	1.	13	.25	14	.25	29	.25	30	.25
14	.42	1.	14	.25	15	.25	30	.25	31	.25
15	.42	1.	15	.25	16	.25	31	.25	32	.25
16	.42	1.	17	.25	18	.25	33	.25	34	.25
17	.42	1.	18	.25	19	.25	34	.25	35	.25
18	.42	1.	19	.25	20	.25	35	.25	36	.25
19	.42	1.	20	.25	21	.25	36	.25	37	.25
20	.42	1.	21	.25	22	.25	37	.25	38	.25
21	.42	1.	22	.25	23	.25	38	.25	39	.25
22	.42	1.	23	.25	24	.25	39	.25	40	.25
23	.42	1.	24	.25	25	.25	40	.25	41	.25
24	.42	1.	25	.25	26	.25	41	.25	42	.25
25	.42	1.	26	.25	27	.25	42	.25	43	.25
26	.42	1.	27	.25	28	.25	43	.25	44	.25
27	.42	1.	28	.25	29	.25	44	.25	45	.25
28	.42	1.	29	.25	30	.25	45	.25	46	.25
29	.42	1.	30	.25	31	.25	46	.25	47	.25
30	.42	1.	31	.25	32	.25	47	.25	48	.25
31	.42	1.	33	.25	34	.25	49	.25	50	.25
32	.42	1.	34	.25	35	.25	50	.25	51	.25
33	0.42	0.	35	.25	36	.25	51	.25	52	.25
34	.42	1.	36	.25	37	.25	52	.25	53	.25
35	.42	1.	37	.25	38	.25	53	.25	54	.25
36	.42	1.	38	.25	39	.25	54	.25	55	.25
37	.42	1.	39	.25	40	.25	55	.25	56	.25
38	.42	1.	40	.25	41	.25	56	.25	57	.25
39	.42	1.	41	.25	42	.25	57	.25	58	.25
40	.42	1.	42	.25	43	.25	58	.25	59	.25
41	.42	1.	43	.25	44	.25	59	.25	60	.25
42	.42	1.	44	.25	45	.25	60	.25	61	.25
43	0.42	0.	45	.25	46	.25	61	.25	62	.25
44	.42	1.	46	.25	47	.25	62	.25	63	.25
45	.42	1.	47	.25	48	.25	63	.25	64	.25
46	.42	1.	49	.25	50	.25	65	.25	66	.25
47	.42	1.	50	.25	51	.25	66	.25	67	.25
48	.42	1.	51	.25	52	.25	67	.25	68	.25
49	.42	1.	52	.25	53	.25	68	.25	69	.25
50	.42	1.	53	.25	54	.25	69	.25	70	.25
51	.42	1.	54	.25	55	.25	70	.25	71	.25
52	.42	1.	55	.25	56	.25	71	.25	72	.25
53	.42	1.	56	.25	57	.25	72	.25	73	.25
54	.42	1.	57	.25	58	.25	73	.25	74	.25
55	.42	1.	58	.25	59	.25	74	.25	75	.25
56	.42	1.	59	.25	60	.25	75	.25	76	.25
57	.42	1.	60	.25	61	.25	76	.25	77	.25
58	.42	1.	61	.25	62	.25	77	.25	78	.25
59	.42	1.	62	.25	63	.25	78	.25	79	.25
60	.42	1.	63	.25	64	.25	79	.25	80	.25
61	.42	0.	65	.25	66	.25	81	.25	82	.25
62	.42	1.	66	.25	67	.25	82	.25	83	.25
63	.42	1.	67	.25	68	.25	83	.25	84	.25

84	.42	1.	68	.25	69	.25	84	.25	85	.25
85	0.42	0.	69	.25	70	.25	85	.25	86	.25
86	.42	1.	70	.25	71	.25	86	.25	87	.25
87	.42	1.	71	.25	72	.25	87	.25	88	.25
88	.42	1.	72	.25	73	.25	88	.25	89	.25
89	.42	1.	73	.25	74	.25	89	.25	90	.25
70	.42	1.	74	.25	75	.25	90	.25	91	.25
71	0.42	0.	75	.25	76	.25	91	.25	92	.25
72	.42	1.	76	.25	77	.25	92	.25	93	.25
73	.42	1.	77	.25	78	.25	93	.25	94	.25
74	.42	1.	78	.25	79	.25	94	.25	95	.25
75	0.42	0.	79	.25	80	.25	95	.25	96	.25
76	.42	1.	81	.25	82	.25	97	.25	98	.25
77	.42	1.	82	.25	83	.25	98	.25	99	.25
78	.42	1.	83	.25	84	.25	99	.25	100	.25
79	.42	1.	84	.25	85	.25	100	.25	101	.25
80	.42	1.	85	.25	86	.25	101	.25	102	.25
81	.42	1.	86	.25	87	.25	102	.25	103	.25
82	.42	1.	87	.25	88	.25	103	.25	104	.25
83	.42	1.	88	.25	89	.25	104	.25	105	.25
84	.42	1.	89	.25	90	.25	105	.25	106	.25
85	.42	1.	90	.25	91	.25	106	.25	107	.25
86	.42	1.	91	.25	92	.25	107	.25	108	.25
87	.42	1.	92	.25	93	.25	108	.25	109	.25
88	.42	1.	93	.25	94	.25	109	.25	110	.25
89	.42	1.	94	.25	95	.25	110	.25	111	.25
90	.42	1.	95	.25	96	.25	111	.25	112	.25
91	.42	1.	97	.25	98	.25	113	.25	114	.25
92	.42	0.	98	.25	99	.25	114	.25	115	.25
93	.42	1.	99	.25	100	.25	115	.25	116	.25
94	.42	1.	100	.25	101	.25	116	.25	117	.25
95	.42	1.	101	.25	102	.25	117	.25	118	.25
96	.42	1.	102	.25	103	.25	118	.25	119	.25
97	.42	1.	103	.25	104	.25	119	.25	120	.25
98	.42	1.	104	.25	105	.25	120	.25	121	.25
99	.42	1.	105	.25	106	.25	121	.25	122	.25
100	.42	1.	106	.25	107	.25	122	.25	123	.25
101	.42	1.	107	.25	108	.25	123	.25	124	.25
102	.42	1.	108	.25	109	.25	124	.25	125	.25
103	.42	1.	109	.25	110	.25	125	.25	126	.25
104	.42	0.	110	.25	111	.25	126	.25	127	.25
105	.42	1.	111	.25	112	.25	127	.25	128	.25
106	.42	1.	113	.25	114	.25	129	.25	130	.25
107	.42	1.	114	.25	115	.25	130	.25	131	.25
108	.42	1.	115	.25	116	.25	131	.25	132	.25
109	.42	1.	116	.25	117	.25	132	.25	133	.25
110	.42	1.	117	.25	118	.25	133	.25	134	.25
111	.42	1.	118	.25	119	.25	134	.25	135	.25
112	.42	1.	119	.25	120	.25	135	.25	136	.25
113	0.42	0.	120	.25	121	.25	136	.25	137	.25
114	.42	1.	121	.25	122	.25	137	.25	138	.25
115	.42	1.	122	.25	123	.25	138	.25	139	.25
116	.42	1.	123	.25	124	.25	139	.25	140	.25
117	.42	1.	124	.25	125	.25	140	.25	141	.25
118	.42	1.	125	.25	126	.25	141	.25	142	.25
119	.42	1.	126	.25	127	.25	142	.25	143	.25
120	.42	1.	127	.25	128	.25	143	.25	144	.25
121	.42	1.	129	.25	130	.25	145	.25	146	.25
122	.42	1.	130	.25	131	.25	146	.25	147	.25
123	.42	1.	131	.25	132	.25	147	.25	148	.25

124	.42	1.	132	.25	133	.25	148	.25	149	.25
125	.42	1.	133	.25	134	.25	149	.25	150	.25
126	.42	1.	134	.25	135	.25	150	.25	151	.25
127	.42	1.	135	.25	136	.25	151	.25	152	.25
128	.42	1.	136	.25	137	.25	152	.25	153	.25
129	.42	1.	137	.25	138	.25	153	.25	154	.25
130	.42	1.	138	.25	139	.25	154	.25	155	.25
131	.42	1.	139	.25	140	.25	155	.25	156	.25
132	.42	1.	140	.25	141	.25	156	.25	157	.25
133	.42	1.	141	.25	142	.25	157	.25	158	.25
134	.42	1.	142	.25	143	.25	158	.25	159	.25
135	.42	1.	143	.25	144	.25	159	.25	160	.25
136	.42	1.	145	.25	146	.25	161	.25	162	.25
137	.42	1.	146	.25	147	.25	162	.25	163	.25
138	.42	1.	147	.25	148	.25	163	.25	164	.25
139	.42	1.	148	.25	149	.25	164	.25	165	.25
140	.42	1.	149	.25	150	.25	165	.25	166	.25
141	.42	1.	150	.25	151	.25	166	.25	167	.25
142	.42	1.	151	.25	152	.25	167	.25	168	.25
143	.42	1.	152	.25	153	.25	168	.25	169	.25
144	.42	1.	153	.25	154	.25	169	.25	170	.25
145	.42	1.	154	.25	155	.25	170	.25	171	.25
146	.42	1.	155	.25	156	.25	171	.25	172	.25
147	.42	1.	156	.25	157	.25	172	.25	173	.25
148	.42	1.	157	.25	158	.25	173	.25	174	.25
149	.42	1.	158	.25	159	.25	174	.25	175	.25
150	.42	1.	159	.25	160	.25	175	.25	176	.25
151	.42	0.	161	.25	162	.25	177	.25	178	.25
152	.42	1.	162	.25	163	.25	178	.25	179	.25
153	.42	1.	163	.25	164	.25	179	.25	180	.25
154	.42	1.	164	.25	165	.25	180	.25	181	.25
155	0.42	0.	165	.25	166	.25	181	.25	182	.25
156	.42	1.	166	.25	167	.25	182	.25	183	.25
157	.42	1.	167	.25	168	.25	183	.25	184	.25
158	.42	1.	168	.25	169	.25	184	.25	185	.25
159	.42	1.	169	.25	170	.25	185	.25	186	.25
160	.42	1.	170	.25	171	.25	186	.25	187	.25
161	0.42	0.	171	.25	172	.25	187	.25	188	.25
162	.42	1.	172	.25	173	.25	188	.25	189	.25
163	.42	1.	173	.25	174	.25	189	.25	190	.25
164	.42	1.	174	.25	175	.25	190	.25	191	.25
165	0.42	0.	175	.25	176	.25	191	.25	192	.25
166	.42	1.	177	.25	178	.25	193	.25	194	.25
167	.42	1.	178	.25	179	.25	194	.25	195	.25
168	.42	1.	179	.25	180	.25	195	.25	196	.25
169	.42	1.	180	.25	181	.25	196	.25	197	.25
170	.42	1.	181	.25	182	.25	197	.25	198	.25
171	.42	1.	182	.25	183	.25	198	.25	199	.25
172	.42	1.	183	.25	184	.25	199	.25	200	.25
173	.42	1.	184	.25	185	.25	200	.25	201	.25
174	.42	1.	185	.25	186	.25	201	.25	202	.25
175	.42	1.	186	.25	187	.25	202	.25	203	.25
176	.42	1.	187	.25	188	.25	203	.25	204	.25
177	.42	1.	188	.25	189	.25	204	.25	205	.25
178	.42	1.	189	.25	190	.25	205	.25	206	.25
179	.42	1.	190	.25	191	.25	206	.25	207	.25
180	.42	1.	191	.25	192	.25	207	.25	208	.25
181	.42	1.	193	.25	194	.25	209	.25	210	.25
182	.42	1.	194	.25	195	.25	210	.25	211	.25
183	0.42	0.	195	.25	196	.25	211	.25	212	.25

184	.42	1.	196	.25	197	.25	212	.25	213	.25
185	.42	1.	197	.25	198	.25	213	.25	214	.25
186	.42	1.	198	.25	199	.25	214	.25	215	.25
187	.42	1.	199	.25	200	.25	215	.25	216	.25
188	.42	1.	200	.25	201	.25	216	.25	217	.25
189	.42	1.	201	.25	202	.25	217	.25	218	.25
190	.42	1.	202	.25	203	.25	218	.25	219	.25
191	.42	1.	203	.25	204	.25	219	.25	220	.25
192	.42	1.	204	.25	205	.25	220	.25	221	.25
193	.42	0.	205	.25	206	.25	221	.25	222	.25
194	.42	1.	206	.25	207	.25	222	.25	223	.25
195	.42	1.	207	.25	208	.25	223	.25	224	.25
196	.42	1.	209	.25	210	.25	225	.25	226	.25
197	.42	1.	210	.25	211	.25	226	.25	227	.25
198	.42	1.	211	.25	212	.25	227	.25	228	.25
199	.42	1.	212	.25	213	.25	228	.25	229	.25
200	.42	1.	213	.25	214	.25	229	.25	230	.25
201	.42	1.	214	.25	215	.25	230	.25	231	.25
202	.42	1.	215	.25	216	.25	231	.25	232	.25
203	.42	1.	216	.25	217	.25	232	.25	233	.25
204	.42	1.	217	.25	218	.25	233	.25	234	.25
205	.42	1.	218	.25	219	.25	234	.25	235	.25
206	.42	1.	219	.25	220	.25	235	.25	236	.25
207	.42	1.	220	.25	221	.25	236	.25	237	.25
208	.42	1.	221	.25	222	.25	237	.25	238	.25
209	.42	1.	222	.25	223	.25	238	.25	239	.25
210	.42	1.	223	.25	224	.25	239	.25	240	.25
211	.42	1.	225	.25	226	.25	241	.25	242	.25
212	.42	1.	226	.25	227	.25	242	.25	243	.25
213	.42	1.	227	.25	228	.25	243	.25	244	.25
214	.42	1.	228	.25	229	.25	244	.25	245	.25
215	.42	1.	229	.25	230	.25	245	.25	246	.25
216	.42	1.	230	.25	231	.25	246	.25	247	.25
217	.42	1.	231	.25	232	.25	247	.25	248	.25
218	.42	1.	232	.25	233	.25	248	.25	249	.25
219	.42	1.	233	.25	234	.25	249	.25	250	.25
220	.42	1.	234	.25	235	.25	250	.25	251	.25
221	.42	1.	235	.25	236	.25	251	.25	252	.25
222	.42	1.	236	.25	237	.25	252	.25	253	.25
223	.42	1.	237	.25	238	.25	253	.25	254	.25
224	.42	1.	238	.25	239	.25	254	.25	255	.25
225	.42	1.	239	.25	240	.25	255	.25	256	.25
2	0	0								
3.0	069	655.	350	10.	0.1	409.	0251000.	420		
slab	2	3	16							
1					3678.					
2					969.					
1	1	.95			2	2	1	8	1	
2	1	.95			1	3	1			
3	1	.95			1	4	1			
4	1	.95			1	5	1			
5	1	.95			1	6	1			
6	1	.95			1	7	1			
7	1	.95			1	8	1			
8	1	.95								
9	2	1.74			2	10	2	16	2	
10	2	1.74			1	11	2			
11	2	1.74			1	12	2			
12	2	1.74			1	13	2			
13	2	1.74			1	14	2			

14	2	1.74			1	15	2							
15	2	1.74			1	16	2							
16	2	1.74												
1		34.20		.5561										
2		12.145		4.614										
3		.0130		6.864										
1	9	1	1	1	1	2	1	1	3	1	1	4	1	
		1	5	1	1	6	1	1	7	1	1	8	1	
		2	1	2										
2	9	1	9	1	1	10	1	1	11	1	1	12	1	
		1	13	1	1	14	1	1	15	1	1	16	1	
		2	2	2										
3	9	1	16	1	1	32	1	1	48	1	1	64	1	
		1	80	1	1	96	1	1	112	1	1	128	1	
		2	3	2										
4	9	1	144	1	1	160	1	1	176	1	1	192	1	
		1	208	1	1	224	1	1	240	1	1	256	1	
		2	4	2										
5	9	1	249	1	1	260	1	1	261	1	1	249	1	
		1	253	1	1	254	1	1	255	1	1	256	1	
		2	5	2										
6	9	1	241	1	1	242	1	1	243	1	1	244	1	
		1	245	1	1	246	1	1	247	1	1	248	1	
		2	6	2										
7	9	1	129	1	1	145	1	1	161	1	1	177	1	
		1	193	1	1	209	1	1	225	1	1	241	1	
		2	7	2										
8	9	1	1	1	1	17	1	1	33	1	1	49	1	
		1	65	1	1	81	1	1	97	1	1	113	1	
		2	8	2										
9	1	2	09	3										
10	1	2	10	3										
11	1	2	11	3										
12	1	2	12	3										
13	1	2	13	3										
14	1	2	14	3										
15	1	2	15	3										
16	1	2	16	3										

radg	2	1	1											
1	16													
14.614	.25	1.0016	2.0	3.0	4.0	5.0	6.0							
		7.0	8.0	9.6888	10.2658	11.0085	12.0							
		13.0	14.0	15.0	16.0435									
24.614	.25	1.0	2.0016	3.0	4.0	5.0	6.0							
		7.0	8.0	9.2658	10.6088	11.0435	12.0							
		13.0	14.0	15.0	16.0085									
34.614	.25	1.0	2.0	3.0016	4.0	5.0	6.0							
		7.0	8.0	9.0	10.0435	11.6088	12.2658							
		13.0085	14.0	15.0	16.0									
44.614	.25	1.0	2.0	3.0	4.0016	5.0	6.0							
		7.0	8.0	9.0	10.0085	11.2658	12.6888							
		13.0435	14.0	15.0	16.0									
54.614	.25	1.0	2.0	3.0	4.0	5.0016	6.0							
		7.0	8.0	9.0	10.0	11.0	12.0435							
		13.6888	14.2658	15.0085	16.0									
64.614	.25	1.0	2.0	3.0	4.0	5.0	6.0016							
		7.0	8.0	9.0	10.0	11.0	12.0085							
		13.2658	14.6088	15.0435	16.0									
74.614	.25	1.0	2.0	3.0	4.0	5.0	6.0							

			7.0016	8.0	9.0085	10.0	11.0	12.0			
			13.0	14.0435	15.0008	16.2656					
84.814	.25		1.0	2.0	3.0	4.0	5.0	6.0			
			7.0	8.0016	9.0435	10.0	11.0	12.0			
			13.0	14.0085	15.2656	16.6888					
96.684	.6		1.4700	2.1033	3.0	4.0	5.0	6.0			
			7.0059	8.03	9.0271	10.0734	11.0037	12.0			
			13.0	14.0134	15.0037	16.0095					
106.684	.6		1.1833	2.4700	3.0300	4.0059	5.0	6.0			
			7.0	8.0	9.0734	10.0271	11.0095	12.0037			
			13.0134	14.0	15.0	16.0037					
116.684	.6		1.0059	2.03	3.47	4.1033	5.0	6.0			
			7.0	8.0	9.0037	10.0095	11.0271	12.0734			
			13.0037	14.0	15.0	16.0134					
126.684	.6		1.0	2.0	3.1033	4.47	5.03	6.0059			
			7.0	8.0	9.0000	10.0037	11.0734	12.0271			
			13.0095	14.0037	15.0134	16.0					
136.684	.6		1.0	2.0	3.0059	4.0300	5.47	6.1033			
			7.0	8.0	9.0	10.0134	11.0037	12.0095			
			13.0271	14.0734	15.0037	16.0					
146.684	.6		1.0	2.0	3.0	4.0	5.1033	6.4700			
			7.0300	8.0059	9.0134	10.0	11.0	12.0037			
			13.0734	14.0271	15.0095	16.0037					
156.684	.6		1.0	2.0	3.0	4.0	5.0059	6.03			
			7.47	8.1033	9.0037	10.0	11.0	12.0134			
			13.0037	14.0095	15.0271	16.0734					
166.684	.6		1.03	2.0059	3.0	4.0	5.0	6.0			
			7.1033	8.4700	9.0095	10.0037	11.0134	12.0			
			13.0	14.0037	15.0734	16.0271					
1	1	8	1	2	3	4	5	6	7	8	
2	-1	10	1	2	3	4	5	6	7	8	9
			10	11	12						
			13	14	15	16					
heat	1	0	1								
			3.66			3.66					
1.0	1.0										
drag	2	2									
100.	-1.0			100.	-1.0	.05					
100.	-1.0			100.	-1.0	.50					
1	16	0									
7	18	240	.066	2.155	2.276	6.393	2.454	8.699	8.		
			.979	8.							
7	1	17	.066	1.155	1.276	4.393	1.454	4.699	4.		
			.979	4.							
7	32	33	.066	1.155	1.276	4.393	1.454	4.699	4.		
			.979	4.							
7	48	49	.066	1.155	1.276	4.393	1.454	4.699	4.		
			.979	4.							
7	64	65	.066	1.155	1.276	4.393	1.454	4.699	4.		
			.979	4.							
7	80	81	.066	1.155	1.276	4.393	1.454	4.699	4.		
			.979	4.							
7	96	97	.066	1.155	1.276	4.393	1.454	4.699	4.		
			.979	4.							
7	112	113	.066	1.155	1.276	4.393	1.454	4.699	4.		
			.979	4.							
7	128	129	.066	1.155	1.276	4.393	1.454	4.699	4.		
			.979	4.							
7	144	145	.066	1.155	1.276	4.393	1.454	4.699	4.		
			.979	4.							
7	160	161	.066	1.155	1.276	4.393	1.454	4.699	4.		

```

      .979 4.
7 176 177 .868 1. 155 1. 276 4. 393 1. 454 4. 699 4.
      .979 4.
7 192 193 .868 1. 155 1. 276 4. 393 1. 454 4. 699 4.
      .979 4.
7 208 209 .868 1. 155 1. 276 4. 393 1. 454 4. 699 4.
      .979 4.
7 224 225 .868 1. 155 1. 276 4. 393 1. 454 4. 699 4.
      .979 4.
7 240 258 .868 1. 155 1. 276 4. 393 1. 454 4. 699 4.
      .979 4.

2 1 0
1 1 16 0.01 30.0
bdry 5 4 8 2
1 .001
2 9.98e-6
3 3.22e-5
4 1.98e-6
5 1.06e-4
1 11-.012137.5.000 199.0.033 237.0.151 293.0.306 338.0.578 368.0
   0.726368.00.856365.01.000332.01.122277.01.186176.0
2 11-.012137.5.000 164.0.033 210.0.151 280.0.306 338.0.578 355.0
   0.726363.00.856361.01.000333.01.122277.01.186176.0
3 11-.012137.5.000 155.0.033 183.0.151 263.0.306 319.0.578 355.0
   0.726362.00.856355.01.000320.01.122267.01.186176.0
4 10-.012137.5.033 165.0.151 243.0.306 306.0.578 340.0.726 353.0
   0.856345.01.000300.01.122259.01.186176.0

9 1 7.07 1
1 1. 1 1. 1
10 1 7.07 1
1 1. 1 1. 1
11 1 7.07 2
1 1. 1 1. 1
12 1 7.07 3
1 1. 1 1. 1
13 1 7.07 4
1 1. 1 1. 1
14 1 7.07 4
1 1. 1 1. 1
15 1 7.07 3
1 1. 1 1. 1
16 1 7.07 2
1 1. 1 1. 1
1 379. 264. 2 2137. 5137. 5
1 1. 3
2 1. 1
1 1. 2
2 1. 1 0 1 2 .95 2. 2 2 .95 2. 3 2 .95 2.
   4 2 .95 2. 5 2 .95 2. 6 2 .95 2.
   7 2 .95 2. 8 2 .95 2.

21340. 240. 2 2271. 2178. 0
1 1. 3
2 1. 1
1 1. 4
2 2.58 5
calc 1 0 0

      0.1

25
oper 1 2 3 1
20. 282. .0001 .002014770 250. .000000 0.0

```

```

1. -.33
1.000
8
0. 0.1043 0.1044 1.9758 1.9759 0. 1.0 0.0
outp 1101
endd

```

```

data from iterative solution using the recirculation module
time = 0.0000 dt = 0.0000 implicit dt = 0.0000 explicit dt = 5.2089 mode = 0

```

iteration no.	sweep no.	peak clad				total flow (lbm/s)	pressure drop(psi)	error			
		temp(f)	fluid	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	518.7	24	98	1	0.496e-10	0.0020492	20.0408	1.9321	0.0371	0.0109
	2	519.6	24	98	1			0.0036	1.9321	0.0177	0.0040
2	1	526.9	24	98	1	0.216e-10	0.0019821	-0.0059	2.4043	0.0575	0.0037
	2	540.6	23	98	1			0.0356	2.4043	0.0904	0.0004
3	1	544.0	22	98	1	-0.302e-10	0.0019761	0.0533	1.1280	0.0314	0.0018
	2	550.1	21	98	1			0.0052	1.1280	0.0958	0.0012
4	1	551.5	21	98	1	0.324e-10	0.0019848	-0.0507	1.5033	0.0704	0.0007
	2	553.7	21	98	1			0.0104	1.5033	0.0484	0.0007
5	1	554.3	20	98	1	0.251e-11	0.0019805	0.0193	1.6377	0.0161	0.0002
	2	555.3	20	98	1			0.0096	1.6377	0.0760	0.0003
6	1	555.5	20	98	1	0.048e-11	0.0019911	0.0022	1.5974	0.0093	0.0002
	2	555.9	20	98	1			0.0072	1.5974	0.0300	0.0002
7	1	556.0	20	98	1	-0.105e-10	0.0019911	0.0039	1.5178	0.0195	0.0002
	2	556.1	20	98	1			0.0039	1.5178	0.0781	0.0002
8	1	556.1	20	98	1	-0.243e-10	0.0019932	-0.0030	1.1606	0.0300	0.0002
	2	556.1	20	98	1			-0.0019	1.1606	0.0600	0.0002
9	1	556.1	20	98	1	-0.224e-12	0.0019920	-0.0030	1.3176	0.0113	0.0002
	2	555.9	20	98	1			0.0043	1.3176	0.0397	0.0002
10	1	556.0	20	98	1	0.000e-12	0.0019922	0.0070	1.0839	0.0062	0.0002
	2	556.0	20	98	1			0.0040	1.0839	0.0542	0.0002
11	1	556.0	20	98	1	0.206e-11	0.0019910	-0.0001	1.1201	0.0284	0.0002
	2	556.0	20	98	1			0.0033	1.1201	0.0343	0.0002
12	1	556.0	20	98	1	0.255e-11	0.0019914	0.0006	1.0051	0.0089	0.0002
	2	556.0	20	98	1			0.0018	1.0051	0.0716	0.0002
13	1	556.0	20	98	1	0.120e-10	0.0019914	0.0006	1.3363	0.0323	0.0002
	2	555.9	20	98	1			0.0030	1.3363	0.0234	0.0002
14	1	555.9	20	98	1	0.574e-11	0.0019916	0.0010	1.1309	0.0066	0.0002
	2	555.9	20	98	1			0.0044	1.1309	0.0327	0.0002

15	1	555.9	28	98	1	-0.147e-10	0.0019913	0.0017	1.0244	0.0035	0.0002
	2	555.9	28	98	1			0.0035	1.0244	0.0555	0.0002
16	1	555.9	28	98	1	0.799e-11	0.0019912	0.0015	0.9096	0.0200	0.0002
	2	555.9	28	98	1			0.0043	0.9096	0.0220	0.0002
17	1	555.9	28	98	1	-0.997e-11	0.0019906	0.0019	1.0186	0.0038	0.0002
	2	555.9	28	98	1			0.0034	1.0186	0.0643	0.0002
18	1	555.9	28	98	1	-0.103e-10	0.0019900	0.0007	1.0090	0.0307	0.0002
	2	555.9	28	98	1			0.0037	1.0090	0.0317	0.0002
19	1	555.9	28	98	1	-0.179e-11	0.0019910	0.0020	1.0091	0.0000	0.0002
	2	555.9	28	98	1			0.0029	1.0091	0.0029	0.0002
20	1	555.9	28	98	1	0.100e-10	0.0019913	0.0003	0.9223	0.0300	0.0002
	2	555.9	28	98	1			0.0044	0.9223	0.0314	0.0002
21	1	555.9	28	98	1	0.234e-11	0.0019916	0.0021	1.1140	0.0000	0.0002
	2	555.9	28	98	1			0.0040	1.1140	0.0512	0.0002
22	1	555.9	28	98	1	0.511e-11	0.0019915	0.0014	1.1300	0.0134	0.0002
	2	555.9	28	98	1			0.0044	1.1300	0.0129	0.0002
23	1	555.9	28	98	1	0.270e-12	0.0019914	0.0020	0.7929	0.0022	0.0002
	2	555.9	28	98	1			0.0045	0.7929	0.0223	0.0002
24	1	555.9	28	98	1	-0.200e-10	0.0019909	0.0021	1.0291	0.0036	0.0002
	2	555.9	28	98	1			0.0033	1.0291	0.0502	0.0002
25	1	555.9	28	98	1	0.102e-10	0.0019910	0.0007	0.0727	0.0200	0.0002
	2	555.9	28	98	1			0.0040	0.0727	0.0325	0.0002

axial zone (inches)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
0.0 - 6.9	166.83	166.79	164.85	162.90	161.83	161.93	163.31	164.97	223.07	223.07
6.9 - 13.8	200.29	200.23	197.57	194.80	192.58	192.73	195.08	197.78	250.68	250.68
13.8 - 20.7	232.74	232.71	230.19	227.09	224.83	224.95	227.50	230.34	270.61	270.61
20.7 - 27.5	260.22	260.20	270.07	275.25	272.93	273.03	275.36	277.92	290.38	290.38
27.5 - 34.4	320.49	320.57	318.57	318.01	313.77	313.83	315.99	318.33	303.07	303.07
34.4 - 41.3	352.50	352.60	350.02	348.49	346.37	346.41	348.41	350.57	314.87	314.87
41.3 - 48.2	377.63	377.70	370.02	373.90	371.91	371.94	373.79	375.77	320.23	320.23
48.2 - 55.1	396.51	396.57	395.02	393.12	391.26	391.28	392.97	394.79	330.52	330.52
55.1 - 62.0	409.25	409.31	407.04	400.09	404.32	404.33	405.92	407.61	340.28	340.28
62.0 - 68.9	418.41	418.46	417.00	415.46	413.79	413.80	415.27	416.83	343.97	343.97
68.9 - 75.8	425.32	425.36	424.04	422.60	421.04	421.04	422.39	423.82	347.64	347.64
75.8 - 82.8	430.70	430.83	429.50	428.31	426.86	426.85	428.00	429.36	351.32	351.32
82.8 - 89.5	435.29	435.34	434.18	433.00	431.73	431.73	432.83	433.90	355.00	355.00
89.5 - 96.4	439.00	439.13	438.05	437.00	435.80	435.85	436.83	437.82	358.60	358.60
96.4 - 103.3	442.03	442.07	441.01	440.07	438.87	438.85	439.81	440.78	361.45	361.45
103.3 - 110.2	444.27	444.32	443.22	442.24	440.99	440.97	441.97	442.99	363.71	363.71
110.2 - 117.1	446.04	446.09	444.95	443.90	442.50	442.56	443.62	444.71	365.95	365.95
117.1 - 124.0	447.20	447.24	446.05	444.91	443.51	443.48	444.82	445.81	367.92	367.92
124.0 - 130.9	447.04	447.09	445.81	444.52	442.95	442.93	444.22	445.57	360.95	360.95
130.9 - 137.7	446.05	446.10	444.75	443.30	441.55	441.52	442.97	444.50	365.94	365.94
137.7 - 144.6	443.70	443.76	442.33	440.72	438.80	438.78	440.38	442.07	364.04	364.04
144.6 - 151.5	437.99	438.04	436.60	434.84	432.75	432.71	434.40	436.34	354.97	354.97

151.5 -158.4	427.75	427.88	428.34	424.42	422.14	422.89	424.84	426.89	345.82	345.82
158.4 -185.3	483.37	483.37	481.98	399.75	397.18	397.12	399.54	401.89	336.75	336.75

side boundary temperature summary time = 0.0000 seconds
 boundary slab node no. 9

axial zone (inches)	(1)	(2)	(
8.8 - 8.9	223.87	222.90	
8.9 - 13.8	250.68	251.88	
13.8 - 28.7	278.61	278.77	
28.7 - 27.5	298.38	298.55	
27.5 - 34.4	303.86	303.13	
34.4 - 41.3	314.67	314.68	
41.3 - 48.2	326.23	326.24	
48.2 - 55.1	338.52	336.57	
55.1 - 62.8	348.28	348.25	
62.8 - 68.9	343.97	343.93	
68.9 - 75.8	347.84	347.60	
75.8 - 82.6	351.32	351.28	
82.6 - 89.5	355.88	354.98	
89.5 - 98.4	358.88	358.83	
98.4 -103.3	361.45	361.41	
103.3 -118.2	363.71	363.67	
118.2 -117.1	365.96	365.92	
117.1 -124.8	367.92	367.92	
124.8 -138.9	368.95	368.92	
138.9 -137.7	365.94	365.91	
137.7 -144.6	364.84	364.88	
144.6 -151.5	354.97	354.92	
151.5 -158.4	345.82	345.75	
158.4 -185.3	336.75	336.58	

calculated rod temperatures at time = 0.0000 seconds
 rod no. 1
 assembly 1 (fuel type 1 - cylinder)
 #rod o.d. = 0.428 (in.) zone-(fuel dia.(in.)) = 1-(0.358)

		* fuel temperatures(f.)			
		*			
axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2) *	fluid	clad
8.8 - 8.9	0.0000	1	1.1	182.7	182.4
8.9 - 13.8	0.0000	1	1.1	189.6	188.5
13.8 - 28.7	0.0000	1	1.2	219.8	217.9
28.7 - 27.5	0.0000	1	1.2	288.5	288.7
27.5 - 34.4	0.0000	1	1.3	327.9	337.5
34.4 - 41.3	0.0000	1	1.4	364.9	375.5

41.3 - 48.2	0.0000	1	1.4	393.3	404.5
48.2 - 55.1	0.0000	1	1.4	414.5	428.2
55.1 - 62.0	0.0000	1	1.4	429.2	441.1
62.0 - 68.9	0.0000	1	1.4	439.6	451.7
68.9 - 75.8	0.0000	1	1.5	447.2	459.5
75.8 - 82.6	0.0000	1	1.5	453.2	465.4
82.6 - 89.5	0.0000	1	1.5	457.9	470.2
89.5 - 96.4	0.0000	1	1.5	461.9	474.1
96.4 - 103.3	0.0000	1	1.5	465.0	477.2
103.3 - 110.2	0.0000	1	1.5	467.3	479.5
110.2 - 117.1	0.0000	1	1.5	469.1	481.3
117.1 - 124.0	0.0000	1	1.5	470.4	482.6
124.0 - 130.9	0.0000	1	1.5	470.4	482.7
130.9 - 137.7	0.0000	1	1.5	469.7	482.0
137.7 - 144.6	0.0000	1	1.5	467.8	480.2
144.6 - 151.5	0.0000	1	1.5	463.0	475.6
151.5 - 158.4	0.0000	1	1.5	454.6	467.6
158.4 - 165.3	0.0000	1	1.4	419.1	423.4

calculated rod temperatures at time = 0.0000 seconds

rod no. 128

assembly 1

(fuel type 1 - cylinder)

rod o.d. - 0.428 (in.) zone-(fuel dia.(in.)) - 1-(0.358)

* fuel temperatures(f.)

*

axial zone (in.)	heat flux (mbtu/hr-ft ²)	type	surf (b/h-f-ft ²)	fluid	clad
0.0 - 6.9	0.0000	1	1.3	154.9	165.6
6.9 - 13.8	0.0000	1	1.3	162.2	162.6
13.8 - 20.7	0.0000	1	1.3	170.8	177.7
20.7 - 27.5	0.0000	1	1.4	276.5	285.1
27.5 - 34.4	0.0000	1	1.6	355.4	362.2
34.4 - 41.3	0.0000	1	1.6	413.4	418.6
41.3 - 48.2	0.0000	1	1.7	454.6	458.6
48.2 - 55.1	0.0000	1	1.8	483.8	487.0
55.1 - 62.0	0.0000	1	1.8	504.1	500.7
62.0 - 68.9	0.0000	1	1.8	518.1	520.3
68.9 - 75.8	0.0000	1	1.8	527.9	529.8
75.8 - 82.6	0.0000	1	1.8	535.1	536.8
82.6 - 89.5	0.0000	1	1.8	540.4	542.6
89.5 - 96.4	0.0000	1	1.8	544.7	546.2
96.4 - 103.3	0.0000	1	1.8	547.9	549.4
103.3 - 110.2	0.0000	1	1.9	550.5	551.9
110.2 - 117.1	0.0000	1	1.9	552.4	553.7
117.1 - 124.0	0.0000	1	1.9	553.8	555.1
124.0 - 130.9	0.0000	1	1.9	554.4	555.7
130.9 - 137.7	0.0000	1	1.9	554.3	555.6
137.7 - 144.6	0.0000	1	1.9	553.4	554.6
144.6 - 151.5	0.0000	1	1.9	551.0	552.1
151.5 - 158.4	0.0000	1	1.8	546.3	547.3
158.4 - 165.3	0.0000	1	1.8	483.2	479.6

+8000

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1 1 agns horizontal nitrogen full-load validation analyses
prop 11 2
1. 100. 133.9 .0154 .240 14.08 .0463
2. 200. 157.9 .0174 .241 16.67 .0518
3. 300. 182.1 .0193 .243 19.23 .0580
4. 400. 208.5 .0212 .245 21.74 .0638
5. 500. 231.1 .0231 .247 24.27 .0688
6. 600. 258.8 .0250 .250 26.81 .0720
7. 700. 281.1 .0268 .253 29.33 .0770
8. 800. 308.7 .0286 .256 31.85 .0810
10. 900. 332.5 .0303 .259 34.36 .0850
15. 1000. 358.6 .0319 .262 36.90 .0889
20. 2000. 617.2 .0471 .286 62.11 .1242

1 can 13.
2 steel 100.

chan 2 24
165.3 90.0
1 1 250 0
1 1 0 0 1
1.21091.321.3299 2.2855 .530 17.2855 .530
2.21061.241.6597 3.2855 .581 18.161 .433
3.21061.241.6597 4.2855 .581 19.161 .433
4.21061.241.6597 5.2855 .581 20.161 .433
5.21061.241.6597 6.2855 .581 21.161 .433
6.21061.241.6597 7.2855 .581 22.161 .433
7.21061.241.6597 8.2855 .581 23.161 .433
8.21061.241.6597 9.2855 .581 24.161 .433
9.21061.241.6597 10.2855 .581 25.161 .433
10.21061.241.6597 11.2855 .581 26.161 .433
11.21061.241.6597 12.2855 .581 27.161 .433
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14.21061.241.6597 15.2855 .581 30.161 .433
15.21061.241.6597 16.2855 .581 31.161 .433
16.21091.321.3299 32.2855 .530
17.21061.241.6597 18.161 .581 33.2855 .433
18.1991.3201.320 19.161 .581 34.161 .581
19.1991.3201.320 20.161 .581 35.161 .581
20.1991.3201.320 21.161 .581 36.161 .581
21.1991.3201.320 22.161 .581 37.161 .581
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23.1991.3201.320 24.161 .581 39.161 .581
24.1991.3201.320 25.161 .581 40.161 .581
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28.1991.3201.320 29.161 .581 44.161 .581
29.1991.3201.320 30.161 .581 45.161 .581
30.1991.3201.320 31.161 .581 46.161 .581
31.1991.3201.320 32.161 .433 47.161 .581
32.21061.241.6597 48.2855 .581
33.21061.241.6597 34.161 .581 49.2855 .433
34.1991.3201.320 35.161 .581 50.161 .581
35.18461.3821.382 36.121 .581 51.121 .581
36.18461.3821.382 37.161 .581 52.121 .581
37.1991.3201.320 38.161 .581 53.161 .581
38.1991.3201.320 39.161 .581 54.161 .581
39.1991.3201.320 40.161 .581 55.161 .581
40.1991.3201.320 41.161 .581 56.161 .581
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41	.1991.3201.320	42	.161.501	57	.161.501
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43	.1991.3201.320	44	.161.501	59	.161.501
44	.1991.3201.320	45	.161.501	60	.161.501
45	.18461.3021.302	46	.121.501	61	.121.501
46	.18461.3021.302	47	.161.501	62	.121.501
47	.1991.3201.320	48	.161.433	63	.161.501
48	.21861.241.6597	64	.2855.501		
49	.21861.241.6597	50	.161.501	65	.2855.433
50	.1991.3201.320	51	.161.501	66	.161.501
51	.18461.3021.302	52	.121.501	67	.161.501
52	.18461.3021.302	53	.161.501	68	.161.501
53	.1991.3201.320	54	.161.501	69	.161.501
54	.1991.3201.320	55	.161.501	70	.161.501
55	.1991.3201.320	56	.161.501	71	.161.501
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57	.1991.3201.320	58	.161.501	73	.161.501
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60	.1991.3201.320	61	.161.501	76	.161.501
61	.18461.3021.302	62	.121.501	77	.161.501
62	.18461.3021.302	63	.161.501	78	.161.501
63	.1991.3201.320	64	.161.433	79	.161.501
64	.21861.241.6597	68	.2855.501		
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66	.1991.3201.320	67	.161.501	82	.161.501
67	.1991.3201.320	68	.161.501	83	.161.501
68	.1991.3201.320	69	.161.501	84	.161.501
69	.18461.3021.302	70	.121.501	85	.121.501
70	.18461.3021.302	71	.161.501	86	.121.501
71	.1991.3201.320	72	.161.501	87	.161.501
72	.1991.3201.320	73	.161.501	88	.161.501
73	.1991.3201.320	74	.161.501	89	.161.501
74	.1991.3201.320	75	.161.501	90	.161.501
75	.18461.3021.302	76	.121.501	91	.121.501
76	.18461.3021.302	77	.161.501	92	.121.501
77	.1991.3201.320	78	.161.501	93	.161.501
78	.1991.3201.320	79	.161.501	94	.161.501
79	.18461.3021.302	80	.121.433	95	.121.501
80	.20421.304.7226	98	.2455.501		
81	.21861.241.6597	82	.161.501	97	.2855.433
82	.1991.3201.320	83	.161.501	98	.161.501
83	.1991.3201.320	84	.161.501	99	.161.501
84	.1991.3201.320	85	.161.501	100	.161.501
85	.18461.3021.302	86	.121.501	101	.161.501
86	.18461.3021.302	87	.161.501	102	.161.501
87	.1991.3201.320	88	.161.501	103	.161.501
88	.1991.3201.320	89	.161.501	104	.161.501
89	.1991.3201.320	90	.161.501	105	.161.501
90	.1991.3201.320	91	.161.501	106	.161.501
91	.18461.3021.302	92	.121.501	107	.161.501
92	.18461.3021.302	93	.161.501	108	.161.501
93	.1991.3201.320	94	.161.501	109	.161.501
94	.1991.3201.320	95	.161.501	110	.161.501
95	.18461.3021.302	96	.121.433	111	.161.501
96	.20421.304.7226	112	.2455.501		
97	.21861.241.6597	98	.161.501	113	.2855.433
98	.1991.3201.320	99	.161.501	114	.161.501
99	.1991.3201.320	100	.161.501	115	.161.501
100	.1991.3201.320	101	.161.501	116	.161.501

101	.1991.3201.320	102	.161	.501	117	.161	.501
102	.1991.3201.320	103	.161	.501	118	.161	.501
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107	.1991.3201.320	108	.161	.501	123	.161	.501
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113	.21061.241.0597	114	.161	.501	129	.2055	.433
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115	.1991.3201.320	116	.161	.501	131	.161	.501
116	.1991.3201.320	117	.161	.501	132	.161	.501
117	.1991.3201.320	118	.161	.501	133	.161	.501
118	.1991.3201.320	119	.161	.501	134	.161	.501
119	.1991.3201.320	120	.161	.501	135	.161	.501
120	.18461.3821.382	121	.121	.501	136	.121	.501
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122	.1991.3201.320	123	.161	.501	138	.161	.501
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124	.1991.3201.320	125	.161	.501	140	.161	.501
125	.1991.3201.320	126	.161	.501	141	.161	.501
126	.1991.3201.320	127	.161	.501	142	.161	.501
127	.1991.3201.320	128	.161	.433	143	.161	.501
128	.21061.241.0597	144	.2055	.501			
129	.21061.241.0597	130	.161	.501	145	.2055	.433
130	.1991.3201.320	131	.161	.501	146	.161	.501
131	.1991.3201.320	132	.161	.501	147	.161	.501
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135	.1991.3201.320	136	.161	.501	151	.161	.501
136	.18461.3821.382	137	.121	.501	152	.161	.501
137	.18461.3821.382	138	.161	.501	153	.161	.501
138	.1991.3201.320	139	.161	.501	154	.161	.501
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142	.1991.3201.320	143	.161	.501	158	.161	.501
143	.1991.3201.320	144	.161	.433	159	.161	.501
144	.21061.241.0597	160	.2055	.501			
145	.21061.241.0597	146	.161	.501	161	.2055	.433
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147	.1991.3201.320	148	.161	.501	163	.161	.501
148	.1991.3201.320	149	.161	.501	164	.161	.501
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153	.1991.3201.320	154	.161	.501	169	.161	.501
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157	.1991.3201.320	158	.161	.501	173	.161	.501
158	.1991.3201.320	159	.161	.501	174	.161	.501
159	.1991.3201.320	160	.161	.433	175	.161	.501
160	.21061.241.0597	176	.2055	.501			

161.21861.241.6597 162 .161 .581 177.2855 .433
162 .1991.3281.328 163 .161 .581 178 .161 .581
163 .1991.3281.328 164 .161 .581 179 .161 .581
164 .1991.3281.328 165 .161 .581 180 .161 .581
165.18461.3821.382 166 .121 .581 181 .121 .581
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167 .1991.3281.328 168 .161 .581 183 .161 .581
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188.18461.3821.382 189 .161 .581 204 .161 .581
189 .1991.3281.328 190 .161 .581 205 .161 .581
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192.28421.384.7226 208.2455 .581
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203 .1991.3281.328 204 .161 .581 219 .161 .581
204 .1991.3281.328 205 .161 .581 220 .161 .581
205.18461.3821.382 206 .121 .581 221 .121 .581
206.18461.3821.382 207 .161 .581 222 .121 .581
207 .1991.3281.328 208 .161 .433 223 .161 .581
208.21861.241.6597 224.2855 .581
209.21861.241.6597 210 .161 .581 225.2855 .433
210 .1991.3281.328 211 .161 .581 226 .161 .581
211.18461.3821.382 212 .121 .581 227 .161 .581
212.18461.3821.382 213 .161 .581 228 .161 .581
213.19901.3281.328 214 .161 .581 229 .161 .581
214.19901.3281.328 215 .161 .581 230 .161 .581
215.19901.3281.328 216 .161 .581 231 .161 .581
216.19901.3281.328 217 .161 .581 232 .161 .581
217.19901.3281.328 218 .161 .581 233 .161 .581
218.19901.3281.328 219 .161 .581 234 .161 .581
219.19901.3281.328 220 .161 .581 235 .161 .581
220.19901.3281.328 221 .161 .581 236 .161 .581

221.18461.3821.382	222.121.581	237.161.581
222.18461.3821.382	223.161.581	238.161.581
223.1991.3201.320	224.161.433	239.161.581
224.21861.241.6597	240.2855.581	
225.21861.241.6597	226.161.581	241.2855.538
226.19901.3201.320	227.161.581	242.161.433
227.19901.3201.320	228.161.581	243.161.433
228.19901.3201.320	229.161.581	244.161.433
229.19901.3201.320	230.161.581	245.161.433
230.19901.3201.320	231.161.581	246.161.433
231.19901.3201.320	232.161.581	247.161.433
232.19901.3201.320	233.161.581	248.161.433
233.19901.3201.320	234.161.581	249.161.433
234.19901.3201.320	235.161.581	250.161.433
235.19901.3201.320	236.161.581	251.161.433
236.19901.3201.320	237.161.581	252.161.433
237.19901.3201.320	238.161.581	253.161.433
238.19901.3201.320	239.161.581	254.161.433
239.19901.3201.320	240.161.433	255.161.433
240.21861.241.6597	258.2855.538	
241.21091.321.3299	242.2855.538	
242.21861.241.6597	243.2855.581	
243.21861.241.6597	244.2855.581	
244.21861.241.6597	245.2855.581	
245.21861.241.6597	246.2855.581	
246.21861.241.6597	247.2855.581	
247.21861.241.6597	248.2855.581	
248.21861.241.6597	249.2855.581	
249.21861.241.6597	250.2855.581	
250.21861.241.6597	251.2855.581	
251.21861.241.6597	252.2855.581	
252.21861.241.6597	253.2855.581	
253.21861.241.6597	254.2855.581	
254.21861.241.6597	255.2855.581	
255.21861.241.6597	258.2855.538	
258.21091.321.3299		

2 2 18

0	1	0	0	1					
2	18.1584.688	0.		21.500	5.44	82.121	5.44	96.188	2.03
2	28.1584.688	0.		32.121	5.44	106.188	2.03		
2	38.1584.688	0.		41.500	5.44	116.188	2.03		
2	48.1584.688	0.		52.121	5.44	126.188	2.03		
2	58.1584.688	0.		61.500	5.44	136.188	2.03		
2	68.1584.688	0.		72.121	5.44	146.188	2.03		
2	78.1584.688	0.		81.500	5.44	156.188	2.03		
2	88.1584.688	0.		106.188	2.03				
2	910.928.872	0.		102.563	4.13				
2	1010.928.872	0.							
2	1110.928.872	0.		122.563	4.13				
2	1210.928.872	0.							
2	1310.928.872	0.		142.563	4.13				
2	1410.928.872	0.							
2	1510.928.872	0.		162.563	4.13				
2	1610.928.872	0.							

rods	1	1	1	0	0	1				
1	1	225								
1	.42	1.	1	.25	2	.25	17	.25	18	.25
2	.42	1.	2	.25	3	.25	18	.25	19	.25
3	.42	1.	3	.25	4	.25	19	.25	20	.25

4	.42	1.	4	.25	5	.25	20	.25	21	.25
5	.42	1.	5	.25	6	.25	21	.25	22	.25
6	.42	1.	6	.25	7	.25	22	.25	23	.25
7	.42	1.	7	.25	8	.25	23	.25	24	.25
8	.42	1.	8	.25	9	.25	24	.25	25	.25
9	.42	1.	9	.25	10	.25	25	.25	26	.25
10	.42	1.	10	.25	11	.25	26	.25	27	.25
11	.42	1.	11	.25	12	.25	27	.25	28	.25
12	.42	1.	12	.25	13	.25	28	.25	29	.25
13	.42	1.	13	.25	14	.25	29	.25	30	.25
14	.42	1.	14	.25	15	.25	30	.25	31	.25
15	.42	1.	15	.25	16	.25	31	.25	32	.25
16	.42	1.	16	.25	17	.25	32	.25	33	.25
17	.42	1.	17	.25	18	.25	33	.25	34	.25
18	.42	1.	18	.25	19	.25	34	.25	35	.25
19	.42	1.	19	.25	20	.25	35	.25	36	.25
20	.42	1.	20	.25	21	.25	36	.25	37	.25
21	.42	1.	21	.25	22	.25	37	.25	38	.25
22	.42	1.	22	.25	23	.25	38	.25	39	.25
23	.42	1.	23	.25	24	.25	39	.25	40	.25
24	.42	1.	24	.25	25	.25	40	.25	41	.25
25	.42	1.	25	.25	26	.25	41	.25	42	.25
26	.42	1.	26	.25	27	.25	42	.25	43	.25
27	.42	1.	27	.25	28	.25	43	.25	44	.25
28	.42	1.	28	.25	29	.25	44	.25	45	.25
29	.42	1.	29	.25	30	.25	45	.25	46	.25
30	.42	1.	30	.25	31	.25	46	.25	47	.25
31	.42	1.	31	.25	32	.25	47	.25	48	.25
32	.42	1.	32	.25	33	.25	48	.25	49	.25
33	.42	1.	33	.25	34	.25	49	.25	50	.25
34	.42	1.	34	.25	35	.25	50	.25	51	.25
35	.42	1.	35	.25	36	.25	51	.25	52	.25
36	.42	1.	36	.25	37	.25	52	.25	53	.25
37	.42	1.	37	.25	38	.25	53	.25	54	.25
38	.42	1.	38	.25	39	.25	54	.25	55	.25
39	.42	1.	39	.25	40	.25	55	.25	56	.25
40	.42	1.	40	.25	41	.25	56	.25	57	.25
41	.42	1.	41	.25	42	.25	57	.25	58	.25
42	.42	1.	42	.25	43	.25	58	.25	59	.25
43	.42	1.	43	.25	44	.25	59	.25	60	.25
44	.42	1.	44	.25	45	.25	60	.25	61	.25
45	.42	1.	45	.25	46	.25	61	.25	62	.25
46	.42	1.	46	.25	47	.25	62	.25	63	.25
47	.42	1.	47	.25	48	.25	63	.25	64	.25
48	.42	1.	48	.25	49	.25	64	.25	65	.25
49	.42	1.	49	.25	50	.25	65	.25	66	.25
50	.42	1.	50	.25	51	.25	66	.25	67	.25
51	.42	1.	51	.25	52	.25	67	.25	68	.25
52	.42	1.	52	.25	53	.25	68	.25	69	.25
53	.42	1.	53	.25	54	.25	69	.25	70	.25
54	.42	1.	54	.25	55	.25	70	.25	71	.25
55	.42	1.	55	.25	56	.25	71	.25	72	.25
56	.42	1.	56	.25	57	.25	72	.25	73	.25
57	.42	1.	57	.25	58	.25	73	.25	74	.25
58	.42	1.	58	.25	59	.25	74	.25	75	.25
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60	.42	1.	60	.25	61	.25	76	.25	77	.25
61	.42	1.	61	.25	62	.25	77	.25	78	.25
62	.42	1.	62	.25	63	.25	78	.25	79	.25
63	.42	1.	63	.25	64	.25	79	.25	80	.25
64	.42	1.	64	.25	65	.25	80	.25	81	.25
65	.42	1.	65	.25	66	.25	81	.25	82	.25
66	.42	1.	66	.25	67	.25	82	.25	83	.25
67	.42	1.	67	.25	68	.25	83	.25	84	.25

64	.42	1.	68	.25	69	.25	64	.25	85	.25
65	0.42	0.	69	.25	70	.25	85	.25	86	.25
66	.42	1.	70	.25	71	.25	86	.25	87	.25
67	.42	1.	71	.25	72	.25	87	.25	88	.25
68	.42	1.	72	.25	73	.25	88	.25	89	.25
69	.42	1.	73	.25	74	.25	89	.25	90	.25
70	.42	1.	74	.25	75	.25	90	.25	91	.25
71	0.42	0.	75	.25	76	.25	91	.25	92	.25
72	.42	1.	76	.25	77	.25	92	.25	93	.25
73	.42	1.	77	.25	78	.25	93	.25	94	.25
74	.42	1.	78	.25	79	.25	94	.25	95	.25
75	0.42	0.	79	.25	80	.25	95	.25	96	.25
76	.42	1.	81	.25	82	.25	97	.25	98	.25
77	.42	1.	82	.25	83	.25	98	.25	99	.25
78	.42	1.	83	.25	84	.25	99	.25	100	.25
79	.42	1.	84	.25	85	.25	100	.25	101	.25
80	.42	1.	85	.25	86	.25	101	.25	102	.25
81	.42	1.	86	.25	87	.25	102	.25	103	.25
82	.42	1.	87	.25	88	.25	103	.25	104	.25
83	.42	1.	88	.25	89	.25	104	.25	105	.25
84	.42	1.	89	.25	90	.25	105	.25	106	.25
85	.42	1.	90	.25	91	.25	106	.25	107	.25
86	.42	1.	91	.25	92	.25	107	.25	108	.25
87	.42	1.	92	.25	93	.25	108	.25	109	.25
88	.42	1.	93	.25	94	.25	109	.25	110	.25
89	.42	1.	94	.25	95	.25	110	.25	111	.25
90	.42	1.	95	.25	96	.25	111	.25	112	.25
91	.42	1.	97	.25	98	.25	113	.25	114	.25
92	.42	0.	98	.25	99	.25	114	.25	115	.25
93	.42	1.	99	.25	100	.25	115	.25	116	.25
94	.42	1.	100	.25	101	.25	116	.25	117	.25
95	.42	1.	101	.25	102	.25	117	.25	118	.25
96	.42	1.	102	.25	103	.25	118	.25	119	.25
97	.42	1.	103	.25	104	.25	119	.25	120	.25
98	.42	1.	104	.25	105	.25	120	.25	121	.25
99	.42	1.	105	.25	106	.25	121	.25	122	.25
100	.42	1.	106	.25	107	.25	122	.25	123	.25
101	.42	1.	107	.25	108	.25	123	.25	124	.25
102	.42	1.	108	.25	109	.25	124	.25	125	.25
103	.42	1.	109	.25	110	.25	125	.25	126	.25
104	.42	0.	110	.25	111	.25	126	.25	127	.25
105	.42	1.	111	.25	112	.25	127	.25	128	.25
106	.42	1.	113	.25	114	.25	129	.25	130	.25
107	.42	1.	114	.25	115	.25	130	.25	131	.25
108	.42	1.	115	.25	116	.25	131	.25	132	.25
109	.42	1.	116	.25	117	.25	132	.25	133	.25
110	.42	1.	117	.25	118	.25	133	.25	134	.25
111	.42	1.	118	.25	119	.25	134	.25	135	.25
112	.42	1.	119	.25	120	.25	135	.25	136	.25
113	0.42	0.	120	.25	121	.25	136	.25	137	.25
114	.42	1.	121	.25	122	.25	137	.25	138	.25
115	.42	1.	122	.25	123	.25	138	.25	139	.25
116	.42	1.	123	.25	124	.25	139	.25	140	.25
117	.42	1.	124	.25	125	.25	140	.25	141	.25
118	.42	1.	125	.25	126	.25	141	.25	142	.25
119	.42	1.	126	.25	127	.25	142	.25	143	.25
120	.42	1.	127	.25	128	.25	143	.25	144	.25
121	.42	1.	129	.25	130	.25	145	.25	146	.25
122	.42	1.	130	.25	131	.25	146	.25	147	.25
123	.42	1.	131	.25	132	.25	147	.25	148	.25

124	.42	1.	132	.25	133	.25	148	.25	149	.25
125	.42	1.	133	.25	134	.25	149	.25	150	.25
126	.42	1.	134	.25	135	.25	150	.25	151	.25
127	.42	1.	135	.25	136	.25	151	.25	152	.25
128	.42	1.	136	.25	137	.25	152	.25	153	.25
129	.42	1.	137	.25	138	.25	153	.25	154	.25
130	.42	1.	138	.25	139	.25	154	.25	155	.25
131	.42	1.	139	.25	140	.25	155	.25	156	.25
132	.42	1.	140	.25	141	.25	156	.25	157	.25
133	.42	1.	141	.25	142	.25	157	.25	158	.25
134	.42	1.	142	.25	143	.25	158	.25	159	.25
135	.42	1.	143	.25	144	.25	159	.25	160	.25
136	.42	1.	145	.25	146	.25	161	.25	162	.25
137	.42	1.	146	.25	147	.25	162	.25	163	.25
138	.42	1.	147	.25	148	.25	163	.25	164	.25
139	.42	1.	148	.25	149	.25	164	.25	165	.25
140	.42	1.	149	.25	150	.25	165	.25	166	.25
141	.42	1.	150	.25	151	.25	166	.25	167	.25
142	.42	1.	151	.25	152	.25	167	.25	168	.25
143	.42	1.	152	.25	153	.25	168	.25	169	.25
144	.42	1.	153	.25	154	.25	169	.25	170	.25
145	.42	1.	154	.25	155	.25	170	.25	171	.25
146	.42	1.	155	.25	156	.25	171	.25	172	.25
147	.42	1.	156	.25	157	.25	172	.25	173	.25
148	.42	1.	157	.25	158	.25	173	.25	174	.25
149	.42	1.	158	.25	159	.25	174	.25	175	.25
150	.42	1.	159	.25	160	.25	175	.25	176	.25
151	.42	0.	161	.25	162	.25	177	.25	178	.25
152	.42	1.	162	.25	163	.25	178	.25	179	.25
153	.42	1.	163	.25	164	.25	179	.25	180	.25
154	.42	1.	164	.25	165	.25	180	.25	181	.25
155	0.42	0.	165	.25	166	.25	181	.25	182	.25
156	.42	1.	166	.25	167	.25	182	.25	183	.25
157	.42	1.	167	.25	168	.25	183	.25	184	.25
158	.42	1.	168	.25	169	.25	184	.25	185	.25
159	.42	1.	169	.25	170	.25	185	.25	186	.25
160	.42	1.	170	.25	171	.25	186	.25	187	.25
161	0.42	0.	171	.25	172	.25	187	.25	188	.25
162	.42	1.	172	.25	173	.25	188	.25	189	.25
163	.42	1.	173	.25	174	.25	189	.25	190	.25
164	.42	1.	174	.25	175	.25	190	.25	191	.25
165	0.42	0.	175	.25	176	.25	191	.25	192	.25
166	.42	1.	177	.25	178	.25	193	.25	194	.25
167	.42	1.	178	.25	179	.25	194	.25	195	.25
168	.42	1.	179	.25	180	.25	195	.25	196	.25
169	.42	1.	180	.25	181	.25	196	.25	197	.25
170	.42	1.	181	.25	182	.25	197	.25	198	.25
171	.42	1.	182	.25	183	.25	198	.25	199	.25
172	.42	1.	183	.25	184	.25	199	.25	200	.25
173	.42	1.	184	.25	185	.25	200	.25	201	.25
174	.42	1.	185	.25	186	.25	201	.25	202	.25
175	.42	1.	186	.25	187	.25	202	.25	203	.25
176	.42	1.	187	.25	188	.25	203	.25	204	.25
177	.42	1.	188	.25	189	.25	204	.25	205	.25
178	.42	1.	189	.25	190	.25	205	.25	206	.25
179	.42	1.	190	.25	191	.25	206	.25	207	.25
180	.42	1.	191	.25	192	.25	207	.25	208	.25
181	.42	1.	193	.25	194	.25	209	.25	210	.25
182	.42	1.	194	.25	195	.25	210	.25	211	.25
183	0.42	0.	195	.25	196	.25	211	.25	212	.25

184	.42	1.	196	.25	197	.25	212	.25	213	.25
185	.42	1.	197	.25	198	.25	213	.25	214	.25
186	.42	1.	198	.25	199	.25	214	.25	215	.25
187	.42	1.	199	.25	200	.25	215	.25	216	.25
188	.42	1.	200	.25	201	.25	216	.25	217	.25
189	.42	1.	201	.25	202	.25	217	.25	218	.25
190	.42	1.	202	.25	203	.25	218	.25	219	.25
191	.42	1.	203	.25	204	.25	219	.25	220	.25
192	.42	1.	204	.25	205	.25	220	.25	221	.25
193	.42	0.	205	.25	206	.25	221	.25	222	.25
194	.42	1.	206	.25	207	.25	222	.25	223	.25
195	.42	1.	207	.25	208	.25	223	.25	224	.25
196	.42	1.	209	.25	210	.25	225	.25	226	.25
197	.42	1.	210	.25	211	.25	226	.25	227	.25
198	.42	1.	211	.25	212	.25	227	.25	228	.25
199	.42	1.	212	.25	213	.25	228	.25	229	.25
200	.42	1.	213	.25	214	.25	229	.25	230	.25
201	.42	1.	214	.25	215	.25	230	.25	231	.25
202	.42	1.	215	.25	216	.25	231	.25	232	.25
203	.42	1.	216	.25	217	.25	232	.25	233	.25
204	.42	1.	217	.25	218	.25	233	.25	234	.25
205	.42	1.	218	.25	219	.25	234	.25	235	.25
206	.42	1.	219	.25	220	.25	235	.25	236	.25
207	.42	1.	220	.25	221	.25	236	.25	237	.25
208	.42	1.	221	.25	222	.25	237	.25	238	.25
209	.42	1.	222	.25	223	.25	238	.25	239	.25
210	.42	1.	223	.25	224	.25	239	.25	240	.25
211	.42	1.	225	.25	226	.25	241	.25	242	.25
212	.42	1.	226	.25	227	.25	242	.25	243	.25
213	.42	1.	227	.25	228	.25	243	.25	244	.25
214	.42	1.	228	.25	229	.25	244	.25	245	.25
215	.42	1.	229	.25	230	.25	245	.25	246	.25
216	.42	1.	230	.25	231	.25	246	.25	247	.25
217	.42	1.	231	.25	232	.25	247	.25	248	.25
218	.42	1.	232	.25	233	.25	248	.25	249	.25
219	.42	1.	233	.25	234	.25	249	.25	250	.25
220	.42	1.	234	.25	235	.25	250	.25	251	.25
221	.42	1.	235	.25	236	.25	251	.25	252	.25
222	.42	1.	236	.25	237	.25	252	.25	253	.25
223	.42	1.	237	.25	238	.25	253	.25	254	.25
224	.42	1.	238	.25	239	.25	254	.25	255	.25
225	.42	1.	239	.25	240	.25	255	.25	256	.25

2	0	0								
3.0	.059	.655	.350	10.	0.1	409.	.0251000	.420		
slab	2	3	15							
1					3678.					
2					989.					
1	1	.95			2	2	1	8	1	
2	1	.95			1	3	1			
3	1	.95			1	4	1			
4	1	.95			1	5	1			
5	1	.95			1	6	1			
6	1	.95			1	7	1			
7	1	.95			1	8	1			
8	1	.95								
9	2	1.74			2	10	2	16	2	
10	2	1.74			1	11	2			
11	2	1.74			1	12	2			
12	2	1.74			1	13	2			
13	2	1.74			1	14	2			

14	2	1.74				1	15	2						
15	2	1.74				1	16	2						
16	2	1.74												
1		34.28		.5561										
2		12.146		4.614		989.								
3		.0138		6.684										
1	9	1	1	1	1	2	1	1	3	1	1	4	1	
			1	5	1	1	6	1	1	7	1	1	8	1
			2	1	2									
2	9	1	9	1	1	10	1	1	11	1	1	12	1	
			1	13	1	1	14	1	1	15	1	1	16	1
			2	2	2									
3	9	1	16	1	1	32	1	1	48	1	1	64	1	
			1	80	1	1	96	1	1	112	1	1	128	1
			2	3	2									
4	9	1	144	1	1	160	1	1	176	1	1	192	1	
			1	208	1	1	224	1	1	240	1	1	256	1
			2	4	2									
5	9	1	249	1	1	264	1	1	251	1	1	249	1	
			1	253	1	1	254	1	1	255	1	1	256	1
			2	5	2									
6	9	1	241	1	1	242	1	1	243	1	1	244	1	
			1	245	1	1	246	1	1	247	1	1	248	1
			2	6	2									
7	9	1	129	1	1	145	1	1	161	1	1	177	1	
			1	193	1	1	209	1	1	225	1	1	241	1
			2	7	2									
8	9	1	1	1	1	17	1	1	33	1	1	49	1	
			1	85	1	1	81	1	1	97	1	1	113	1
			2	8	2									
9	1	2	89	3										
10	1	2	16	3										
11	1	2	11	3										
12	1	2	12	3										
13	1	2	13	3										
14	1	2	14	3										
15	1	2	15	3										
16	1	2	16	3										

radg	2	1	1											
1	16													
14.614	.25	1.0016	2.0	3.0	4.0	5.0	6.0							
		7.0	8.0	9.6888	10.2656	11.8885	12.0							
		13.0	14.0	15.0	16.8435									
24.614	.25	1.0	2.0016	3.0	4.0	5.0	6.0							
		7.0	8.0	9.2656	10.6888	11.8435	12.0							
		13.0	14.0	15.0	16.8885									
34.614	.25	1.0	2.0	3.0016	4.0	5.0	6.0							
		7.0	8.0	9.0	10.8435	11.6888	12.2656							
		13.0085	14.0	15.0	16.0									
44.614	.25	1.0	2.0	3.0	4.0016	5.0	6.0							
		7.0	8.0	9.0	10.8885	11.2656	12.6888							
		13.8435	14.0	15.0	16.0									
54.614	.25	1.0	2.0	3.0	4.0	5.0016	6.0							
		7.0	8.0	9.0	10.0	11.0	12.8435							
		13.6888	14.2656	15.8885	16.0									
64.614	.25	1.0	2.0	3.0	4.0	5.0	6.0016							
		7.0	8.0	9.0	10.0	11.0	12.8885							
		13.2656	14.6888	15.8435	16.0									
74.614	.25	1.0	2.0	3.0	4.0	5.0	6.0							

			7.0016	8.0	9.0085	10.0	11.0	12.0			
			13.0	14.0435	15.0808	16.2658					
84.614	.25		1.0	2.0	3.0	4.0	5.0	6.0			
			7.0	8.0016	9.0435	10.0	11.0	12.0			
			13.0	14.0085	15.2658	16.6808					
96.684	.6		1.4700	2.1833	3.0	4.0	5.0	6.0			
			7.0059	8.03	9.0271	10.0734	11.0637	12.0			
			13.0	14.0134	15.0637	16.0695					
106.684	.6		1.1833	2.4700	3.0300	4.0059	5.0	6.0			
			7.0	8.0	9.0734	10.0271	11.0095	12.0637			
			13.0134	14.0	15.0	16.0637					
116.684	.6		1.0059	2.03	3.47	4.1833	5.0	6.0			
			7.0	8.0	9.0637	10.0695	11.0271	12.0734			
			13.0637	14.0	15.0	16.0134					
126.684	.6		1.0	2.0	3.1833	4.47	5.03	6.0059			
			7.0	8.0	9.0000	10.0037	11.0734	12.0271			
			13.0695	14.0637	15.0134	16.0					
136.684	.6		1.0	2.0	3.0059	4.0300	5.47	6.1833			
			7.0	8.0	9.0	10.0134	11.0637	12.0095			
			13.0271	14.0734	15.0637	16.0					
146.684	.6		1.0	2.0	3.0	4.0	5.1833	6.4700			
			7.0300	8.0059	9.0134	10.0	11.0	12.0637			
			13.0734	14.0271	15.0695	16.0637					
156.684	.6		1.0	2.0	3.0	4.0	5.0059	6.03			
			7.47	8.1833	9.0637	10.0	11.0	12.0134			
			13.0637	14.0695	15.0271	16.0734					
166.684	.6		1.03	2.0059	3.0	4.0	5.0	6.0			
			7.1833	8.4700	9.0095	10.0037	11.0134	12.0			
			13.0	14.0637	15.0734	16.0271					
1	1	8	1	2	3	4	5	6	7	8	
2	-1	16	1	2	3	4	5	6	7	8	9
			13	14	15	16					10
11											11
12											12
heat	1	0	1								
			3.06		3.06						
1.0	1.0										
drag	2	2									
100.	-1.0			100.	-1.0	.95					
100.	-1.0			100.	-1.0	1.0					
1	16	8									
7	18	240	.066	2.	.155	2.	.276	4.	.393	2.	.454
			.979	8.				8.	.699	8.	
7	1	17	.066	1.	.155	1.	.276	4.	.393	1.	.454
			.979	4.				4.	.699	4.	
7	32	33	.066	1.	.155	1.	.276	4.	.393	1.	.454
			.979	4.				4.	.699	4.	
7	48	49	.066	1.	.155	1.	.276	4.	.393	1.	.454
			.979	4.				4.	.699	4.	
7	64	65	.066	1.	.155	1.	.276	4.	.393	1.	.454
			.979	4.				4.	.699	4.	
7	80	81	.066	1.	.155	1.	.276	4.	.393	1.	.454
			.979	4.				4.	.699	4.	
7	96	97	.066	1.	.155	1.	.276	4.	.393	1.	.454
			.979	4.				4.	.699	4.	
7	112	113	.066	1.	.155	1.	.276	4.	.393	1.	.454
			.979	4.				4.	.699	4.	
7	128	129	.066	1.	.155	1.	.276	4.	.393	1.	.454
			.979	4.				4.	.699	4.	
7	144	145	.066	1.	.155	1.	.276	4.	.393	1.	.454
			.979	4.				4.	.699	4.	
7	160	161	.066	1.	.155	1.	.276	4.	.393	1.	.454
			.979	4.				4.	.699	4.	

```

      .979 4.
7 176 177 .066 1. .155 1. .276 4. .393 1. .454 4. .699 4.
      .979 4.
7 192 193 .066 1. .155 1. .276 4. .393 1. .454 4. .699 4.
      .979 4.
7 208 209 .066 1. .155 1. .276 4. .393 1. .454 4. .699 4.
      .979 4.
7 224 225 .066 1. .155 1. .276 4. .393 1. .454 4. .699 4.
      .979 4.
7 240 256 .066 1. .155 1. .276 4. .393 1. .454 4. .699 4.
      .979 4.
2 1 0
1 1 16 6.01 36.6
bdry 5 4 0 2
1 .001
2 9.98e-6
3 3.22e-6
4 1.98e-6
5 1.86e-4
1 23-.015 189.-.066 260. .0056 283. .0219 299. .0459 313. .0900 334.
      .1567 350. .2112 360. .2829 370. .3548 377. .4529 381. .6854 381.
      .7942 376. .8383 371. .8664 363. .9483 347. 1.030 316. 1.071 296.
      1.128 274. 1.134 253. 1.153 231. 1.171 205. 1.184 166.
2 23-.015 188.-.012 247.-.002 267. .0112 281. .0424 300. .0767 316.
      .1238 331. .1741 344. .2526 357. .3349 366. .3870 367. .7386 367.
      .7877 365. .8542 360. .8948 353. .9413 342. 1.009 323. 1.061 303.
      1.091 287. 1.129 262. 1.151 239. 1.170 216. 1.185 167.
3 23-.014 188.-.005 234.-.0007 250. .0258 271. .0400 284. .0922 302.
      .1487 317. .2176 333. .2840 343. .3349 348. .3873 351. .7521 353.
      .8034 351. .8818 342. .9484 329. 1.015 310. 1.076 284. 1.110 265.
      1.134 249. 1.153 230. 1.169 209. 1.178 189. 1.185 166.
4 23-.012 188.-.002 210. .0153 225. .0427 244. .0736 261. .1099 276.
      .1673 293. .2172 305. .3106 324. .3579 329. .4164 334. .4931 336.
      .7748 337. .8246 335. .8710 330. .9082 322. .9629 308. 1.024 288.
      1.069 270. 1.114 245. 1.161 220. 1.171 199. 1.188 166.
9 1 7.07 1
1 1. 1 1. 1
10 1 7.07 1
1 1. 1 1. 1
11 1 7.07 2
1 1. 1 1. 1
12 1 7.07 3
1 1. 1 1. 1
13 1 7.07 4
1 1. 1 1. 1
14 1 7.07 4
1 1. 1 1. 1
15 1 7.07 3
1 1. 1 1. 1
16 1 7.07 2
1 1. 1 1. 1
1 379. 254. 2 2166.7188.7
1 1. 3
2 1. 1
1 1. 2
2 1. 1 0 1 2 .95 2. 2 2 .95 2. 3 2 .95 2.
      4 2 .95 2. 5 2 .95 2. 6 2 .95 2.
      7 2 .95 2. 8 2 .95 2.
21340. 240. 2 2255.7162.8
1 1. 3

```



```

2 1. 1
1 1. 4
2 2.56 5
calc 1 0 0
                                0.1
25
oper 1 2 3 1                                1
20. 202. .0001 .001997821 250. .000000 0.0
1. -.33
1.000
6
0. 0.1043 0.1044 1.9750 1.9750 0. 1.0 0.0
outp 11011
endd

```

data from iterative solution using the recirculation module
time = 0.0000 dt = ***** implicit dt = 0.0000 explicit dt = ***** mode = 0

iteration no.	sweep no.	peak clad				Total flow (lbm/s)	pressure drop(psi)	error			
		temp(f)	fluid	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	522.3	24	90	1	0.397e-10	0.0000057	17.7506	9.6060	0.0220	0.0100
	2	524.1	24	90	1			0.0362	9.6060	0.0449	0.0024
2	1	533.1	23	90	1	0.191e-10	0.0000001	-0.0300	1.1146	0.0325	0.0098
	2	544.3	21	90	1			0.0644	1.1146	0.0077	0.0059
3	1	549.1	20	90	1	0.462e-11	0.0000000	0.0665	0.3706	0.0043	0.0029
	2	553.1	19	90	1			0.0299	0.3706	0.0042	0.0010
4	1	554.9	18	90	1	-0.374e-11	0.0000000	-0.0329	0.1873	0.0027	0.0019
	2	556.1	18	90	1			0.0125	0.1873	0.0033	0.0004
5	1	556.7	17	90	1	-0.556e-11	0.0000000	0.0104	0.0048	0.0019	0.0011
	2	557.0	17	90	1			0.0056	0.0048	0.0026	0.0005
6	1	557.2	17	90	1	-0.547e-11	0.0000000	0.0042	0.0417	0.0020	0.0006
	2	557.3	16	90	1			0.0025	0.0417	0.0024	0.0006
7	1	557.3	16	90	1	-0.430e-11	0.0000000	-0.0022	0.0200	0.0020	0.0006
	2	557.3	16	90	1			0.0012	0.0200	0.0023	0.0005
8	1	557.3	16	90	1	0.365e-11	0.0000000	0.0011	0.0173	0.0020	0.0006
	2	557.3	16	90	1			0.0000	0.0173	0.0022	0.0005
9	1	557.3	16	90	1	0.930e-11	0.0000000	0.0006	0.0112	0.0020	0.0006
	2	557.3	16	90	1			0.0005	0.0112	0.0022	0.0005
10	1	557.3	16	90	1	0.747e-11	0.0000000	-0.0003	0.0072	0.0020	0.0005
	2	557.3	16	90	1			0.0003	0.0072	0.0021	0.0005

axial zone (1) (2) (3) (4) (5) (6) (7) (8) (9) (10)

(inches)

0.0 - 6.9	238.94	238.94	236.38	232.94	229.00	229.00	232.93	236.38	298.02	298.02
6.9 - 13.8	291.08	291.09	288.54	283.93	279.03	279.02	283.92	288.53	319.46	319.46
13.8 - 20.7	334.93	334.95	331.48	326.84	322.04	322.03	326.80	331.44	335.47	335.47
20.7 - 27.5	399.39	399.43	395.99	391.73	387.27	387.27	391.47	395.77	346.92	346.92
27.5 - 34.4	423.78	423.83	420.55	416.50	412.24	412.23	416.23	420.32	355.58	355.58
34.4 - 41.3	434.92	434.98	431.81	427.95	423.84	423.83	427.60	431.58	362.45	362.45
41.3 - 48.2	441.21	441.25	438.16	434.44	430.52	430.52	434.18	437.94	368.26	368.26
48.2 - 55.1	445.44	445.48	442.44	438.87	435.23	435.22	438.61	442.23	372.84	372.84
55.1 - 62.0	448.34	448.38	445.29	441.76	438.23	438.23	441.51	445.07	376.86	376.86
62.0 - 68.9	449.95	450.00	446.88	443.48	440.16	440.15	443.23	446.06	378.61	378.61
68.9 - 75.8	450.95	450.99	447.78	444.46	441.37	441.36	444.21	447.57	380.27	380.27
75.8 - 82.6	451.47	451.51	448.29	445.85	442.13	442.12	444.88	448.07	380.90	380.90
82.6 - 89.5	451.68	451.70	448.50	445.31	442.48	442.45	445.06	448.20	380.91	380.91
89.5 - 96.4	451.74	451.78	448.59	445.41	442.54	442.53	445.15	448.37	380.91	380.91
96.4 -103.3	451.78	451.80	448.62	445.44	442.54	442.54	445.19	448.40	380.91	380.91
103.3 -110.2	451.73	451.77	448.60	445.42	442.51	442.50	445.17	448.39	380.90	380.90
110.2 -117.1	451.55	451.59	448.45	445.38	442.38	442.37	445.05	448.24	380.79	380.79
117.1 -124.0	450.83	450.88	447.93	444.89	442.00	441.99	444.64	447.72	378.92	378.92
124.0 -130.9	449.52	449.56	446.75	443.85	441.00	441.00	443.50	446.54	377.00	377.00
130.9 -137.7	448.00	447.82	444.35	441.57	438.90	438.89	441.31	444.14	373.84	373.84
137.7 -144.6	442.21	442.25	439.81	437.13	434.50	434.50	438.07	439.59	367.94	367.94
144.6 -151.5	438.15	438.19	436.96	428.43	425.80	425.80	428.17	430.74	359.35	359.35
151.5 -158.4	413.97	414.00	411.87	409.40	406.81	406.80	409.16	411.67	349.48	349.48
158.4 -165.3	365.41	365.42	363.66	361.15	358.47	358.48	361.11	363.62	335.43	335.43

side boundary temperature summary time = 0.0000 seconds
boundary slab node no. 9

axial zone (inches)	(1)	(2)	(
0.0 - 6.9	298.02	297.90	
6.9 - 13.8	319.46	319.59	
13.8 - 20.7	335.47	335.68	
20.7 - 27.5	346.92	347.04	
27.5 - 34.4	355.58	355.85	
34.4 - 41.3	362.45	362.51	
41.3 - 48.2	368.26	368.32	
48.2 - 55.1	372.84	372.80	
55.1 - 62.0	376.86	376.94	
62.0 - 68.9	378.61	378.67	
68.9 - 75.8	380.27	380.37	
75.8 - 82.6	380.90	381.00	
82.6 - 89.5	380.91	381.00	
89.5 - 96.4	380.91	381.00	
96.4 -103.3	380.91	381.00	
103.3 -110.2	380.90	381.00	
110.2 -117.1	380.79	380.90	
117.1 -124.0	378.92	378.99	
124.0 -130.9	377.00	377.07	

130.9 -137.7	373.84	373.93
137.7 -144.6	367.94	367.98
144.6 -151.5	359.35	359.36
151.5 -158.4	349.48	349.54
158.4 -165.3	335.43	335.29

calculated rod temperatures at time = 0.0000 seconds
 rod no. 1
 assembly 1 (fuel type 1 - cylinder)
 #rod o.d. - 0.420 (in.) zone-(fuel dia.(in.)) - 1-(0.350)

```

* fuel temperatures(f.)
*
axial zone heat flux type hsurf * fluid clad
(in.) (mbtu/hr-ft2) (b/h-f-ft2) *
0.0 - 6.9 0.0000 1 1.2 237.2 237.0
6.9 - 13.8 0.0000 1 1.3 269.6 269.4
13.8 - 20.7 0.0000 1 1.3 332.7 332.4
20.7 - 27.5 0.0000 1 1.4 423.3 430.3
27.5 - 34.4 0.0000 1 1.5 446.9 459.5
34.4 - 41.3 0.0000 1 1.5 457.5 470.0
41.3 - 48.2 0.0000 1 1.5 463.7 475.9
48.2 - 55.1 0.0000 1 1.5 467.7 479.9
55.1 - 62.0 0.0000 1 1.5 470.5 482.5
62.0 - 68.9 0.0000 1 1.5 472.0 484.1
68.9 - 75.8 0.0000 1 1.5 472.9 485.0
75.8 - 82.6 0.0000 1 1.5 473.4 485.5
82.6 - 89.5 0.0000 1 1.5 473.6 485.7
89.5 - 96.4 0.0000 1 1.5 473.7 485.7
96.4 - 103.3 0.0000 1 1.5 473.7 485.0
103.3 - 110.2 0.0000 1 1.5 473.7 485.7
110.2 - 117.1 0.0000 1 1.5 473.8 485.6
117.1 - 124.0 0.0000 1 1.5 473.0 485.0
124.0 - 130.9 0.0000 1 1.5 471.9 483.9
130.9 - 137.7 0.0000 1 1.5 469.6 481.7
137.7 - 144.6 0.0000 1 1.5 465.2 477.4
144.6 - 151.5 0.0000 1 1.5 458.9 469.3
151.5 - 158.4 0.0000 1 1.4 439.6 452.5
158.4 - 165.3 0.0000 1 1.4 384.5 384.5

```

calculated rod temperatures at time = 0.0000 seconds
 rod no. 128
 assembly 1 (fuel type 1 - cylinder)
 #rod o.d. - 0.420 (in.) zone-(fuel dia.(in.)) - 1-(0.350)

```

* fuel temperatures(f.)
*
axial zone heat flux type hsurf * fluid clad
(in.) (mbtu/hr-ft2) (b/h-f-ft2) *
0.0 - 6.9 0.0000 1 1.4 233.1 233.1
6.9 - 13.8 0.0000 1 1.5 284.4 284.5
13.8 - 20.7 0.0000 1 1.5 327.6 327.0
20.7 - 27.5 0.0000 1 1.8 514.1 515.6
27.5 - 34.4 0.0000 1 1.8 533.5 534.0
34.4 - 41.3 0.0000 1 1.8 542.1 543.4
41.3 - 48.2 0.0000 1 1.8 547.0 548.3

```


48.2 - 55.1	0.0000	1	1.9	550.4	551.7
55.1 - 62.0	0.0000	1	1.9	552.0	553.9
62.0 - 68.9	0.0000	1	1.9	554.0	555.2
68.9 - 75.8	0.0000	1	1.9	554.0	556.0
75.8 - 82.6	0.0000	1	1.9	555.2	556.5
82.6 - 89.5	0.0000	1	1.9	555.4	556.7
89.5 - 96.4	0.0000	1	1.9	555.5	556.7
96.4 - 103.3	0.0000	1	1.9	555.5	556.7
103.3 - 110.2	0.0000	1	1.9	555.5	556.7
110.2 - 117.1	0.0000	1	1.9	555.4	556.6
117.1 - 124.0	0.0000	1	1.9	555.0	556.2
124.0 - 130.9	0.0000	1	1.9	554.2	555.4
130.9 - 137.7	0.0000	1	1.9	552.4	553.7
137.7 - 144.6	0.0000	1	1.8	549.1	550.3
144.6 - 151.5	0.0000	1	1.8	542.5	543.0
151.5 - 158.4	0.0000	1	1.8	528.0	530.1
158.4 - 165.3	0.0000	1	1.8	303.6	303.5

iterations = 10

APPENDIX C

REA SINGLE ASSEMBLY CONSOLIDATED ROD TEST SIMULATIONS
INPUT, OUTPUT, AND CONVERGENCE LISTS

APPENDIX C

REA SINGLE ASSEMBLY CONSOLIDATED ROD TEST SIMULATIONS
INPUT, OUTPUT, AND CONVERGENCE LISTS

<u>Test Case</u>	<u>Input</u>	<u>Page Number Convergence List</u>	<u>Output</u>
Horizontal, air	C.2	C.12	C.14
Horizontal, helium	C.16	C.26	C.28

+1000

1 1 COND. ZeRO-GAP, SYMM, air; CASE 4 (800 WATTS) validation run.

prop 11 1

1.	00.0	109.9	.0133	.239	11.63	.040
2.	200.	157.9	.0174	.241	16.67	.0510
3.	300.	182.1	.0193	.243	19.23	.0580
4.	400.	206.5	.0212	.245	21.74	.0630
5.	500.	231.1	.0231	.247	24.27	.0680
6.	600.	256.0	.0250	.250	26.81	.0720
7.	700.	281.1	.0268	.253	29.33	.0770
8.	800.	306.7	.0286	.256	31.85	.0810
10.	900.	332.5	.0303	.259	34.36	.0850
15.	1000.	358.6	.0319	.262	36.90	.0889
20.	2000.	617.2	.0471	.286	62.11	.1242

1 SST 9.8

chan 2 2

24. 90.0

1 1 242 0 0

1 1 0 0 1

1.04211.1420.393

2.04211.1420.393

3.02681.2950.785 14.0001.3000

4.02681.2950.785 16.0001.3000

5.02681.2950.785 18.0001.3000

6.02681.2950.785 20.0001.3000

7.02681.2950.785 22.0001.3000

8.02681.2950.785 24.0001.3000

9.02681.2950.785 25.0001.3000

10.02681.2950.785 26.0001.3000

11.02681.2950.785 30.0001.3000

12.02681.2950.785 32.0001.3000

13.12042.1921.309 14.0001.3000 34.0001.3000

14.01010.7850.785 15.0001.3000

15.01010.7850.785 16.0001.3000 35.0001.3000

16.01010.7850.785 17.0001.3000

17.01010.7850.785 18.0001.3000 37.0001.3000

18.01010.7850.785 19.0001.3000

19.01010.7850.785 20.0001.3000 39.0001.3000

20.01010.7850.785 21.0001.3000

21.01010.7850.785 22.0001.3000 41.0001.3000

22.01010.7850.785 23.0001.3000

23.01010.7850.785 24.0001.3000 43.0001.3000

24.01010.7850.785 25.0001.3000

25.01010.7850.785 26.0001.3000 45.0001.3000

26.01010.7850.785 27.0001.3000

27.01010.7850.785 28.0001.3000 47.0001.3000

28.01010.7850.785 29.0001.3000

29.01010.7850.785 30.0001.3000 49.0001.3000

30.01010.7850.785 31.0001.3000

31.01010.7850.785 32.0001.3000 51.0001.3000

32.01010.7850.785 33.0001.3000

33.12042.1921.309 52.0001.3000

34.01010.7850.785 35.0001.3000 54.0001.3000

35.01010.7850.785 36.0001.3000

36.01010.7850.785 37.0001.3000 56.0001.3000

37.01010.7850.785 38.0001.3000

38.01010.7850.785 39.0001.3000 58.0001.3000

39.01010.7850.785 40.0001.3000

40.01010.7850.785 41.0001.3000 60.0001.3000

41.01010.7850.785 42.0001.3000

42.01010.7850.785	43.0001.3000	62.0001.3000
43.01010.7850.785	44.0001.3000	
44.01010.7850.785	45.0001.3000	64.0001.3000
45.01010.7850.785	46.0001.3000	
46.01010.7850.785	47.0001.3000	86.0001.3000
47.01010.7850.785	48.0001.3000	
48.01010.7850.785	49.0001.3000	68.0001.3000
49.01010.7850.785	50.0001.3000	
50.01010.7850.785	51.0001.3000	70.0001.3000
51.01010.7850.785	52.0001.3000	
52.01010.7850.785	72.0001.3000	
53.12842.1921.309	54.0001.3000	74.0001.3000
54.01010.7850.785	55.0001.3000	
55.01010.7850.785	56.0001.3000	75.0001.3000
56.01010.7850.785	57.0001.3000	
57.01010.7850.785	58.0001.3000	77.0001.3000
58.01010.7850.785	59.0001.3000	
59.01010.7850.785	60.0001.3000	79.0001.3000
60.01010.7850.785	61.0001.3000	
61.01010.7850.785	62.0001.3000	81.0001.3000
62.01010.7850.785	63.0001.3000	
63.01010.7850.785	64.0001.3000	83.0001.3000
64.01010.7850.785	65.0001.3000	
65.01010.7850.785	66.0001.3000	85.0001.3000
66.01010.7850.785	67.0001.3000	
67.01010.7850.785	68.0001.3000	87.0001.3000
68.01010.7850.785	69.0001.3000	
69.01010.7850.785	70.0001.3000	89.0001.3000
70.01010.7850.785	71.0001.3000	
71.01010.7850.785	72.0001.3000	91.0001.3000
72.01010.7850.785	73.0001.3000	
73.12842.1921.309	92.0001.3000	
74.01010.7850.785	75.0001.3000	94.0001.3000
75.01010.7850.785	76.0001.3000	
76.01010.7850.785	77.0001.3000	96.0001.3000
77.01010.7850.785	78.0001.3000	
78.01010.7850.785	79.0001.3000	98.0001.3000
79.01010.7850.785	80.0001.3000	
80.01010.7850.785	81.0001.3000	100.0001.3000
81.01010.7850.785	82.0001.3000	
82.01010.7850.785	83.0001.3000	102.0001.3000
83.01010.7850.785	84.0001.3000	
84.01010.7850.785	85.0001.3000	104.0001.3000
85.01010.7850.785	86.0001.3000	
86.01010.7850.785	87.0001.3000	106.0001.3000
87.01010.7850.785	88.0001.3000	
88.01010.7850.785	89.0001.3000	108.0001.3000
89.01010.7850.785	90.0001.3000	
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92.01010.7850.785	112.0001.3000	
93.12842.1921.309	94.0001.3000	114.0001.3000
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95.01010.7850.785	96.0001.3000	115.0001.3000
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97.01010.7850.785	98.0001.3000	117.0001.3000
98.01010.7850.785	99.0001.3000	
99.01010.7850.785	100.0001.3000	119.0001.3000
100.01010.7850.785	101.0001.3000	
101.01010.7850.785	102.0001.3000	121.0001.3000

102.01010.7850.785	103.0001.3000	
103.01010.7850.785	104.0001.3000	123.0001.3000
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105.01010.7850.785	106.0001.3000	125.0001.3000
106.01010.7850.785	107.0001.3000	
107.01010.7850.785	108.0001.3000	127.0001.3000
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113.12842.1921.309	132.0001.3000	
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116.01010.7850.785	117.0001.3000	136.0001.3000
117.01010.7850.785	118.0001.3000	
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119.01010.7850.785	120.0001.3000	
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121.01010.7850.785	122.0001.3000	
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124.01010.7850.785	125.0001.3000	144.0001.3000
125.01010.7850.785	126.0001.3000	
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127.01010.7850.785	128.0001.3000	
128.01010.7850.785	129.0001.3000	148.0001.3000
129.01010.7850.785	130.0001.3000	
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131.01010.7850.785	132.0001.3000	
132.01010.7850.785	152.0001.3000	
133.12842.1921.309	134.0001.3000	154.0001.3000
134.01010.7850.785	135.0001.3000	
135.01010.7850.785	136.0001.3000	155.0001.3000
136.01010.7850.785	137.0001.3000	
137.01010.7850.785	138.0001.3000	157.0001.3000
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139.01010.7850.785	140.0001.3000	159.0001.3000
140.01010.7850.785	141.0001.3000	
141.01010.7850.785	142.0001.3000	161.0001.3000
142.01010.7850.785	143.0001.3000	
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145.01010.7850.785	146.0001.3000	165.0001.3000
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148.01010.7850.785	149.0001.3000	
149.01010.7850.785	150.0001.3000	169.0001.3000
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151.01010.7850.785	152.0001.3000	171.0001.3000
152.01010.7850.785	153.0001.3000	
153.12842.1921.309	172.0001.3000	
154.01010.7850.785	155.0001.3000	174.0001.3000
155.01010.7850.785	156.0001.3000	
156.01010.7850.785	157.0001.3000	176.0001.3000
157.01010.7850.785	158.0001.3000	
158.01010.7850.785	159.0001.3000	178.0001.3000
159.01010.7850.785	160.0001.3000	
160.01010.7850.785	161.0001.3000	180.0001.3000
161.01010.7850.785	162.0001.3000	

162.01010.7850.785	163.0001.3000	162.0001.3000
163.01010.7850.785	164.0001.3000	
164.01010.7850.785	165.0001.3000	164.0001.3000
165.01010.7850.785	166.0001.3000	
166.01010.7850.785	167.0001.3000	166.0001.3000
167.01010.7850.785	168.0001.3000	
168.01010.7850.785	169.0001.3000	168.0001.3000
169.01010.7850.785	170.0001.3000	
170.01010.7850.785	171.0001.3000	190.0001.3000
171.01010.7850.785	172.0001.3000	
172.01010.7850.785	192.0001.3000	
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174.01010.7850.785	175.0001.3000	
175.01010.7850.785	176.0001.3000	195.0001.3000
176.01010.7850.785	177.0001.3000	
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180.01010.7850.785	181.0001.3000	
181.01010.7850.785	182.0001.3000	201.0001.3000
182.01010.7850.785	183.0001.3000	
183.01010.7850.785	184.0001.3000	203.0001.3000
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187.01010.7850.785	188.0001.3000	207.0001.3000
188.01010.7850.785	189.0001.3000	
189.01010.7850.785	190.0001.3000	209.0001.3000
190.01010.7850.785	191.0001.3000	
191.01010.7850.785	192.0001.3000	211.0001.3000
192.01010.7850.785	193.0001.3000	
193.12042.1921.309	212.0001.3000	
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197.01010.7850.785	198.0001.3000	
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203.01010.7850.785	204.0001.3000	
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205.01010.7850.785	206.0001.3000	
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209.01010.7850.785	210.0001.3000	
210.01010.7850.785	211.0001.3000	230.0001.3000
211.01010.7850.785	212.0001.3000	
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213.14012.3611.178	214.0001.3000	
214.01010.7850.785	215.0001.3000	
215.01010.7850.785	216.0001.3000	234.0001.3000
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217.01010.7850.785	218.0001.3000	235.0001.3000
218.01010.7850.785	219.0001.3000	
219.01010.7850.785	220.0001.3000	236.0001.3000
220.01010.7850.785	221.0001.3000	
221.01010.7850.785	222.0001.3000	237.0001.3000

222.01010.7850.785 223.0001.3000
 223.01010.7850.785 224.0001.3000 238.0001.3000
 224.01010.7850.785 225.0001.3000
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 227.01010.7850.785 228.0001.3000 240.0001.3000
 228.01010.7850.785 229.0001.3000
 229.01010.7850.785 230.0001.3000 241.0001.3000
 230.01010.7850.785 231.0001.3000
 231.01010.7850.785 232.0001.3000 242.0001.3000
 232.01010.7850.785 233.0001.3000
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 2 2 4 0
 1 2 0 0 1
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 2.292011.6611.66 3.098 5.66
 3.642416.8016.80 4.098 5.66
 4.292011.6611.66

rods 2 1 1 1 126 31
 1 1 126
 10.5001.000 1.2500 3.2500 14.1667 13.3333 0.0000 0.0000
 20.5001.000 3.2500 4.2500 14.1667 15.1667 16.1667 0.0000
 30.5001.000 4.2500 5.2500 16.1667 17.1667 18.1667 0.0000
 40.5001.000 5.2500 6.2500 18.1667 19.1667 20.1667 0.0000
 50.5001.000 6.2500 7.2500 20.1667 21.1667 22.1667 0.0000
 60.5001.000 7.2500 8.2500 22.1667 23.1667 24.1667 0.0000
 70.5001.000 8.2500 9.2500 24.1667 25.1667 26.1667 0.0000
 80.5001.000 9.2500 10.2500 26.1667 27.1667 28.1667 0.0000
 90.5001.000 10.2500 11.2500 28.1667 29.1667 30.1667 0.0000
 100.5001.000 11.2500 12.2500 30.1667 31.1667 32.1667 0.0000
 110.5001.000 12.2500 2.2500 32.1667 33.3333 0.0000 0.0000
 120.5001.000 13.3333 14.1667 15.1667 34.1667 35.1667 0.0000
 130.5001.000 15.1667 16.1667 17.1667 35.1667 36.1667 37.1667
 140.5001.000 17.1667 18.1667 19.1667 37.1667 38.1667 39.1667
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 170.5001.000 23.1667 24.1667 25.1667 43.1667 44.1667 45.1667
 180.5001.000 25.1667 26.1667 27.1667 45.1667 46.1667 47.1667
 190.5001.000 27.1667 28.1667 29.1667 47.1667 48.1667 49.1667
 200.5001.000 29.1667 30.1667 31.1667 49.1667 50.1667 51.1667
 210.5001.000 31.1667 32.1667 33.3333 51.1667 52.1667 0.0000
 220.5001.000 13.3333 34.1667 54.1667 53.3333 0.0000 0.0000
 230.5001.000 34.1667 35.1667 36.1667 54.1667 55.1667 56.1667
 240.5001.000 36.1667 37.1667 38.1667 56.1667 57.1667 58.1667
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 260.5001.000 40.1667 41.1667 42.1667 60.1667 61.1667 62.1667
 270.5001.000 42.1667 43.1667 44.1667 62.1667 63.1667 64.1667
 280.5001.000 44.1667 45.1667 46.1667 64.1667 65.1667 66.1667
 290.5001.000 46.1667 47.1667 48.1667 66.1667 67.1667 68.1667
 300.5001.000 48.1667 49.1667 50.1667 68.1667 69.1667 70.1667

310.5001.000	50.1667	51.1667	52.1667	70.1667	71.1667	72.1667
320.5001.000	33.3333	52.1667	72.1667	73.3333	0.0000	0.0000
330.5001.000	53.3333	54.1667	55.1667	74.1667	75.1667	0.0000
340.5001.000	55.1667	58.1667	57.1667	75.1667	76.1667	77.1667
350.5001.000	57.1667	58.1667	59.1667	77.1667	78.1667	79.1667
360.5001.000	59.1667	60.1667	61.1667	79.1667	80.1667	81.1667
370.5001.000	61.1667	62.1667	63.1667	81.1667	82.1667	83.1667
380.5001.000	63.1667	64.1667	65.1667	83.1667	84.1667	85.1667
390.5001.000	65.1667	68.1667	67.1667	85.1667	86.1667	87.1667
400.5001.000	67.1667	68.1667	69.1667	87.1667	88.1667	89.1667
410.5001.000	69.1667	70.1667	71.1667	89.1667	90.1667	91.1667
420.5001.000	71.1667	72.1667	73.3333	91.1667	92.1667	0.0000
430.5001.000	53.3333	74.1667	94.1667	93.3333	0.0000	0.0000
440.5001.000	74.1667	75.1667	76.1667	94.1667	95.1667	96.1667
450.5001.000	76.1667	77.1667	78.1667	96.1667	97.1667	98.1667
460.5001.000	78.1667	79.1667	80.1667	98.1667	99.1667	100.1667
470.5001.000	80.1667	81.1667	82.1667	100.1667	101.1667	102.1667
480.5001.000	82.1667	83.1667	84.1667	102.1667	103.1667	104.1667
490.5001.000	84.1667	85.1667	86.1667	104.1667	105.1667	106.1667
500.5001.000	86.1667	87.1667	88.1667	106.1667	107.1667	108.1667
510.5001.000	88.1667	89.1667	90.1667	108.1667	109.1667	110.1667
520.5001.000	90.1667	91.1667	92.1667	110.1667	111.1667	112.1667
530.5001.000	73.3333	92.1667	112.1667	113.3333	0.0000	0.0000
540.5001.000	93.3333	94.1667	95.1667	114.1667	115.1667	0.0000
550.5001.000	95.1667	96.1667	97.1667	115.1667	116.1667	117.1667
560.5001.000	97.1667	98.1667	99.1667	117.1667	118.1667	119.1667
570.5001.000	99.1667	100.1667	101.1667	119.1667	120.1667	121.1667
580.5001.000	101.1667	102.1667	103.1667	121.1667	122.1667	123.1667
590.5001.000	103.1667	104.1667	106.1667	123.1667	124.1667	125.1667
600.5001.000	105.1667	106.1667	107.1667	125.1667	126.1667	127.1667
610.5001.000	107.1667	108.1667	109.1667	127.1667	128.1667	129.1667
620.5001.000	109.1667	110.1667	111.1667	129.1667	130.1667	131.1667
630.5001.000	111.1667	112.1667	113.3333	131.1667	132.1667	0.0000
640.5001.000	93.3333	114.1667	134.1667	133.3333	0.0000	0.0000
650.5001.000	114.1667	115.1667	116.1667	134.1667	135.1667	136.1667
660.5001.000	116.1667	117.1667	118.1667	136.1667	137.1667	138.1667
670.5001.000	118.1667	119.1667	120.1667	138.1667	139.1667	140.1667
680.5001.000	120.1667	121.1667	122.1667	140.1667	141.1667	142.1667
690.5001.000	122.1667	123.1667	124.1667	142.1667	143.1667	144.1667
700.5001.000	124.1667	125.1667	126.1667	144.1667	145.1667	146.1667
710.5001.000	126.1667	127.1667	128.1667	146.1667	147.1667	148.1667
720.5001.000	128.1667	129.1667	130.1667	148.1667	149.1667	150.1667
730.5001.000	130.1667	131.1667	132.1667	150.1667	151.1667	152.1667
740.5001.000	113.3333	132.1667	152.1667	153.3333	0.0000	0.0000
750.5001.000	133.3333	134.1667	135.1667	154.1667	155.1667	0.0000
760.5001.000	135.1667	136.1667	137.1667	155.1667	156.1667	157.1667
770.5001.000	137.1667	138.1667	139.1667	157.1667	158.1667	159.1667
780.5001.000	139.1667	140.1667	141.1667	159.1667	160.1667	161.1667
790.5001.000	141.1667	142.1667	143.1667	161.1667	162.1667	163.1667
800.5001.000	143.1667	144.1667	145.1667	163.1667	164.1667	165.1667
810.5001.000	145.1667	146.1667	147.1667	165.1667	166.1667	167.1667
820.5001.000	147.1667	148.1667	149.1667	167.1667	168.1667	169.1667
830.5001.000	149.1667	150.1667	151.1667	169.1667	170.1667	171.1667
840.5001.000	151.1667	152.1667	153.3333	171.1667	172.1667	0.0000
850.5001.000	133.3333	154.1667	174.1667	173.3333	0.0000	0.0000
860.5001.000	154.1667	155.1667	156.1667	174.1667	175.1667	176.1667
870.5001.000	156.1667	157.1667	158.1667	176.1667	177.1667	178.1667
880.5001.000	158.1667	159.1667	160.1667	178.1667	179.1667	180.1667
890.5001.000	160.1667	161.1667	162.1667	180.1667	181.1667	182.1667
900.5001.000	162.1667	163.1667	164.1667	182.1667	183.1667	184.1667

910.5001.000	164.1667	165.1667	166.1667	167.1667	168.1667	169.1667	170.1667
920.5001.000	166.1667	167.1667	168.1667	169.1667	170.1667	171.1667	172.1667
930.5001.000	168.1667	169.1667	170.1667	171.1667	172.1667	173.1667	174.1667
940.5001.000	170.1667	171.1667	172.1667	173.1667	174.1667	175.1667	176.1667
950.5001.000	172.1667	173.1667	174.1667	175.1667	176.1667	177.1667	178.1667
960.5001.000	174.1667	175.1667	176.1667	177.1667	178.1667	179.1667	180.1667
970.5001.000	176.1667	177.1667	178.1667	179.1667	180.1667	181.1667	182.1667
980.5001.000	178.1667	179.1667	180.1667	181.1667	182.1667	183.1667	184.1667
990.5001.000	179.1667	180.1667	181.1667	182.1667	183.1667	184.1667	185.1667
1000.5001.000	181.1667	182.1667	183.1667	184.1667	185.1667	186.1667	187.1667
1010.5001.000	183.1667	184.1667	185.1667	186.1667	187.1667	188.1667	189.1667
1020.5001.000	185.1667	186.1667	187.1667	188.1667	189.1667	190.1667	191.1667
1030.5001.000	187.1667	188.1667	189.1667	190.1667	191.1667	192.1667	193.1667
1040.5001.000	189.1667	190.1667	191.1667	192.1667	193.1667	194.1667	195.1667
1050.5001.000	191.1667	192.1667	193.1667	194.1667	195.1667	196.1667	197.1667
1060.5001.000	193.1667	194.1667	195.1667	196.1667	197.1667	198.1667	199.1667
1070.5001.000	194.1667	195.1667	196.1667	197.1667	198.1667	199.1667	200.1667
1080.5001.000	196.1667	197.1667	198.1667	199.1667	200.1667	201.1667	202.1667
1090.5001.000	198.1667	199.1667	200.1667	201.1667	202.1667	203.1667	204.1667
1100.5001.000	200.1667	201.1667	202.1667	203.1667	204.1667	205.1667	206.1667
1110.5001.000	202.1667	203.1667	204.1667	205.1667	206.1667	207.1667	208.1667
1120.5001.000	204.1667	205.1667	206.1667	207.1667	208.1667	209.1667	210.1667
1130.5001.000	206.1667	207.1667	208.1667	209.1667	210.1667	211.1667	212.1667
1140.5001.000	208.1667	209.1667	210.1667	211.1667	212.1667	213.1667	214.1667
1150.5001.000	210.1667	211.1667	212.1667	213.1667	214.1667	215.1667	216.1667
1160.5001.000	193.3333	212.1667	232.1667	233.3333	0.0000	0.0000	0.0000
1170.5001.000	213.4167	214.1667	215.1667	234.2500	0.0000	0.0000	0.0000
1180.5001.000	215.1667	216.1667	217.1667	234.2500	235.2500	0.0000	0.0000
1190.5001.000	217.1667	218.1667	219.1667	235.2500	236.2500	0.0000	0.0000
1200.5001.000	219.1667	220.1667	221.1667	236.2500	237.2500	0.0000	0.0000
1210.5001.000	221.1667	222.1667	223.1667	237.2500	238.2500	0.0000	0.0000
1220.5001.000	223.1667	224.1667	225.1667	238.2500	239.2500	0.0000	0.0000
1230.5001.000	225.1667	226.1667	227.1667	239.2500	240.2500	0.0000	0.0000
1240.5001.000	227.1667	228.1667	229.1667	240.2500	241.2500	0.0000	0.0000
1250.5001.000	229.1667	230.1667	231.1667	241.2420	242.2420	0.0000	0.0000
1260.5001.000	231.1667	232.1667	233.4167	242.2420	0.0000	0.0000	0.0000

2 0 0
2.903 .200184 1 .33 11. .11 488 .050 100. .5
0.5e-4

1	2	2	12	0	0	0	0
2	4	3	12	13	1	0	0
3	4	4	13	14	2	0	0
4	4	5	14	15	3	0	0
5	4	6	15	16	4	0	0
6	4	7	16	17	5	0	0
7	4	8	17	18	6	0	0
8	4	9	18	19	7	0	0
9	4	10	19	20	8	0	0
10	4	11	20	21	9	0	0
11	2	21	10	0	0	0	0
12	5	1	2	13	23	22	0
13	6	2	3	14	24	23	12
14	6	3	4	15	25	24	13
15	6	4	5	16	26	25	14
16	6	5	6	17	27	26	15
17	6	6	7	18	28	27	16
18	6	7	8	19	29	28	17
19	6	8	9	20	30	29	18
20	6	9	10	21	31	30	19
21	5	10	11	20	32	31	0

22	3	12	23	33	6	8	8
23	6	12	13	24	34	33	22
24	6	13	14	25	35	34	23
25	6	14	15	26	36	35	24
26	6	15	16	27	37	36	25
27	6	16	17	28	38	37	26
28	6	17	18	29	39	38	27
29	6	18	19	30	40	39	28
30	6	19	20	31	41	40	29
31	6	20	21	32	42	41	30
32	3	21	31	42	6	8	6
33	5	22	23	34	44	43	6
34	6	23	24	35	45	44	33
35	6	24	25	36	46	45	34
36	6	25	26	37	47	46	35
37	6	26	27	38	48	47	36
38	6	27	28	39	49	48	37
39	6	28	29	40	50	49	38
40	6	29	30	41	51	50	39
41	6	30	31	42	52	51	40
42	5	31	32	41	53	52	6
43	3	33	44	54	6	8	6
44	6	33	34	45	55	54	43
45	6	34	35	46	56	55	44
46	6	35	36	47	57	56	45
47	6	36	37	48	58	57	46
48	6	37	38	49	59	58	47
49	6	38	39	50	60	59	48
50	6	39	40	51	61	60	49
51	6	40	41	52	62	61	50
52	6	41	42	53	63	62	51
53	3	42	52	63	6	8	6
54	5	43	44	55	65	64	6
55	6	44	45	56	66	65	54
56	6	45	46	57	67	66	55
57	6	46	47	58	68	67	56
58	6	47	48	59	69	68	57
59	6	48	49	60	70	69	58
60	6	49	50	61	71	70	59
61	6	50	51	62	72	71	60
62	6	51	52	63	73	72	61
63	5	52	53	62	74	73	6
64	3	54	65	75	6	8	6
65	6	54	55	66	76	75	64
66	6	55	56	67	77	76	65
67	6	56	57	68	78	77	66
68	6	57	58	69	79	78	67
69	6	58	59	70	80	79	68
70	6	59	60	71	81	80	69
71	6	60	61	72	82	81	70
72	6	61	62	73	83	82	71
73	6	62	63	74	84	83	72
74	3	63	73	84	6	8	6
75	5	64	65	76	66	65	6
76	6	65	66	77	87	86	75
77	6	66	67	78	88	87	76
78	6	67	68	79	89	88	77
79	6	68	69	80	90	89	78
80	6	69	70	81	91	90	79
81	6	70	71	82	92	91	80

82	8	71	72	83	93	92	81
83	6	72	73	84	94	93	82
84	5	73	74	85	95	94	8
85	3	75	86	96	0	8	0
86	6	75	76	87	97	96	85
87	6	76	77	88	98	97	86
88	6	77	78	89	99	98	87
89	6	78	79	90	100	99	88
90	6	79	80	91	101	100	89
91	6	80	81	92	102	101	90
92	6	81	82	93	103	102	91
93	6	82	83	94	104	103	92
94	6	83	84	95	105	104	93
95	3	84	94	105	0	8	0
96	5	85	86	97	107	106	8
97	6	86	87	98	108	107	96
98	6	87	88	99	109	108	97
99	6	88	89	100	110	109	98
100	6	89	90	101	111	110	99
101	6	90	91	102	112	111	100
102	6	91	92	103	113	112	101
103	6	92	93	104	114	113	102
104	6	93	94	105	115	114	103
105	5	94	95	104	116	115	0
106	3	98	107	117	0	0	0
107	6	96	97	108	118	117	106
108	6	97	98	109	119	118	107
109	6	98	99	110	120	119	108
110	6	99	100	111	121	120	109
111	6	100	101	112	122	121	110
112	6	101	102	113	123	122	111
113	6	102	103	114	124	123	112
114	6	103	104	115	125	124	113
115	6	104	105	116	126	125	114
116	3	105	116	126	0	0	0
117	3	106	107	118	0	0	0
118	4	107	108	119	117	0	0
119	4	108	109	120	118	0	0
120	4	109	110	121	119	0	0
121	4	110	111	122	120	0	0
122	4	111	112	123	121	0	0
123	4	112	113	124	122	0	0
124	4	113	114	125	123	0	0
125	4	114	115	126	124	0	0
126	3	115	116	125	0	0	0

0.5a-4

1	2	1	4
2	1	1	
3	1	1	
4	1	1	
5	1	1	
6	1	1	
7	1	1	
8	1	1	
9	1	1	
10	1	1	
11	2	1	2
22	1	4	
32	1	2	
43	1	4	

```

53  1  2
64  1  4
74  1  2
85  1  4
95  1  2
100 1  4
116 1  2
117 1  3
118 1  3
119 1  3
120 1  3
121 1  3
122 1  3
123 1  3
124 1  3
125 1  3
128 1  3
slab      8  8
  1  1 5.68
  2 15.263
  3  1 5.68
  4 15.263
  5  1 6.
  6  1 6.
  7  1 8.
  8  1 8.
  1  39.32  .3746
  2  29.45   .5
  3  17.30  .88683
  4  21.68  .88381
  5  29.45   .5
  6  2.5925  6.68
  7  2.7053  5.443
  8  1.78438 6.888
  1 13  1  1  1  1  2  1  1  3  2  1  4  2
     1  5  2  1  6  2  1  7  2  1  8  2
     1  9  2  1 10  2  1 11  2  1 12  2
     2  1  8
  2  8  1  2  1  1 33  3  1 73  3  1 113  3
     1 153  3  1 193  3  1 233  4  2  2  7
  3 12  1 213  5  1 234  2  1 235  2  1 236  2
     1 237  2  1 238  2  1 239  2  1 240  2
     1 241  2  1 242  2  1 233  5  2  3  8
  4  8  1 213  4  1 173  3  1 133  3  1  93  3
     1  53  3  1  13  3  1  1  1  2  4  7
  5  1  2  1  8
  6  1  2  2  8
  7  1  2  3  8
  8  1  2  4  8

radg  2  1  1
  1  8
  1 5.68 .2  1  8.  2  8.  3  8.  4  8.  5.9788  6.8188
     7  8.  8.8188
 25.443 .2  1  8.  2  8.  3  8.  4  8.  5.8888  6.9989
     7.8888  8  8.
  3 5 68 .2  1  8.  2  8.  3  8.  4  8.  5  8.  6.8188
     7.9788  8.8188
 45.443 .2  1  8.  2  8.  3  8.  4  8.  5.8888  6  8.
     7.8888  8.9989

```

```

5 6. .2 1.9633 2.0005 3 0. 4.0005 5 0. 6.0178
7 0. 8.0178
6 6. .2 1.0104 2.9428 3.0104 4 0 5.0178 6 0.
7 0.178 8.0008
7 6. .2 1 0. 2.0005 3.9633 4.0005 5 0. 6.0178
7 0. 8.0178
8 6. .2 1.0104 2 0. 3.0104 4.9428 5.0178 6.0008
7.0178 8 0.
1 1 4 1 2 3 4
2 -1 0 1 2 3 4 5 6 7 8
heat 2 1
1.326 1.326
2. 2.

```

```

1.0 1.0
drag 2
98.53 -1. 0. 0. .05
100.0 -1. 0. 0. .05
bdry 1 1 4 0
1 1.0e-3
1 2 0.392. 1.392.
1 1 8.0 1
5 1. 1 1. 1
2 1 8.0 1
6 1. 1 1. 1
3 1 8.0 1
7 1. 1 1. 1
4 1 8.0 1
8 1. 1 1. 1
calc 1

```

```

30
oper 1 3 0 1
20.0 392.5 1.0e-08 .00304030 392.5 0. 0.
2
0 1. 1. 1.
outp 1
endd

```

data from iterative solution using the recirculation module
time = 0.0000 dt = ***** implicit dt = 0.0000 explicit dt = ***** mode = 0

iteration no.	sweep no.	peak clad				total flow (lbw/s)	pressure drop(psi)	error			
		temp(f)	fluid	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	390.3	3	55	1	-0.144e-08	0.0000000	-0.2150	0.1183	0.0033	0.0009
	2	401.9	3	70	1			0.7888	0.1183	0.0033	0.0005
2	1	405.4	3	89	1	0.472e-08	0.0000000	0.6881	0.0001	0.0029	0.0003
3	1	408.7	3	89	1	-0.187e-08	0.0000000	0.6094	0.0000	0.0026	0.0005
	2	411.7	3	89	1			0.5427	0.0000	0.0023	0.0004
4	1	414.5	3	89	1	0.532e-09	0.0000000	-0.1238	0.0000	0.0019	0.0004

5	1	417.8	3	89	1	-8.111e-08	8.0000000	8.4326	8.0000	8.0019	8.0003
	2	419.2	3	89	1			8.3881	8.0000	8.0017	8.0003
6	1	421.2	3	89	1	-8.113e-09	8.0000000	8.3479	8.0000	8.0015	8.0003
	2	423.1	3	89	1			8.3122	8.0000	8.0013	8.0002
7	1	424.7	3	89	1	-8.467e-09	8.0000000	-8.0677	8.0000	8.0011	8.0002
	2	428.2	3	89	1			8.2581	8.0000	8.0011	8.0002
8	1	427.5	3	89	1	-8.758e-10	8.0000000	8.2245	8.0000	8.0018	8.0002
	2	428.7	3	89	1			8.2815	8.0000	8.0008	8.0002
9	1	429.7	3	89	1	-8.148e-09	8.0000000	8.1885	8.0000	8.0008	8.0001
	2	438.7	3	89	1			8.1818	8.0000	8.0007	8.0001
10	1	431.5	3	89	1	-8.131e-10	8.0000000	-8.0353	8.0000	8.0005	8.0001
	2	432.3	3	89	1			8.1296	8.0000	8.0005	8.0001
11	1	433.8	3	89	1	-8.331e-10	8.0000000	8.1181	8.0000	8.0006	8.0001
	2	433.6	3	89	1			8.1835	8.0000	8.0004	8.0001
12	1	434.1	3	89	1	8.825e-11	8.0000000	8.0934	8.0000	8.0005	8.0001
	2	434.8	3	89	1			8.0832	8.0000	8.0003	8.0001
13	1	435.1	3	89	1	-8.318e-11	8.0000000	-8.0184	8.0000	8.0004	8.0001
	2	435.5	3	89	1			8.0655	8.0000	8.0003	8.0001
14	1	435.8	3	89	1	8.828e-11	8.0000000	8.0882	8.0000	8.0003	8.0000
	2	436.1	3	89	1			8.0528	8.0000	8.0002	8.0000
15	1	436.4	3	89	1	8.148e-11	8.0000000	8.0482	8.0000	8.0003	8.0000
	2	436.7	3	89	1			8.0417	8.0000	8.0002	8.0000
16	1	436.9	3	89	1	8.386e-11	8.0000000	-8.0894	8.0000	8.0003	8.0000
	2	437.1	3	89	1			8.0332	8.0000	8.0001	8.0000
17	1	437.3	3	89	1	8.853e-12	8.0000000	8.0318	8.0000	8.0002	8.0000
	2	437.5	3	89	1			8.0283	8.0000	8.0001	8.0000
18	1	437.6	3	89	1	8.183e-11	8.0000000	8.0248	8.0000	8.0002	8.0000
	2	437.7	3	89	1			8.0288	8.0000	8.0001	8.0000
19	1	437.9	3	89	1	8.219e-12	8.0000000	-8.0858	8.0000	8.0002	8.0000
	2	438.8	3	89	1			8.0183	8.0000	8.0001	8.0000
20	1	438.1	3	89	1	8.233e-12	8.0000000	8.0158	8.0000	8.0002	8.0000
	2	438.1	3	89	1			8.0127	8.0000	8.0001	8.0000
21	1	438.2	3	89	1	-8.128e-13	8.0000000	8.0126	8.0000	8.0002	8.0000
	2	438.3	3	89	1			8.0099	8.0000	8.0001	8.0000
22	1	438.4	3	89	1	8.128e-13	8.0000000	-8.0826	8.0000	8.0001	8.0000
	2	438.4	3	89	1			8.0075	8.0000	8.0001	8.0000
23	1	438.5	3	89	1	-8.431e-13	8.0000000	8.0088	8.0000	8.0001	8.0000
	2	438.5	3	89	1			8.0057	8.0000	8.0001	8.0000
24	1	438.5	3	89	1	-8.197e-13	8.0000000	8.0083	8.0000	8.0001	8.0000
	2	438.6	3	89	1			8.0042	8.0000	8.0001	8.0000

25	1	438.6	3	69	1	-0.264e-13	0.0000000	-0.0013	0.0000	0.0001	0.0000
	2	438.6	3	69	1			0.0030	0.0000	0.0001	0.0000
26	1	438.7	3	69	1	-0.136e-13	0.0000000	0.0039	0.0000	0.0001	0.0000
	2	438.7	3	69	1			0.0021	0.0000	0.0001	0.0000
27	1	438.7	3	69	1	-0.115e-13	0.0000000	0.0031	0.0000	0.0001	0.0000
	2	438.7	3	69	1			0.0013	0.0000	0.0001	0.0000
28	1	438.7	3	69	1	-0.559e-14	0.0000000	-0.0007	0.0000	0.0001	0.0000
	2	438.7	3	69	1			0.0007	0.0000	0.0001	0.0000

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

axial zone (inches)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0.0 - 12.0	392.27	392.17	392.27	392.17	392.25	392.17	392.25	392.17	
12.0 - 24.0	392.27	392.17	392.27	392.17	392.25	392.17	392.25	392.17	

side boundary temperature summary time = 0.0000 seconds
boundary slab node no. 1

axial zone (inches)	(1)	(2)	(3)
0.0 - 12.0	392.27	392.00	
12.0 - 24.0	392.27	392.00	

calculated rod temperatures at time = 0.0000 seconds

rod no. 6
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.500 (in.) zone-(fuel dia.(in.)) - 1-(0.330)

				* fuel temperatures(f.)		
				*		
axial zone	heat flux	type	hsurf	* fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-ft2)	*		
0.0 - 12.0	0.0000	1	5.3	412.9	414.4	
12.0 - 24.0	0.0000	1	5.3	413.0	414.5	

calculated rod temperatures at time = 0.0000 seconds

rod no. 69
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.500 (in.) zone-(fuel dia.(in.)) - 1-(0.330)

				* fuel temperatures(f.)		
				*		
axial zone	heat flux	type	hsurf	* fluid	clad	

(in.)	(mbtu/hr-ft2)		(b/h-f-ft2) *		
0.0 - 12.0	0.0000	1	6.7	438.2	438.7
12.0 - 24.0	0.0000	1	6.7	438.2	438.8

calculated rod temperatures at time = 0.0000 seconds

rod no. 121

assembly 1 (fuel type 1 - cylinder)

rod o.d. - 0.500 (in.) zone-(fuel dia.(in.)) - 1-(0.330)

			* fuel temperatures(f.)		
			*		
axial zone	heat flux	type	hsurf	fluid	clad
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2) *		
0.0 - 12.0	0.0000	1	5.3	412.8	414.3
12.0 - 24.0	0.0000	1	5.3	412.8	414.3

+1000

1 1 CONS. ZERO-GAP, SYMM., HeLIUM; CASE 8 (800 WATTS) validation run.

prop	8	1					
	0.5	-50.	38.	.0732	1.24	73.80	.0409
	1.	0.	100.0	.0780	1.24	83.33	.0410
	2.	200.	348.0	.0970	1.24	119.76	.0533
	3.	400.	596.0	.1150	1.24	156.25	.0641
	5.	600.	844.0	.1290	1.24	192.31	.0727
	10.	800.	1092.0	.1380	1.24	229.36	.0823
	15.	1000.	1340.0	.1380	1.24	265.25	.0907
	20.	1500.	1588.0	.1380	1.24	357.14	.1138

1 SST 9.8

chan 2 2

	24.	90.0							
1	1	242	0	0					
1	1	0	0	1					
1	04211	1420	393						
2	04211	1420	393						
3	02681	2950	785	14	0001	3000			
4	02681	2950	785	16	0001	3000			
5	02681	2950	785	18	0001	3000			
6	02681	2950	785	20	0001	3000			
7	02681	2950	785	22	0001	3000			
8	02681	2950	785	24	0001	3000			
9	02681	2950	785	26	0001	3000			
10	02681	2950	785	28	0001	3000			
11	02681	2950	785	30	0001	3000			
12	02681	2950	785	32	0001	3000			
13	12842	1921	309	14	0001	3000	34	0001	3000
14	01010	7850	785	15	0001	3000			
15	01010	7850	785	16	0001	3000	35	0001	3000
16	01010	7850	785	17	0001	3000			
17	01010	7850	785	18	0001	3000	37	0001	3000
18	01010	7850	785	19	0001	3000			
19	01010	7850	785	20	0001	3000	39	0001	3000
20	01010	7850	785	21	0001	3000			
21	01010	7850	785	22	0001	3000	41	0001	3000
22	01010	7850	785	23	0001	3000			
23	01010	7850	785	24	0001	3000	43	0001	3000
24	01010	7850	785	25	0001	3000			
25	01010	7850	785	26	0001	3000	45	0001	3000
26	01010	7850	785	27	0001	3000			
27	01010	7850	785	28	0001	3000	47	0001	3000
28	01010	7850	785	29	0001	3000			
29	01010	7850	785	30	0001	3000	49	0001	3000
30	01010	7850	785	31	0001	3000			
31	01010	7850	785	32	0001	3000	51	0001	3000
32	01010	7850	785	33	0001	3000			
33	12842	1921	309	52	0001	3000			
34	01010	7850	785	35	0001	3000	54	0001	3000
35	01010	7850	785	36	0001	3000			
36	01010	7850	785	37	0001	3000	56	0001	3000
37	01010	7850	785	38	0001	3000			
38	01010	7850	785	39	0001	3000	58	0001	3000
39	01010	7850	785	40	0001	3000			
40	01010	7850	785	41	0001	3000	60	0001	3000
41	01010	7850	785	42	0001	3000			
42	01010	7850	785	43	0001	3000	62	0001	3000
43	01010	7850	785	44	0001	3000			
44	01010	7850	785	45	0001	3000	64	0001	3000

45.01010.7850.785	46.0001.3000	
46.01010.7850.785	47.0001.3000	66.0001.3000
47.01010.7850.785	48.0001.3000	
48.01010.7850.785	49.0001.3000	68.0001.3000
49.01010.7850.785	50.0001.3000	
50.01010.7850.785	51.0001.3000	70.0001.3000
51.01010.7850.785	52.0001.3000	
52.01010.7850.785	72.0001.3000	
53.12042.1921.309	54.0001.3000	74.0001.3000
54.01010.7850.785	55.0001.3000	
55.01010.7850.785	56.0001.3000	75.0001.3000
56.01010.7850.785	57.0001.3000	
57.01010.7850.785	58.0001.3000	77.0001.3000
58.01010.7850.785	59.0001.3000	
59.01010.7850.785	60.0001.3000	79.0001.3000
60.01010.7850.785	61.0001.3000	
61.01010.7850.785	62.0001.3000	81.0001.3000
62.01010.7850.785	63.0001.3000	
63.01010.7850.785	64.0001.3000	83.0001.3000
64.01010.7850.785	65.0001.3000	
65.01010.7850.785	66.0001.3000	85.0001.3000
66.01010.7850.785	67.0001.3000	
67.01010.7850.785	68.0001.3000	87.0001.3000
68.01010.7850.785	69.0001.3000	
69.01010.7850.785	70.0001.3000	89.0001.3000
70.01010.7850.785	71.0001.3000	
71.01010.7850.785	72.0001.3000	91.0001.3000
72.01010.7850.785	73.0001.3000	
73.12042.1921.309	92.0001.3000	
74.01010.7850.785	75.0001.3000	94.0001.3000
75.01010.7850.785	76.0001.3000	
76.01010.7850.785	77.0001.3000	96.0001.3000
77.01010.7850.785	78.0001.3000	
78.01010.7850.785	79.0001.3000	98.0001.3000
79.01010.7850.785	80.0001.3000	
80.01010.7850.785	81.0001.3000	100.0001.3000
81.01010.7850.785	82.0001.3000	
82.01010.7850.785	83.0001.3000	102.0001.3000
83.01010.7850.785	84.0001.3000	
84.01010.7850.785	85.0001.3000	104.0001.3000
85.01010.7850.785	86.0001.3000	
86.01010.7850.785	87.0001.3000	106.0001.3000
87.01010.7850.785	88.0001.3000	
88.01010.7850.785	89.0001.3000	108.0001.3000
89.01010.7850.785	90.0001.3000	
90.01010.7850.785	91.0001.3000	110.0001.3000
91.01010.7850.785	92.0001.3000	
92.01010.7850.785	112.0001.3000	
93.12042.1921.309	94.0001.3000	114.0001.3000
94.01010.7850.785	95.0001.3000	
95.01010.7850.785	96.0001.3000	115.0001.3000
96.01010.7850.785	97.0001.3000	
97.01010.7850.785	98.0001.3000	117.0001.3000
98.01010.7850.785	99.0001.3000	
99.01010.7850.785	100.0001.3000	119.0001.3000
100.01010.7850.785	101.0001.3000	
101.01010.7850.785	102.0001.3000	121.0001.3000
102.01010.7850.785	103.0001.3000	
103.01010.7850.785	104.0001.3000	123.0001.3000
104.01010.7850.785	105.0001.3000	

185.01010.7850.785	106.0001.3000	125.0001.3000
186.01010.7850.785	107.0001.3000	
187.01010.7850.785	108.0001.3000	127.0001.3000
188.01010.7850.785	109.0001.3000	
189.01010.7850.785	110.0001.3000	129.0001.3000
110.01010.7850.785	111.0001.3000	
111.01010.7850.785	112.0001.3000	131.0001.3000
112.01010.7850.785	113.0001.3000	
113.12842.1921.309	132.0001.3000	
114.01010.7850.785	115.0001.3000	134.0001.3000
115.01010.7850.785	116.0001.3000	
116.01010.7850.785	117.0001.3000	136.0001.3000
117.01010.7850.785	118.0001.3000	
118.01010.7850.785	119.0001.3000	138.0001.3000
119.01010.7850.785	120.0001.3000	
120.01010.7850.785	121.0001.3000	140.0001.3000
121.01010.7850.785	122.0001.3000	
122.01010.7850.785	123.0001.3000	142.0001.3000
123.01010.7850.785	124.0001.3000	
124.01010.7850.785	125.0001.3000	144.0001.3000
125.01010.7850.785	126.0001.3000	
126.01010.7850.785	127.0001.3000	146.0001.3000
127.01010.7850.785	128.0001.3000	
128.01010.7850.785	129.0001.3000	148.0001.3000
129.01010.7850.785	130.0001.3000	
130.01010.7850.785	131.0001.3000	150.0001.3000
131.01010.7850.785	132.0001.3000	
132.01010.7850.785	152.0001.3000	
133.12842.1921.309	134.0001.3000	154.0001.3000
134.01010.7850.785	135.0001.3000	
135.01010.7850.785	136.0001.3000	165.0001.3000
136.01010.7850.785	137.0001.3000	
137.01010.7850.785	138.0001.3000	157.0001.3000
138.01010.7850.785	139.0001.3000	
139.01010.7850.785	140.0001.3000	159.0001.3000
140.01010.7850.785	141.0001.3000	
141.01010.7850.785	142.0001.3000	161.0001.3000
142.01010.7850.785	143.0001.3000	
143.01010.7850.785	144.0001.3000	163.0001.3000
144.01010.7850.785	145.0001.3000	
145.01010.7850.785	146.0001.3000	165.0001.3000
146.01010.7850.785	147.0001.3000	
147.01010.7850.785	148.0001.3000	167.0001.3000
148.01010.7850.785	149.0001.3000	
149.01010.7850.785	150.0001.3000	169.0001.3000
150.01010.7850.785	151.0001.3000	
151.01010.7850.785	152.0001.3000	171.0001.3000
152.01010.7850.785	153.0001.3000	
153.12842.1921.309	172.0001.3000	
154.01010.7850.785	155.0001.3000	174.0001.3000
155.01010.7850.785	156.0001.3000	
156.01010.7850.785	157.0001.3000	176.0001.3000
157.01010.7850.785	158.0001.3000	
158.01010.7850.785	159.0001.3000	178.0001.3000
159.01010.7850.785	160.0001.3000	
160.01010.7850.785	161.0001.3000	180.0001.3000
161.01010.7850.785	162.0001.3000	
162.01010.7850.785	163.0001.3000	182.0001.3000
163.01010.7850.785	164.0001.3000	
164.01010.7850.785	165.0001.3000	184.0001.3000

165.01010.7850.785 166.0001.3000
166.01010.7850.785 167.0001.3000 166.0001.3000
167.01010.7850.785 168.0001.3000
168.01010.7850.785 169.0001.3000 168.0001.3000
169.01010.7850.785 170.0001.3000
170.01010.7850.785 171.0001.3000 190.0001.3000
171.01010.7850.785 172.0001.3000
172.01010.7850.785 192.0001.3000
173.12042.1921.309 174.0001.3000 194.0001.3000
174.01010.7850.785 175.0001.3000
175.01010.7850.785 176.0001.3000 195.0001.3000
176.01010.7850.785 177.0001.3000
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179.01010.7850.785 180.0001.3000 199.0001.3000
180.01010.7850.785 181.0001.3000
181.01010.7850.785 182.0001.3000 201.0001.3000
182.01010.7850.785 183.0001.3000
183.01010.7850.785 184.0001.3000 203.0001.3000
184.01010.7850.785 185.0001.3000
185.01010.7850.785 186.0001.3000 205.0001.3000
186.01010.7850.785 187.0001.3000
187.01010.7850.785 188.0001.3000 207.0001.3000
188.01010.7850.785 189.0001.3000
189.01010.7850.785 190.0001.3000 209.0001.3000
190.01010.7850.785 191.0001.3000
191.01010.7850.785 192.0001.3000 211.0001.3000
192.01010.7850.785 193.0001.3000
193.12042.1921.309 212.0001.3000
194.01010.7850.785 195.0001.3000 214.0001.3000
195.01010.7850.785 196.0001.3000
196.01010.7850.785 197.0001.3000 216.0001.3000
197.01010.7850.785 198.0001.3000
198.01010.7850.785 199.0001.3000 218.0001.3000
199.01010.7850.785 200.0001.3000
200.01010.7850.785 201.0001.3000 220.0001.3000
201.01010.7850.785 202.0001.3000
202.01010.7850.785 203.0001.3000 222.0001.3000
203.01010.7850.785 204.0001.3000
204.01010.7850.785 205.0001.3000 224.0001.3000
205.01010.7850.785 206.0001.3000
206.01010.7850.785 207.0001.3000 226.0001.3000
207.01010.7850.785 208.0001.3000
208.01010.7850.785 209.0001.3000 228.0001.3000
209.01010.7850.785 210.0001.3000
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211.01010.7850.785 212.0001.3000
212.01010.7850.785 232.0001.3000
213.14012.3011.178 214.0001.3000
214.01010.7850.785 215.0001.3000
215.01010.7850.785 216.0001.3000 234.0001.3000
216.01010.7850.785 217.0001.3000
217.01010.7850.785 218.0001.3000 235.0001.3000
218.01010.7850.785 219.0001.3000
219.01010.7850.785 220.0001.3000 236.0001.3000
220.01010.7850.785 221.0001.3000
221.01010.7850.785 222.0001.3000 237.0001.3000
222.01010.7850.785 223.0001.3000
223.01010.7850.785 224.0001.3000 238.0001.3000
224.01010.7850.785 225.0001.3000

225.01010.7850.785 226.0001.3000 239.0001.3000
 226.01010.7850.785 227.0001.3000
 227.01010.7850.785 228.0001.3000 240.0001.3000
 228.01010.7850.785 229.0001.3000
 229.01010.7850.785 230.0001.3000 241.0001.3000
 230.01010.7850.785 231.0001.3000
 231.01010.7850.785 232.0001.3000 242.0001.3000
 232.01010.7850.785 233.0001.3000
 233.14012.3611.178
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 2 2 4 0
 1 2 0 0 1
 1.642416.8016.80 2.098 5.86 4.098 5.86
 2.292011.6611.66 3.098 5.86
 3.642416.8016.80 4.098 5.86
 4.292011.6611.66

rods 2 1 1 1 126 31
 1 1 126
 10.5001.000 1.2500 3.2500 14.1667 13.3333 0.0000 0.0000
 20.5001.000 3.2500 4.2500 14.1667 15.1667 16.1667 0.0000
 30.5001.000 4.2500 5.2500 16.1667 17.1667 18.1667 0.0000
 40.5001.000 5.2500 6.2500 18.1667 19.1667 20.1667 0.0000
 50.5001.000 6.2500 7.2500 20.1667 21.1667 22.1667 0.0000
 60.5001.000 7.2500 8.2500 22.1667 23.1667 24.1667 0.0000
 70.5001.000 8.2500 9.2500 24.1667 25.1667 26.1667 0.0000
 80.5001.000 9.2500 10.2500 26.1667 27.1667 28.1667 0.0000
 90.5001.000 10.2500 11.2500 28.1667 29.1667 30.1667 0.0000
 100.5001.000 11.2500 12.2500 30.1667 31.1667 32.1667 0.0000
 110.5001.000 12.2500 2.2500 32.1667 33.3333 0.0000 0.0000
 120.5001.000 13.3333 14.1667 15.1667 34.1667 35.1667 0.0000
 130.5001.000 15.1667 16.1667 17.1667 35.1667 36.1667 37.1667
 140.5001.000 17.1667 18.1667 19.1667 37.1667 38.1667 39.1667
 150.5001.000 19.1667 20.1667 21.1667 39.1667 40.1667 41.1667
 160.5001.000 21.1667 22.1667 23.1667 41.1667 42.1667 43.1667
 170.5001.000 23.1667 24.1667 25.1667 43.1667 44.1667 45.1667
 180.5001.000 25.1667 26.1667 27.1667 45.1667 46.1667 47.1667
 190.5001.000 27.1667 28.1667 29.1667 47.1667 48.1667 49.1667
 200.5001.000 29.1667 30.1667 31.1667 49.1667 50.1667 51.1667
 210.5001.000 31.1667 32.1667 33.3333 51.1667 52.1667 0.0000
 220.5001.000 13.3333 34.1667 54.1667 53.3333 0.0000 0.0000
 230.5001.000 34.1667 35.1667 36.1667 54.1667 55.1667 56.1667
 240.5001.000 36.1667 37.1667 38.1667 56.1667 57.1667 58.1667
 250.5001.000 38.1667 39.1667 40.1667 58.1667 59.1667 60.1667
 260.5001.000 40.1667 41.1667 42.1667 60.1667 61.1667 62.1667
 270.5001.000 42.1667 43.1667 44.1667 62.1667 63.1667 64.1667
 280.5001.000 44.1667 45.1667 46.1667 64.1667 65.1667 66.1667
 290.5001.000 46.1667 47.1667 48.1667 66.1667 67.1667 68.1667
 300.5001.000 48.1667 49.1667 50.1667 68.1667 69.1667 70.1667
 310.5001.000 50.1667 51.1667 52.1667 70.1667 71.1667 72.1667
 320.5001.000 33.3333 52.1667 72.1667 73.3333 0.0000 0.0000
 330.5001.000 53.3333 54.1667 55.1667 74.1667 75.1667 0.0000

340.5001.000	55.1667	56.1667	57.1667	75.1667	76.1667	77.1667
350.5001.000	57.1667	58.1667	59.1667	77.1667	78.1667	79.1667
360.5001.000	59.1667	60.1667	61.1667	79.1667	80.1667	81.1667
370.5001.000	61.1667	62.1667	63.1667	81.1667	82.1667	83.1667
380.5001.000	63.1667	64.1667	65.1667	83.1667	84.1667	85.1667
390.5001.000	65.1667	66.1667	67.1667	85.1667	86.1667	87.1667
400.5001.000	67.1667	68.1667	69.1667	87.1667	88.1667	89.1667
410.5001.000	69.1667	70.1667	71.1667	89.1667	90.1667	91.1667
420.5001.000	71.1667	72.1667	73.3333	91.1667	92.1667	0.0000
430.5001.000	53.3333	74.1667	94.1667	93.3333	0.0000	0.0000
440.5001.000	74.1667	75.1667	76.1667	94.1667	95.1667	96.1667
450.5001.000	76.1667	77.1667	78.1667	96.1667	97.1667	98.1667
460.5001.000	78.1667	79.1667	80.1667	98.1667	99.1667	100.1667
470.5001.000	80.1667	81.1667	82.1667	100.1667	101.1667	102.1667
480.5001.000	82.1667	83.1667	84.1667	102.1667	103.1667	104.1667
490.5001.000	84.1667	85.1667	86.1667	104.1667	105.1667	106.1667
500.5001.000	86.1667	87.1667	88.1667	106.1667	107.1667	108.1667
510.5001.000	88.1667	89.1667	90.1667	108.1667	109.1667	110.1667
520.5001.000	90.1667	91.1667	92.1667	110.1667	111.1667	112.1667
530.5001.000	73.3333	92.1667	112.1667	113.3333	0.0000	0.0000
540.5001.000	93.3333	94.1667	95.1667	114.1667	115.1667	0.0000
550.5001.000	95.1667	96.1667	97.1667	115.1667	116.1667	117.1667
560.5001.000	97.1667	98.1667	99.1667	117.1667	118.1667	119.1667
570.5001.000	99.1667	100.1667	101.1667	119.1667	120.1667	121.1667
580.5001.000	101.1667	102.1667	103.1667	121.1667	122.1667	123.1667
590.5001.000	103.1667	104.1667	105.1667	123.1667	124.1667	125.1667
600.5001.000	105.1667	106.1667	107.1667	125.1667	126.1667	127.1667
610.5001.000	107.1667	108.1667	109.1667	127.1667	128.1667	129.1667
620.5001.000	109.1667	110.1667	111.1667	129.1667	130.1667	131.1667
630.5001.000	111.1667	112.1667	113.3333	131.1667	132.1667	0.0000
640.5001.000	93.3333	114.1667	134.1667	133.3333	0.0000	0.0000
650.5001.000	114.1667	115.1667	116.1667	134.1667	135.1667	136.1667
660.5001.000	116.1667	117.1667	118.1667	136.1667	137.1667	138.1667
670.5001.000	118.1667	119.1667	120.1667	138.1667	139.1667	140.1667
680.5001.000	120.1667	121.1667	122.1667	140.1667	141.1667	142.1667
690.5001.000	122.1667	123.1667	124.1667	142.1667	143.1667	144.1667
700.5001.000	124.1667	125.1667	126.1667	144.1667	145.1667	146.1667
710.5001.000	126.1667	127.1667	128.1667	146.1667	147.1667	148.1667
720.5001.000	128.1667	129.1667	130.1667	148.1667	149.1667	150.1667
730.5001.000	130.1667	131.1667	132.1667	150.1667	151.1667	152.1667
740.5001.000	113.3333	132.1667	152.1667	153.3333	0.0000	0.0000
750.5001.000	133.3333	134.1667	135.1667	154.1667	155.1667	0.0000
760.5001.000	135.1667	136.1667	137.1667	155.1667	156.1667	157.1667
770.5001.000	137.1667	138.1667	139.1667	157.1667	158.1667	159.1667
780.5001.000	139.1667	140.1667	141.1667	159.1667	160.1667	161.1667
790.5001.000	141.1667	142.1667	143.1667	161.1667	162.1667	163.1667
800.5001.000	143.1667	144.1667	145.1667	163.1667	164.1667	165.1667
810.5001.000	145.1667	146.1667	147.1667	165.1667	166.1667	167.1667
820.5001.000	147.1667	148.1667	149.1667	167.1667	168.1667	169.1667
830.5001.000	149.1667	150.1667	151.1667	169.1667	170.1667	171.1667
840.5001.000	151.1667	152.1667	153.3333	171.1667	172.1667	0.0000
850.5001.000	133.3333	154.1667	174.1667	173.3333	0.0000	0.0000
860.5001.000	154.1667	155.1667	156.1667	174.1667	175.1667	176.1667
870.5001.000	156.1667	157.1667	158.1667	176.1667	177.1667	178.1667
880.5001.000	158.1667	159.1667	160.1667	178.1667	179.1667	180.1667
890.5001.000	160.1667	161.1667	162.1667	180.1667	181.1667	182.1667
900.5001.000	162.1667	163.1667	164.1667	182.1667	183.1667	184.1667
910.5001.000	164.1667	165.1667	166.1667	184.1667	185.1667	186.1667
920.5001.000	166.1667	167.1667	168.1667	186.1667	187.1667	188.1667
930.5001.000	168.1667	169.1667	170.1667	188.1667	189.1667	190.1667

940.5001.000	170.1667	171.1667	172.1667	190.1667	191.1667	192.1667		
950.5001.000	153.3333	172.1667	192.1667	193.3333	0.0000	0.0000		
960.5001.000	173.3333	174.1667	175.1667	194.1667	195.1667	0.0000		
970.5001.000	175.1667	176.1667	177.1667	195.1667	196.1667	197.1667		
980.5001.000	177.1667	178.1667	179.1667	197.1667	198.1667	199.1667		
990.5001.000	179.1667	180.1667	181.1667	199.1667	200.1667	201.1667		
1000.5001.000	181.1667	182.1667	183.1667	201.1667	202.1667	203.1667		
1010.5001.000	183.1667	184.1667	185.1667	203.1667	204.1667	205.1667		
1020.5001.000	185.1667	186.1667	187.1667	205.1667	206.1667	207.1667		
1030.5001.000	187.1667	188.1667	189.1667	207.1667	208.1667	209.1667		
1040.5001.000	189.1667	190.1667	191.1667	209.1667	210.1667	211.1667		
1050.5001.000	191.1667	192.1667	193.3333	211.1667	212.1667	0.0000		
1060.5001.000	173.3333	194.1667	214.1667	213.3333	0.0000	0.0000		
1070.5001.000	194.1667	195.1667	195.1667	214.1667	215.1667	216.1667		
1080.5001.000	196.1667	197.1667	198.1667	216.1667	217.1667	218.1667		
1090.5001.000	198.1667	199.1667	200.1667	218.1667	219.1667	220.1667		
1100.5001.000	200.1667	201.1667	202.1667	220.1667	221.1667	222.1667		
1110.5001.000	202.1667	203.1667	204.1667	222.1667	223.1667	224.1667		
1120.5001.000	204.1667	205.1667	206.1667	224.1667	225.1667	226.1667		
1130.5001.000	206.1667	207.1667	208.1667	226.1667	227.1667	228.1667		
1140.5001.000	208.1667	209.1667	210.1667	228.1667	229.1667	230.1667		
1150.5001.000	210.1667	211.1667	212.1667	230.1667	231.1667	232.1667		
1160.5001.000	193.3333	212.1667	232.1667	233.3333	0.0000	0.0000		
1170.5001.000	213.4167	214.1667	215.1667	234.2500	0.0000	0.0000		
1180.5001.000	215.1667	216.1667	217.1667	234.2500	235.2500	0.0000		
1190.5001.000	217.1667	218.1667	219.1667	235.2500	236.2500	0.0000		
1200.5001.000	219.1667	220.1667	221.1667	236.2500	237.2500	0.0000		
1210.5001.000	221.1667	222.1667	223.1667	237.2500	238.2500	0.0000		
1220.5001.000	223.1667	224.1667	225.1667	238.2500	239.2500	0.0000		
1230.5001.000	225.1667	226.1667	227.1667	239.2500	240.2500	0.0000		
1240.5001.000	227.1667	228.1667	229.1667	240.2500	241.2500	0.0000		
1250.5001.000	229.1667	230.1667	231.1667	241.2420	242.2420	0.0000		
1260.5001.000	231.1667	232.1667	233.4167	242.2420	0.0000	0.0000		

2 0 0

2.903 200184.1 33 11. 11 488. 050 100. 5

0.5e-4

1	2	2	12	0	0	0	0
2	4	3	12	13	1	0	0
3	4	4	13	14	2	0	0
4	4	5	14	15	3	0	0
5	4	6	15	16	4	0	0
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7	4	8	17	18	6	0	0
8	4	9	18	19	7	0	0
9	4	10	19	20	8	0	0
10	4	11	20	21	9	0	0
11	2	21	10	0	0	0	0
12	5	1	2	13	23	22	0
13	6	2	3	14	24	23	12
14	6	3	4	15	25	24	13
15	6	4	5	16	26	25	14
16	6	5	6	17	27	26	15
17	6	6	7	18	28	27	16
18	6	7	8	19	29	28	17
19	6	8	9	20	30	29	18
20	6	9	10	21	31	30	19
21	5	10	11	20	32	31	0
22	3	12	23	33	0	0	0
23	6	12	13	24	34	33	22
24	6	13	14	25	35	34	23

25	6	14	15	26	36	35	24
26	6	15	18	27	37	36	25
27	6	16	17	28	38	37	26
28	6	17	18	29	39	38	27
29	6	18	19	30	40	39	28
30	6	19	20	31	41	40	29
31	6	20	21	32	42	41	30
32	3	21	31	42	0	0	0
33	5	22	23	34	44	43	0
34	6	23	24	35	45	44	33
35	6	24	25	36	46	45	34
36	6	25	26	37	47	46	35
37	6	26	27	38	48	47	36
38	6	27	28	39	49	48	37
39	6	28	29	40	50	49	38
40	6	29	30	41	51	50	39
41	6	30	31	42	52	51	40
42	5	31	32	41	53	52	0
43	3	33	44	54	0	0	0
44	6	33	34	45	55	54	43
45	6	34	35	46	56	55	44
46	6	35	36	47	57	56	45
47	6	36	37	48	58	57	46
48	6	37	38	49	59	58	47
49	6	38	39	50	60	59	48
50	6	39	40	51	61	60	49
51	6	40	41	52	62	61	50
52	6	41	42	53	63	62	51
53	3	42	52	63	0	0	0
54	5	43	44	55	65	64	0
55	6	44	45	56	66	65	54
56	6	45	46	57	67	66	55
57	6	46	47	58	68	67	56
58	6	47	48	59	69	68	57
59	6	48	49	60	70	69	58
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61	6	50	51	62	72	71	60
62	6	51	52	63	73	72	61
63	5	52	53	62	74	73	0
64	3	54	65	75	0	0	0
65	6	54	55	66	76	75	64
66	6	55	56	67	77	76	65
67	6	56	57	68	78	77	66
68	6	57	58	69	79	78	67
69	6	58	59	70	80	79	68
70	6	59	60	71	81	80	69
71	6	60	61	72	82	81	70
72	6	61	62	73	83	82	71
73	6	62	63	74	84	83	72
74	3	63	73	84	0	0	0
75	5	64	65	76	86	85	0
76	6	65	66	77	87	86	75
77	6	66	67	78	88	87	76
78	6	67	68	79	89	88	77
79	6	68	69	80	90	89	78
80	6	69	70	81	91	90	79
81	6	70	71	82	92	91	80
82	6	71	72	83	93	92	81
83	6	72	73	84	94	93	82
84	5	73	74	83	95	94	0

85	3	75	86	96	0	0	0
86	6	75	76	87	97	96	85
87	6	76	77	88	98	97	86
88	6	77	78	89	99	98	87
89	6	78	79	90	100	99	88
90	6	79	80	91	101	100	89
91	6	80	81	92	102	101	90
92	6	81	82	93	103	102	91
93	6	82	83	94	104	103	92
94	6	83	84	95	105	104	93
95	3	84	94	105	0	0	0
96	5	85	86	97	107	106	0
97	6	86	87	98	108	107	96
98	6	87	88	99	109	108	97
99	6	88	89	100	110	109	98
100	6	89	90	101	111	110	99
101	6	90	91	102	112	111	100
102	6	91	92	103	113	112	101
103	6	92	93	104	114	113	102
104	6	93	94	105	115	114	103
105	5	94	95	104	116	115	0
106	3	96	107	117	0	0	0
107	6	96	97	108	118	117	106
108	6	97	98	109	119	118	107
109	6	98	99	110	120	119	108
110	6	99	100	111	121	120	109
111	6	100	101	112	122	121	110
112	6	101	102	113	123	122	111
113	6	102	103	114	124	123	112
114	6	103	104	115	125	124	113
115	6	104	105	116	126	125	114
116	3	105	115	126	0	0	0
117	3	106	107	118	0	0	0
118	4	107	108	119	117	0	0
119	4	108	109	120	118	0	0
120	4	109	110	121	119	0	0
121	4	110	111	122	120	0	0
122	4	111	112	123	121	0	0
123	4	112	113	124	122	0	0
124	4	113	114	125	123	0	0
125	4	114	115	126	124	0	0
126	3	115	116	125	0	0	0

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1	2	1	4
2	1	1	
3	1	1	
4	1	1	
5	1	1	
6	1	1	
7	1	1	
8	1	1	
9	1	1	
10	1	1	
11	2	1	2
22	1	4	
32	1	2	
43	1	4	
53	1	2	
64	1	4	
74	1	2	


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85 1 4
95 1 2
100 1 4
116 1 2
117 1 3
118 1 3
119 1 3
120 1 3
121 1 3
122 1 3
123 1 3
124 1 3
125 1 3
126 1 3
slab      0 8
1 1 5.60
2 15.263
3 1 5.60
4 15.263
5 1 6.
6 1 6.
7 1 6.
8 1 6.
1 39.32 .3745
2 29.45 .5
3 17.30 .86683
4 21.60 .80381
5 29.45 .5
6 2.5925 5.60
7 2.7853 5.443
8 1.78438 6.800
1 13 1 1 1 1 2 1 1 3 2 1 4 2
   1 5 2 1 6 2 1 7 2 1 8 2
   1 9 2 1 10 2 1 11 2 1 12 2
   2 1 8
2 8 1 2 1 1 33 3 1 73 3 1 113 3
   1 163 3 1 193 3 1 233 4 2 2 7
3 12 1 213 5 1 234 2 1 235 2 1 236 2
   1 237 2 1 238 2 1 239 2 1 240 2
   1 241 2 1 242 2 1 233 5 2 3 8
4 8 1 213 4 1 173 3 1 133 3 1 93 3
   1 53 3 1 13 3 1 1 1 2 4 7
5 1 2 1 8
6 1 2 2 8
7 1 2 3 8
8 1 2 4 8
radg 2 1 1
1 8
1 5.60 .2 1 0. 2 0. 3 0. 4 0. 5.9788 6.0106
   7 0. 8.0106
25.443 .2 1 0. 2 0. 3 0. 4 0. 5.0006 6.9989
   7.0006 8 0.
3 5.60 .2 1 0. 2 0. 3 0. 4 0. 5 0. 6.0106
   7.9788 8.0106
45.443 .2 1 0. 2 0. 3 0. 4 0. 5.0006 6 0.
   7.0006 8.9989
5 5. .2 1.9633 2.0005 3 0. 4.0005 5 0. 6.0178
   7 0. 8.0178
6 5. .2 1.0104 2.9428 3.0104 4 0. 5.0178 6 0.

```

```

      7.0178  8.0000
7  6.  .2  1  8.  2.0005  3.9633  4.0005  5  8.  6.0178
      7  8.  8.0178
8  6.  .2  1.0184  2  8.  3.0184  4.9428  5.0178  6.0000
      7.0178  8  8.
1  1  4  1  2  3  4
2  -1  8  1  2  3  4  5  6  7  8
heat  2  1
      1.328  1.328
      2.  2.
1.0  1.0
drag  2
96.53 -1.  0.  0.  .05
100.0 -1.  0.  0.  .05
bdry  1  1  4  0
      1  1.0e-3
      1  2  0.392  1.392.
      1  1  6.0  1
5  1.  1  1.  1
2  1  6.0  1
6  1.  1  1.  1
3  1  6.0  1
7  1.  1  1.  1
4  1  6.0  1
8  1.  1  1.  1
calc  1
      30
oper  1  3  8  1
      20.0  392.5  1.0e-06  .00304030  392.5  0.  0.
2
0.  1.  1.  1.
outp  1
endd

```

data from iterative solution using the recirculation module
time = 0.0000 dt = 0.0000 implicit dt = 0.0000 explicit dt = 0.0000 mode = 0

iteration no.	sweep no.	peak clad				total flow (lbm/s)	pressure drop(psi)	error			
		temp(f)	fluid	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	394.9	3	56	1	-0.128e-08	0.0000000	-0.2333	0.8502	0.0028	0.0001
	2	396.8	3	59	1			0.7529	0.8502	0.0025	0.0000
2	1	398.6	3	59	1	0.291e-07	0.0000000	0.6485	0.8078	0.0022	0.0001
	2	400.3	3	59	1	-0.129e-07	0.0000000	0.5849	0.8009	0.0019	0.0000
3	1	401.8	3	59	1			0.4943	0.8009	0.0017	0.0000
	2	403.2	3	59	1	0.110e-08	0.0000000	-0.1307	0.8022	0.0013	0.0000
4	1	404.4	3	59	1	-0.845e-08	0.0000000	0.3792	0.8000	0.0013	0.0000
	2	405.4	3	59	1			0.3343	0.8000	0.0011	0.0000

6	1	406.4	3	59	1	-0.190e-08	0.0000000	0.2941	0.0005	0.0010	0.0000
	2	407.2	3	59	1			0.2589	0.0005	0.0009	0.0000
7	1	407.9	3	59	1	-0.355e-08	0.0000000	-0.0660	0.0002	0.0007	0.0000
	2	408.6	3	59	1			0.1995	0.0002	0.0007	0.0000
8	1	409.1	3	59	1	-0.067e-09	0.0000000	0.1758	0.0000	0.0006	0.0000
	2	409.6	3	59	1			0.1549	0.0000	0.0005	0.0000
9	1	410.1	3	59	1	-0.108e-08	0.0000000	0.1361	0.0001	0.0005	0.0000
	2	410.5	3	59	1			0.1198	0.0001	0.0004	0.0000
10	1	410.8	3	59	1	-0.158e-09	0.0000000	-0.0308	0.0000	0.0003	0.0000
	2	411.1	3	59	1			0.0921	0.0000	0.0003	0.0000
11	1	411.4	3	59	1	-0.218e-09	0.0000000	0.0809	0.0001	0.0003	0.0000
	2	411.6	3	59	1			0.0712	0.0001	0.0002	0.0000
12	1	411.8	3	59	1	0.435e-10	0.0000000	0.0624	0.0000	0.0002	0.0000
13	1	412.0	3	59	1	-0.542e-11	0.0000000	-0.0074	0.0000	0.0002	0.0000
	2	412.1	3	59	1			0.0479	0.0000	0.0002	0.0000
14	1	412.3	3	59	1	0.502e-10	0.0000000	0.0420	0.0000	0.0002	0.0000
15	1	412.4	3	59	1	0.179e-10	0.0000000	0.0368	0.0000	0.0001	0.0000
16	1	412.5	3	59	1	0.245e-10	0.0000000	-0.0045	0.0000	0.0001	0.0000
17	1	412.6	3	59	1	0.003e-11	0.0000000	0.0201	0.0000	0.0001	0.0000
18	1	412.7	3	59	1	0.016e-11	0.0000000	0.0240	0.0000	0.0001	0.0000
19	1	412.8	3	59	1	0.222e-11	0.0000000	-0.0031	0.0000	0.0001	0.0000
	2	412.8	3	59	1			0.0187	0.0000	0.0001	0.0000
20	1	412.9	3	59	1	0.177e-11	0.0000000	0.0163	0.0000	0.0001	0.0000
	2	412.9	3	59	1			0.0127	0.0000	0.0000	0.0000
21	1	413.0	3	59	1	0.290e-13	0.0000000	0.0128	0.0000	0.0001	0.0000
	2	413.0	3	59	1			0.0094	0.0000	0.0000	0.0000
22	1	413.0	3	59	1	0.746e-13	0.0000000	-0.0029	0.0000	0.0001	0.0000
	2	413.1	3	59	1			0.0074	0.0000	0.0000	0.0000
23	1	413.1	3	59	1	-0.287e-12	0.0000000	0.0073	0.0000	0.0001	0.0000
	2	413.1	3	59	1			0.0052	0.0000	0.0000	0.0000
24	1	413.1	3	59	1	-0.143e-12	0.0000000	0.0055	0.0000	0.0000	0.0000
	2	413.2	3	59	1			0.0038	0.0000	0.0000	0.0000
25	1	413.2	3	59	1	-0.171e-12	0.0000000	-0.0015	0.0000	0.0000	0.0000
	2	413.2	3	59	1			0.0024	0.0000	0.0000	0.0000
26	1	413.2	3	59	1	-0.787e-13	0.0000000	0.0029	0.0000	0.0000	0.0000
	2	413.2	3	59	1			0.0015	0.0000	0.0000	0.0000
27	1	413.2	3	59	1	-0.028e-13	0.0000000	0.0021	0.0000	0.0000	0.0000
	2	413.2	3	59	1			0.0007	0.0000	0.0000	0.0000

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

axial zone (inches)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(
0.0 - 12.0	392.28	392.16	392.28	392.15	392.26	392.18	392.25	392.15	
12.0 - 24.0	392.28	392.16	392.28	392.15	392.26	392.18	392.25	392.15	

side boundary temperature summary time = 0.0000 seconds
 boundary slab node no. 1

axial zone (inches)	(1)	(2)	(
0.0 - 12.0	392.28	392.00	
12.0 - 24.0	392.28	392.00	

calculated rod temperatures at time = 0.0000 seconds
 rod no. 6
 assembly 1 (fuel type 1 - cylinder)
 rod o.d. - 0.500 (in.) zone-(fuel dia.(in.)) - 1-(0.330)

* fuel temperatures(f.)						
*						
axial zone	heat flux	type	hsurf	* fluid	clad	
(in.)	(mbtu/hr-ft ²)		(b/h-f-ft ²)	*		
0.0 - 12.0	0.0000	1	28.7	481.4	481.8	
12.0 - 24.0	0.0000	1	28.7	481.4	481.9	

calculated rod temperatures at time = 0.0000 seconds
 rod no. 69
 assembly 1 (fuel type 1 - cylinder)
 rod o.d. - 0.500 (in.) zone-(fuel dia.(in.)) - 1-(0.330)

* fuel temperatures(f.)						
*						
axial zone	heat flux	type	hsurf	* fluid	clad	
(in.)	(mbtu/hr-ft ²)		(b/h-f-ft ²)	*		
0.0 - 12.0	0.0000	1	35.6	412.9	413.2	
12.0 - 24.0	0.0000	1	35.6	413.0	413.2	

calculated rod temperatures at time = 0.0000 seconds
 rod no. 121
 assembly 1 (fuel type 1 - cylinder)
 rod o.d. - 0.500 (in.) zone-(fuel dia.(in.)) - 1-(0.330)

				* fuel temperatures(f.)		
				*		
axial zone	heat flux	type	hsurf	fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2)	*	*	
0.0 - 12.0	0.0000	1	20.8	401.0	401.4	
12.0 - 24.0	0.0000	1	20.6	401.0	401.4	

APPENDIX D

CASTOR-1C BWR SPENT FUEL STORAGE CASK PERFORMANCE TEST SIMULATIONS
INPUT, OUTPUT, AND CONVERGENCE LISTS

APPENDIX D

CASTOR-1C BWR SPENT FUEL STORAGE CASK PERFORMANCE TEST SIMULATIONS
INPUT, OUTPUT, AND CONVERGENCE LISTS

<u>Test Case</u>	<u>Input</u>	<u>Page Number</u> <u>Convergence</u> <u>List</u>	<u>Output</u>
Vertical, helium	D.2	D.22	D.23

-5300

1 castor 1c vertical helium full-load validation cask simulation

prop	7	3					
	1.	0.	100.0	0780	1.24	83.33	.0410
	2.	200.	348.0	0970	1.24	119.76	0533
	3.	400.	598.0	1150	1.24	158.25	0641
	5.	600.	844.0	1290	1.24	192.31	0727
	10.	800.	1092.0	1380	1.24	229.36	0823
	15.	1000.	1340.0	1380	1.24	265.25	0907
	20.	1500.	1588.0	1380	1.24	357.14	1138
	1	can		10.2			
	2	Fe		24.3			
	3	mix		13.5			

chan 0 18

	176.0	0					
1	1	00	0	0			
1	1	0	0	1			
	1.66202.5811.105		2.4569.7382	7.7829		8.1756.7382	
	2.42071.622.8837		3.4569.7382	9.1756.7382			
	3.42071.622.8837		4.4569.7382	10.1756.7382			
	4.42071.622.8837		5.4569.7382	11.1756.7382			
	5.42071.622.8837		6.4569.7382	12.1756.7382			
	6.66202.5811.105		13.1756.7382	14.7629			
2	71.4472.5811.105		8.17561.004	15.9884.7382			
	8.29641.7671.767		9.1756.7382	16.1756.7382			
	9.29641.7671.767		10.1756.7382	17.1756.7382			
	10.29641.7671.767		11.1756.7382	18.1756.7382			
	11.29641.7671.767		12.1756.7382	19.1756.7382			
	12.29641.7671.767		13.1756.7382	20.1756.7382			
	13.29641.7671.767		14.1756.7382	21.1756.7382			
	14.66202.5811.105		22.4569.7382				
2	15.81301.622.8837		16.17561.004	23.9884.7382			
	16.29641.7671.767		17.1756.7382	24.1756.7382			
	17.29641.7671.767		18.1756.7382	25.1756.7382			
	18.29641.7671.767		19.1756.7382	26.1756.7382			
	19.29641.7671.767		20.1756.7382	27.1756.7382			
	20.29641.7671.767		21.1756.7382	28.1756.7382			
	21.29641.7671.767		22.1756.7382	29.1756.7382			
	22.42071.622.8837		30.4569.7382				
2	23.81301.622.8837		24.17561.004	31.9884.7382			
	24.29641.7671.767		25.1756.7382	32.1756.7382			
	25.29641.7671.767		26.1756.7382	33.1756.7382			
	26.29641.7671.767		27.1756.7382	34.1756.7382			
	27.29641.7671.767		28.1756.7382	35.1756.7382			
	28.29641.7671.767		29.1756.7382	36.1756.7382			
	29.29641.7671.767		30.1756.7382	37.1756.7382			
	30.42071.622.8837		38.4569.7382				
2	31.81301.622.8837		32.17561.004	39.9884.7382			
	32.29641.7671.767		33.1756.7382	40.1756.7382			
	33.29641.7671.767		34.1756.7382	41.1756.7382			
	34.29641.7671.767		35.1756.7382	42.1756.7382			
	35.29641.7671.767		36.1756.7382	43.1756.7382			
	36.29641.7671.767		37.1756.7382	44.1756.7382			
	37.29641.7671.767		38.1756.7382	45.1756.7382			
	38.42071.622.8837		46.4569.7382				
2	39.81301.622.8837		40.17561.004	47.9884.7382			
	40.29641.7671.767		41.1756.7382	48.1756.7382			
	41.29641.7671.767		42.1756.7382	49.1756.7382			
	42.29641.7671.767		43.1756.7382	50.1756.7382			
	43.29641.7671.767		44.1756.7382	51.1756.7382			

44.	29641.7671.767	45.1756.7382	52.1756.7382	
45.	29641.7671.767	46.1756.7382	53.1756.7382	
46.	42071.622.8837	54.4569.7382		
2 47.	4472.5811.105	46.17561.004	55.7629	
48.	29641.7671.767	49.1756.7382	55.1756.7382	
49.	29641.7671.767	50.1756.7382	56.1756.7382	
50.	29641.7671.767	51.1756.7382	57.1756.7382	
51.	29641.7671.767	52.1756.7382	58.1756.7382	
52.	29641.7671.767	53.1756.7382	59.1756.7382	
53.	29641.7671.767	54.1756.7382	60.1756.7382	
54.	66202.5811.105	60.7629		
55.	66202.5811.105	56.4569.7382		
56.	42071.622.8837	57.4569.7382		
57.	42071.622.8837	58.4569.7382		
58.	42071.622.8837	59.4569.7382		
59.	42071.622.8837	60.4569.7382		
60.	66202.5811.105			
2	2	60	0	
1	1	0	0	1
1.	66202.5811.105	2.4569.7382	7.7629	8.1756.7382
2.	42071.622.8837	3.4569.7382	9.1756.7382	
3.	42071.622.8837	4.4569.7382	10.1756.7382	
4.	42071.622.8837	5.4569.7382	11.1756.7382	
5.	42071.622.8837	6.4569.7382	12.1756.7382	
6.	66202.5811.105	13.1756.7382	14.7629	
7.	66202.5811.105	8.1756.7382	15.4569.7382	
8.	29641.7671.767	9.1756.7382	16.1756.7382	
9.	29641.7671.767	10.1756.7382	17.1756.7382	
10.	29641.7671.767	11.1756.7382	18.1756.7382	
11.	29641.7671.767	12.1756.7382	19.1756.7382	
12.	29641.7671.767	13.1756.7382	20.1756.7382	
13.	29641.7671.767	14.1756.7382	21.1756.7382	
14.	66202.5811.105	22.4569.7382		
15.	42071.622.8837	16.1756.7382	23.4569.7382	
16.	29641.7671.767	17.1756.7382	24.1756.7382	
17.	29641.7671.767	18.1756.7382	25.1756.7382	
18.	29641.7671.767	19.1756.7382	26.1756.7382	
19.	29641.7671.767	20.1756.7382	27.1756.7382	
20.	29641.7671.767	21.1756.7382	28.1756.7382	
21.	29641.7671.767	22.1756.7382	29.1756.7382	
22.	42071.622.8837	30.4569.7382		
23.	42071.622.8837	24.1756.7382	31.4569.7382	
24.	29641.7671.767	25.1756.7382	32.1756.7382	
25.	29641.7671.767	26.1756.7382	33.1756.7382	
26.	29641.7671.767	27.1756.7382	34.1756.7382	
27.	29641.7671.767	28.1756.7382	35.1756.7382	
28.	29641.7671.767	29.1756.7382	36.1756.7382	
29.	29641.7671.767	30.1756.7382	37.1756.7382	
30.	42071.622.8837	38.4569.7382		
31.	42071.622.8837	32.1756.7382	39.4569.7382	
32.	29641.7671.767	33.1756.7382	40.1756.7382	
33.	29641.7671.767	34.1756.7382	41.1756.7382	
34.	29641.7671.767	35.1756.7382	42.1756.7382	
35.	29641.7671.767	36.1756.7382	43.1756.7382	
36.	29641.7671.767	37.1756.7382	44.1756.7382	
37.	29641.7671.767	38.1756.7382	45.1756.7382	
38.	42071.622.8837	46.4569.7382		
39.	42071.622.8837	40.1756.7382	47.4569.7382	
40.	29641.7671.767	41.1756.7382	48.1756.7382	
41.	29641.7671.767	42.1756.7382	49.1756.7382	

42.29841.7671.767	43.1756.7382	50.1756.7382
43.29841.7671.767	44.1756.7382	51.1756.7382
44.29841.7671.767	45.1756.7382	52.1756.7382
45.29841.7671.767	46.1756.7382	53.1756.7382
46.42071.822.8837	54.4569.7382	
47.66202.5811.105	48.1756.7382	55.7629
48.29841.7671.767	49.1756.7382	56.1756.7382
49.29841.7671.767	50.1756.7382	56.1756.7382
50.29841.7671.767	51.1756.7382	57.1756.7382
51.29841.7671.767	52.1756.7382	58.1756.7382
52.29841.7671.767	53.1756.7382	59.1756.7382
53.29841.7671.767	54.1756.7382	60.1756.7382
54.66202.5811.105	60.7629	
55.66202.5811.105	58.4569.7382	
56.42071.822.8837	57.4569.7382	
57.42071.822.8837	58.4569.7382	
58.42071.822.8837	59.4569.7382	
59.42071.822.8837	60.4569.7382	
60.66202.5811.105		

3 3 77 0 0

1 1 0 0 1

1.59232.320.9661	2.4675.6398	8.7629	9.1476.6398
2.36151.413.7730	3.1476.6398	10.1476.6398	
3.36151.413.7730	4.1476.6398	11.1476.6398	
4.36151.413.7730	5.1476.6398	12.1476.6398	
5.36151.413.7730	6.1476.6398	13.1476.6398	
6.36151.413.7730	7.1476.6398	14.1476.6398	
7.59232.320.9661	15.1476.6398	18.7629	
8.59232.320.9661	9.1476.6398	17.4675.6398	
9.21901.5461.546	10.1476.6398	18.1476.6398	
10.21901.5461.546	11.1476.6398	19.1476.6398	
11.21901.5461.546	12.1476.6398	20.1476.6398	
12.21901.5461.546	13.1476.6398	21.1476.6398	
13.21901.5461.546	14.1476.6398	22.1476.6398	
14.21901.5461.546	15.1476.6398	23.1476.6398	
15.21901.5461.546	16.1476.6398	24.1476.6398	
16.59232.320.9661	25.4675.6398		
17.36151.413.7730	18.1476.6398	26.1476.6398	
18.21901.5461.546	19.1476.6398	27.1476.6398	
19.21901.5461.546	20.1476.6398	28.1476.6398	
20.21901.5461.546	21.1476.6398	29.1476.6398	
21.21901.5461.546	22.1476.6398	30.1476.6398	
22.21901.5461.546	23.1476.6398	31.1476.6398	
23.21901.5461.546	24.1476.6398	32.1476.6398	
24.21901.5461.546	25.1476.6398	33.1476.6398	
25.36151.413.7730	34.4675.6398		
26.36151.413.7730	27.1476.6398	35.4675.6398	
27.21901.5461.546	28.1476.6398	36.1476.6398	
28.21901.5461.546	29.1476.6398	37.1476.6398	
29.21901.5461.546	30.1476.6398	38.1476.6398	
30.21901.5461.546	31.1476.6398	39.1476.6398	
31.21901.5461.546	32.1476.6398	40.1476.6398	
32.21901.5461.546	33.1476.6398	41.1476.6398	
33.21901.5461.546	34.1476.6398	42.1476.6398	
34.36151.413.7730	43.4675.6398		
35.36151.413.7730	36.1476.6398	44.4675.6398	
36.21901.5461.546	37.1476.6398	45.1476.6398	
37.21901.5461.546	38.1476.6398	46.1476.6398	
38.21901.5461.546	39.1476.6398	47.1476.6398	
39.21901.5461.546	40.1476.6398	48.1476.6398	

40.21901.5461.546	41.1476.6398	49.1476.6398	
41.21901.5461.546	42.1476.6398	50.1476.6398	
42.21901.5461.546	43.1476.6398	51.1476.6398	
43.36151.413.7730	52.4675.6398		
44.36151.413.7730	45.1476.6398	53.4675.6398	
45.21901.5461.546	46.1476.6398	54.1476.6398	
46.21901.5461.546	47.1476.6398	55.1476.6398	
47.21901.5461.546	48.1476.6398	56.1476.6398	
48.21901.5461.546	49.1476.6398	57.1476.6398	
49.21901.5461.546	50.1476.6398	58.1476.6398	
50.21901.5461.546	51.1476.6398	59.1476.6398	
51.21901.5461.546	52.1476.6398	60.1476.6398	
52.36151.413.7730	61.4675.6398		
53.36151.413.7730	54.1476.6398	62.4675.6398	
54.21901.5461.546	55.1476.6398	63.1476.6398	
55.21901.5461.546	56.1476.6398	64.1476.6398	
56.21901.5461.546	57.1476.6398	65.1476.6398	
57.21901.5461.546	58.1476.6398	66.1476.6398	
58.21901.5461.546	59.1476.6398	67.1476.6398	
59.21901.5461.546	60.1476.6398	68.1476.6398	
60.21901.5461.546	61.1476.6398	69.1476.6398	
61.36151.413.7730	70.4675.6398		
62.59232.320.9661	63.1476.6398	71.7629	
63.21901.5461.546	64.1476.6398	71.1476.6398	
64.21901.5461.546	65.1476.6398	72.1476.6398	
65.21901.5461.546	66.1476.6398	73.1476.6398	
66.21901.5461.546	67.1476.6398	74.1476.6398	
67.21901.5461.546	68.1476.6398	75.1476.6398	
68.21901.5461.546	69.1476.6398	76.1476.6398	
69.21901.5461.546	70.1476.6398	77.7629	
70.59232.320.9661	77.7629		
71.59232.320.9661	72.4675.6398		
72.36151.413.7730	73.4675.6398		
73.36151.413.7730	74.4675.6398		
74.36151.413.7730	75.4675.6398		
75.36151.413.7730	76.4675.6398		
76.36151.413.7730	77.4675.6398		
77.59232.320.9661			
4 4 77 0	0		
1 1 0 0	1		
1.59232.320.9661	2.4675.6398	8.7629	9.1476.6398
2.36151.413.7730	3.1476.6398	10.1476.6398	
3.36151.413.7730	4.1476.6398	11.1476.6398	
4.36151.413.7730	5.1476.6398	12.1476.6398	
5.36151.413.7730	6.1476.6398	13.1476.6398	
6.36151.413.7730	7.1476.6398	14.1476.6398	
7.59232.320.9661	15.1476.6398	16.7629	
8.59232.320.9661	9.1476.6398	17.4675.6398	
9.21901.5461.546	10.1476.6398	18.1476.6398	
10.21901.5461.546	11.1476.6398	19.1476.6398	
11.21901.5461.546	12.1476.6398	20.1476.6398	
12.21901.5461.546	13.1476.6398	21.1476.6398	
13.21901.5461.546	14.1476.6398	22.1476.6398	
14.21901.5461.546	15.1476.6398	23.1476.6398	
15.21901.5461.546	16.14761.065	24.14761.065	
2 161.3122.320.9661	25.9990.6398		
17.36151.413.7730	18.1476.6398	26.1476.6398	
18.21901.5461.546	19.1476.6398	27.1476.6398	
19.21901.5461.546	20.1476.6398	28.1476.6398	
20.21901.5461.546	21.1476.6398	29.1476.6398	

21.21901.5461.546	22.1476.6398	30.1476.6398
22.21901.5461.546	23.1476.6398	31.1476.6398
23.21901.5461.546	24.1476.6398	32.1476.6398
24.21901.5461.546	25.14761.065	33.14761.065
2 25.70151.413.7730	34.9990.6398	
26.36151.413.7730	27.1476.6398	35.4675.6398
27.21901.5461.546	28.1476.6398	36.1476.6398
28.21901.5461.546	29.1476.6398	37.1476.6398
29.21901.5461.546	30.1476.6398	38.1476.6398
30.21901.5461.546	31.1476.6398	39.1476.6398
31.21901.5461.546	32.1476.6398	40.1476.6398
32.21901.5461.546	33.1476.6398	41.1476.6398
33.21901.5461.546	34.14761.065	42.14761.065
2 34.70151.413.7730	43.9990.6398	
35.36151.413.7730	36.1476.6398	44.4675.6398
36.21901.5461.546	37.1476.6398	45.1476.6398
37.21901.5461.546	38.1476.6398	46.1476.6398
38.21901.5461.546	39.1476.6398	47.1476.6398
39.21901.5461.546	40.1476.6398	48.1476.6398
40.21901.5461.546	41.1476.6398	49.1476.6398
41.21901.5461.546	42.1476.6398	50.1476.6398
42.21901.5461.546	43.14761.065	51.1476.6398
2 43.70151.413.7730	52.9990.6398	
44.36151.413.7730	45.1476.6398	53.4675.6398
45.21901.5461.546	46.1476.6398	54.1476.6398
46.21901.5461.546	47.1476.6398	55.1476.6398
47.21901.5461.546	48.1476.6398	56.1476.6398
48.21901.5461.546	49.1476.6398	57.1476.6398
49.21901.5461.546	50.1476.6398	58.1476.6398
50.21901.5461.546	51.1476.6398	59.1476.6398
51.21901.5461.546	52.14761.065	60.1476.6398
2 52.70151.413.7730	61.9990.6398	
53.36151.413.7730	54.1476.6398	62.4675.6398
54.21901.5461.546	55.1476.6398	63.1476.6398
55.21901.5461.546	56.1476.6398	64.1476.6398
56.21901.5461.546	57.1476.6398	65.1476.6398
57.21901.5461.546	58.1476.6398	66.1476.6398
58.21901.5461.546	59.1476.6398	67.1476.6398
59.21901.5461.546	60.1476.6398	68.1476.6398
60.21901.5461.546	61.14761.065	69.1476.6398
2 61.70151.413.7730	70.9990.6398	
62.59232.320.9661	63.1476.6398	71.7629
63.21901.5461.546	64.1476.6398	71.1476.6398
64.21901.5461.546	65.1476.6398	72.1476.6398
65.21901.5461.546	66.1476.6398	73.1476.6398
66.21901.5461.546	67.1476.6398	74.1476.6398
67.21901.5461.546	68.1476.6398	75.1476.6398
68.21901.5461.546	69.1476.6398	76.1476.6398
69.21901.5461.546	70.1476.6398	77.7629
2 701.3122.320.9661	77.7629	
71.59232.320.9661	72.4675.6398	
72.36151.413.7730	73.4675.6398	
73.36151.413.7730	74.4675.6398	
74.36151.413.7730	75.4675.6398	
75.36151.413.7730	76.4675.6398	
76.36151.413.7730	77.4675.6398	
77.59232.320.9661		
5 5 60 0 0		
1 1 0 0 1		
1.66202.5011.105	2.4569.7302	7.7629 a.1756.7302

2	42071.622.8837	3.4569.7382	9.1756.7382
3	42071.622.8837	4.4569.7382	10.1756.7382
4	42071.622.8837	5.4569.7382	11.1756.7382
5	42071.622.8837	6.4569.7382	12.1756.7382
6	66202.5811.105	13.1756.7382	14.7629
2	71.4472.5811.105	8.17561.004	15.9884.7382
8	29641.7671.767	9.1756.7382	16.1756.7382
9	29641.7671.767	10.1756.7382	17.1756.7382
10	29641.7671.767	11.1756.7382	18.1756.7382
11	29641.7671.767	12.1756.7382	19.1756.7382
12	29641.7671.767	13.1756.7382	20.1756.7382
13	29641.7671.767	14.1756.7382	21.1756.7382
14	66202.5811.105	22.4569.7382	
2	15.81301.622.8837	16.17561.004	23.9884.7382
16	29641.7671.767	17.1756.7382	24.1756.7382
17	29641.7671.767	18.1756.7382	25.1756.7382
18	29641.7671.767	19.1756.7382	26.1756.7382
19	29641.7671.767	20.1756.7382	27.1756.7382
20	29641.7671.767	21.1756.7382	28.1756.7382
21	29641.7671.767	22.1756.7382	29.1756.7382
22	42071.622.8837	30.4569.7382	
2	23.81301.622.8837	24.17561.004	31.9884.7382
24	29641.7671.767	25.1756.7382	32.1756.7382
25	29641.7671.767	26.1756.7382	33.1756.7382
26	29641.7671.767	27.1756.7382	34.1756.7382
27	29641.7671.767	28.1756.7382	35.1756.7382
28	29641.7671.767	29.1756.7382	36.1756.7382
29	29641.7671.767	30.1756.7382	37.1756.7382
30	42071.622.8837	38.4569.7382	
2	31.81301.622.8837	32.17561.004	39.9884.7382
32	29641.7671.767	33.1756.7382	40.1756.7382
33	29641.7671.767	34.1756.7382	41.1756.7382
34	29641.7671.767	35.1756.7382	42.1756.7382
35	29641.7671.767	36.1756.7382	43.1756.7382
36	29641.7671.767	37.1756.7382	44.1756.7382
37	29641.7671.767	38.1756.7382	45.1756.7382
38	42071.622.8837	46.4569.7382	
2	39.81301.622.8837	40.17561.004	47.9884.7382
40	29641.7671.767	41.1756.7382	48.1756.7382
41	29641.7671.767	42.1756.7382	49.1756.7382
42	29641.7671.767	43.1756.7382	50.1756.7382
43	29641.7671.767	44.1756.7382	51.1756.7382
44	29641.7671.767	45.1756.7382	52.1756.7382
45	29641.7671.767	46.1756.7382	53.1756.7382
46	42071.622.8837	54.4569.7382	
2	471.5873.1131.105	48.17561.004	55.7629
48	29641.7671.767	49.1756.7382	55.1756.7382
49	29641.7671.767	50.1756.7382	56.1756.7382
50	29641.7671.767	51.1756.7382	57.1756.7382
51	29641.7671.767	52.1756.7382	58.1756.7382
52	29641.7671.767	53.1756.7382	59.1756.7382
53	29641.7671.767	54.1756.7382	60.1756.7382
54	66202.5811.105	60.7629	
2	551.5873.1131.105	56.9884.7382	
2	56.81301.7671.767	57.9884.7382	
2	57.81301.7671.767	58.9884.7382	
2	58.81301.7671.767	59.9884.7382	
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2	601.4472.5811.105		

8 1 60 0 0

1	1	0	0	1				
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1	1	0	0	1				
8	5	77	0	0				
1	1	0	0	1				
1.	59232.320.9661			2.4675.6398		8.7629		9.1476.6398
2.	36151.413.7730			3.1476.6398		10.1476.6398		
3.	36151.413.7730			4.1476.6398		11.1476.6398		
4.	36151.413.7730			5.1476.6398		12.1476.6398		
5.	36151.413.7730			6.1476.6398		13.1476.6398		
6.	36151.413.7730			7.1476.6398		14.1476.6398		
7.	59232.320.9661			15.1476.6398		16.7629		
8.	59232.320.9661			9.1476.6398		17.4675.6398		
9.	21901.5461.546			18.1476.6398		18.1476.6398		
10.	21901.5461.546			11.1476.6398		19.1476.6398		
11.	21901.5461.546			12.1476.6398		20.1476.6398		
12.	21901.5461.546			13.1476.6398		21.1476.6398		
13.	21901.5461.546			14.1476.6398		22.1476.6398		
14.	21901.5461.546			15.1476.6398		23.1476.6398		
15.	21901.5461.546			16.14761.065		24.1476.6398		
2	181.3122.320.9661			25.9998.6398				
17.	36151.413.7730			18.1476.6398		26.1476.6398		
18.	21901.5461.546			19.1476.6398		27.1476.6398		
19.	21901.5461.546			20.1476.6398		28.1476.6398		
20.	21901.5461.546			21.1476.6398		29.1476.6398		
21.	21901.5461.546			22.1476.6398		30.1476.6398		
22.	21901.5461.546			23.1476.6398		31.1476.6398		
23.	21901.5461.546			24.1476.6398		32.1476.6398		
24.	21901.5461.546			25.14761.065		33.1476.6398		
2	25.70151.413.7730			34.9998.6398				
26.	36151.413.7730			27.1476.6398		35.4675.6398		
27.	21901.5461.546			28.1476.6398		36.1476.6398		
28.	21901.5461.546			29.1476.6398		37.1476.6398		
29.	21901.5461.546			30.1476.6398		38.1476.6398		
30.	21901.5461.546			31.1476.6398		39.1476.6398		
31.	21901.5461.546			32.1476.6398		40.1476.6398		
32.	21901.5461.546			33.1476.6398		41.1476.6398		
33.	21901.5461.546			34.14761.065		42.1476.6398		
2	34.70151.413.7730			43.9998.6398				
35.	36151.413.7730			36.1476.6398		44.4675.6398		
36.	21901.5461.546			37.1476.6398		45.1476.6398		
37.	21901.5461.546			38.1476.6398		46.1476.6398		
38.	21901.5461.546			39.1476.6398		47.1476.6398		
39.	21901.5461.546			40.1476.6398		48.1476.6398		
40.	21901.5461.546			41.1476.6398		49.1476.6398		
41.	21901.5461.546			42.1476.6398		50.1476.6398		
42.	21901.5461.546			43.14761.065		51.1476.6398		
2	43.70151.413.7730			52.9998.6398				
44.	36151.413.7730			45.1476.6398		53.4675.6398		
45.	21901.5461.546			46.1476.6398		54.1476.6398		
46.	21901.5461.546			47.1476.6398		55.1476.6398		
47.	21901.5461.546			48.1476.6398		56.1476.6398		
48.	21901.5461.546			49.1476.6398		57.1476.6398		
49.	21901.5461.546			50.1476.6398		58.1476.6398		
50.	21901.5461.546			51.1476.6398		59.1476.6398		
51.	21901.5461.546			52.14761.065		60.1476.6398		
2	52.70151.413.7730			61.9998.6398				
53.	36151.413.7730			54.1476.6398		62.4675.6398		
54.	21901.5461.546			55.1476.6398		63.1476.6398		
55.	21901.5461.546			56.1476.6398		64.1476.6398		

56.21901.5461.546	57.1478.8398	65.1478.8398
57.21901.5461.546	58.1478.8398	66.1478.8398
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59.21901.5461.546	60.1478.8398	68.1478.8398
60.21901.5461.546	61.1478.8398	69.1478.8398
2 61.70151.413.7730	70.9990.8398	
62.59232.320.9661	63.1478.8398	71.7829
63.21901.5461.546	64.1478.8398	71.1478.8398
64.21901.5461.546	65.1478.8398	72.1478.8398
65.21901.5461.546	66.1478.8398	73.1478.8398
66.21901.5461.546	67.1478.8398	74.1478.8398
67.21901.5461.546	68.1478.8398	75.1478.8398
68.21901.5461.546	69.1478.8398	76.1478.8398
69.21901.5461.546	70.1478.8398	77.7829
2 701.4532.851.9861	77.7829	
2 711.3122.320.9661	72.9990.8398	
2 72.70151.413.7730	73.9990.8398	
2 73.70151.413.7730	74.9990.8398	
2 74.70151.413.7730	75.9990.8398	
2 75.70151.413.7730	76.9990.8398	
2 76.70151.413.7730	77.9990.8398	
2 771.4532.851.9861		

rods	0	1	2	0	0	1
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1	.563	1.0	1.375	2.375	8.250	
2	.563	1.0	1.250	2.250	8.250	9.250
3	.563	1.0	2.250	3.250	9.250	10.250
4	.563	1.0	3.250	4.250	10.250	11.250
5	.563	1.0	4.250	5.250	11.250	12.250
6	.563	1.0	5.250	6.250	12.250	13.250
7	.563	1.0	6.375	13.250	14.375	
8	.563	1.0	7.250	8.250	15.250	16.250
9	.563	1.0	8.250	9.250	16.250	17.250
10	.563	1.0	9.250	10.250	17.250	18.250
11	.563	1.0	10.250	11.250	18.250	19.250
12	.563	1.0	11.250	12.250	19.250	20.250
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16	.563	1.0	16.250	17.250	24.250	25.250
17	.563	1.0	17.250	18.250	25.250	26.250
18	.563	1.0	18.250	19.250	26.250	27.250
19	.563	1.0	19.250	20.250	27.250	28.250
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23	.563	1.0	24.250	25.250	32.250	33.250
24	.563	1.0	25.250	26.250	33.250	34.250
25	.563	1.0	26.250	27.250	34.250	35.250
26	.563	1.0	27.250	28.250	35.250	36.250
27	.563	1.0	28.250	29.250	36.250	37.250
28	.563	1.0	29.250	30.250	37.250	38.250
29	.563	1.0	31.250	32.250	39.250	40.250
30	.563	1.0	32.250	33.250	40.250	41.250
31	.563	1.0	33.250	34.250	41.250	42.250
32	.563	1.0	34.250	35.250	42.250	43.250
33	.563	1.0	35.250	36.250	43.250	44.250
34	.563	1.0	36.250	37.250	44.250	45.250
35	.563	1.0	37.250	38.250	45.250	46.250

36	563	1.0	39	250	40	250	47	250	48	250
37	563	1.0	40	250	41	250	48	250	49	250
38	563	1.0	41	250	42	250	49	250	50	250
39	563	1.0	42	250	43	250	50	250	51	250
40	563	1.0	43	250	44	250	51	250	52	250
41	563	1.0	44	250	45	250	52	250	53	250
42	563	1.0	45	250	46	250	53	250	54	250
43	563	1.0	47	375	48	250	55	375		
44	563	1.0	48	250	49	250	55	250	56	250
45	563	1.0	49	250	50	250	56	250	57	250
46	563	1.0	50	250	51	250	57	250	58	250
47	563	1.0	51	250	52	250	58	250	59	250
48	563	1.0	52	250	53	250	59	250	60	250
49	563	1.0	53	250	54	375	60	375		
2	2	49	0							
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3	563	1.0	2	250	3	250	9	250	10	250
4	563	1.0	3	250	4	250	10	250	11	250
5	563	1.0	4	250	5	250	11	250	12	250
6	563	1.0	5	250	6	250	12	250	13	250
7	563	1.0	6	375	13	250	14	375		
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9	563	1.0	8	250	9	250	16	250	17	250
10	563	1.0	9	250	10	250	17	250	18	250
11	563	1.0	10	250	11	250	18	250	19	250
12	563	1.0	11	250	12	250	19	250	20	250
13	563	1.0	12	250	13	250	20	250	21	250
14	563	1.0	13	250	14	250	21	250	22	250
15	563	1.0	15	250	16	250	23	250	24	250
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21	563	1.0	21	250	22	250	29	250	30	250
22	563	1.0	23	250	24	250	31	250	32	250
23	563	1.0	24	250	25	250	32	250	33	250
24	563	1.0	25	250	26	250	33	250	34	250
25	563	1.0	26	250	27	250	34	250	35	250
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31	563	1.0	33	250	34	250	41	250	42	250
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38	563	1.0	41	250	42	250	49	250	50	250
39	563	1.0	42	250	43	250	50	250	51	250
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42	563	1.0	45	250	46	250	53	250	54	250
43	563	1.0	47	375	48	250	55	375		
44	563	1.0	48	250	49	250	55	250	56	250
45	563	1.0	49	250	50	250	56	250	57	250

46	563	1.0	50	250	51	250	57	250	58	250	
47	563	1.0	51	250	52	250	58	250	59	250	
48	563	1.0	52	250	53	250	59	250	60	250	
49	563	1.0	53	250	54	375	60	375			
3	3	64	0								
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2	2	.492	1.0	1	.250	2	.250	9	.250	10	.250
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2	4	.492	1.0	3	.250	4	.250	11	.250	12	.250
2	5	.492	1.0	4	.250	5	.250	12	.250	13	.250
2	6	.492	1.0	5	.250	6	.250	13	.250	14	.250
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2	8	.492	1.0	7	.375	15	.250	16	.375		
2	9	.492	1.0	8	.250	9	.250	17	.250	18	.250
2	10	.492	1.0	9	.250	10	.250	18	.250	19	.250
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2	12	.492	1.0	11	.250	12	.250	20	.250	21	.250
2	13	.492	1.0	12	.250	13	.250	21	.250	22	.250
2	14	.492	1.0	13	.250	14	.250	22	.250	23	.250
2	15	.492	1.0	14	.250	15	.250	23	.250	24	.250
2	16	.492	1.0	15	.250	16	.250	24	.250	25	.250
2	17	.492	1.0	17	.250	18	.250	26	.250	27	.250
2	18	.492	1.0	18	.250	19	.250	27	.250	28	.250
2	19	.492	1.0	19	.250	20	.250	28	.250	29	.250
2	20	.492	1.0	20	.250	21	.250	29	.250	30	.250
2	21	.492	1.0	21	.250	22	.250	30	.250	31	.250
2	22	.492	1.0	22	.250	23	.250	31	.250	32	.250
2	23	.492	1.0	23	.250	24	.250	32	.250	33	.250
2	24	.492	1.0	24	.250	25	.250	33	.250	34	.250
2	25	.492	1.0	25	.250	27	.250	35	.250	36	.250
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2	27	.492	1.0	28	.250	29	.250	37	.250	38	.250
2	28	.492	1.0	29	.250	30	.250	38	.250	39	.250
2	29	.492	1.0	30	.250	31	.250	39	.250	40	.250
2	30	.492	1.0	31	.250	32	.250	40	.250	41	.250
2	31	.492	1.0	32	.250	33	.250	41	.250	42	.250
2	32	.492	1.0	33	.250	34	.250	42	.250	43	.250
2	33	.492	1.0	35	.250	36	.250	44	.250	45	.250
2	34	.492	1.0	36	.250	37	.250	45	.250	46	.250
2	35	.492	1.0	37	.250	38	.250	46	.250	47	.250
2	36	.492	1.0	38	.250	39	.250	47	.250	48	.250
2	37	.492	1.0	39	.250	40	.250	48	.250	49	.250
2	38	.492	1.0	40	.250	41	.250	49	.250	50	.250
2	39	.492	1.0	41	.250	42	.250	50	.250	51	.250
2	40	.492	1.0	42	.250	43	.250	51	.250	52	.250
2	41	.492	1.0	44	.250	45	.250	53	.250	54	.250
2	42	.492	1.0	45	.250	46	.250	54	.250	55	.250
2	43	.492	1.0	46	.250	47	.250	55	.250	56	.250
2	44	.492	1.0	47	.250	48	.250	56	.250	57	.250
2	45	.492	1.0	48	.250	49	.250	57	.250	58	.250
2	46	.492	1.0	49	.250	50	.250	58	.250	59	.250
2	47	.492	1.0	50	.250	51	.250	59	.250	60	.250
2	48	.492	1.0	51	.250	52	.250	60	.250	61	.250
2	49	.492	1.0	53	.250	54	.250	62	.250	63	.250
2	50	.492	1.0	54	.250	55	.250	63	.250	64	.250
2	51	.492	1.0	55	.250	56	.250	64	.250	65	.250
2	52	.492	1.0	56	.250	57	.250	65	.250	66	.250
2	53	.492	1.0	57	.250	58	.250	66	.250	67	.250
2	54	.492	1.0	58	.250	59	.250	67	.250	68	.250
2	55	.492	1.0	59	.250	60	.250	68	.250	69	.250

2 56	.492	1.0	60 .250	81 .250	89 .250	70 .250
2 57	.492	1.0	62 .375	63 .250	71 .375	
2 58	.492	1.0	63 .250	64 .250	71 .250	72 .250
2 59	.492	1.0	64 .250	65 .250	72 .250	73 .250
2 60	.492	1.0	65 .250	66 .250	73 .250	74 .250
2 61	.492	1.0	66 .250	67 .250	74 .250	75 .250
2 62	.492	1.0	67 .250	68 .250	75 .250	76 .250
2 63	.492	1.0	68 .250	69 .250	76 .250	77 .250
2 64	.492	1.0	69 .250	70 .375	77 .375	
4	4	84	0			
2 1	.492	1.0	1 .375	8 .375	9 .250	
2 2	.492	1.0	1 .250	2 .250	9 .250	10 .250
2 3	.492	1.0	2 .250	3 .250	10 .250	11 .250
2 4	.492	1.0	3 .250	4 .250	11 .250	12 .250
2 5	.492	1.0	4 .250	5 .250	12 .250	13 .250
2 6	.492	1.0	5 .250	6 .250	13 .250	14 .250
2 7	.492	1.0	6 .250	7 .250	14 .250	15 .250
2 8	.492	1.0	7 .375	15 .250	16 .375	
2 9	.492	1.0	8 .250	9 .250	17 .250	18 .250
2 10	.492	1.0	9 .250	10 .250	18 .250	19 .250
2 11	.492	1.0	10 .250	11 .250	19 .250	20 .250
2 12	.492	1.0	11 .250	12 .250	20 .250	21 .250
2 13	.492	1.0	12 .250	13 .250	21 .250	22 .250
2 14	.492	1.0	13 .250	14 .250	22 .250	23 .250
2 15	.492	1.0	14 .250	15 .250	23 .250	24 .250
2 16	.492	1.0	15 .250	16 .250	24 .250	25 .250
2 17	.492	1.0	17 .250	18 .250	26 .250	27 .250
2 18	.492	1.0	18 .250	19 .250	27 .250	28 .250
2 19	.492	1.0	19 .250	20 .250	28 .250	29 .250
2 20	.492	1.0	20 .250	21 .250	29 .250	30 .250
2 21	.492	1.0	21 .250	22 .250	30 .250	31 .250
2 22	.492	1.0	22 .250	23 .250	31 .250	32 .250
2 23	.492	1.0	23 .250	24 .250	32 .250	33 .250
2 24	.492	1.0	24 .250	25 .250	33 .250	34 .250
2 25	.492	1.0	26 .250	27 .250	35 .250	36 .250
2 26	.492	1.0	27 .250	28 .250	36 .250	37 .250
2 27	.492	1.0	28 .250	29 .250	37 .250	38 .250
2 28	.492	1.0	29 .250	30 .250	38 .250	39 .250
2 29	.492	1.0	30 .250	31 .250	39 .250	40 .250
2 30	.492	1.0	31 .250	32 .250	40 .250	41 .250
2 31	.492	1.0	32 .250	33 .250	41 .250	42 .250
2 32	.492	1.0	33 .250	34 .250	42 .250	43 .250
2 33	.492	1.0	35 .250	36 .250	44 .250	45 .250
2 34	.492	1.0	36 .250	37 .250	45 .250	46 .250
2 35	.492	1.0	37 .250	38 .250	46 .250	47 .250
2 36	.492	1.0	38 .250	39 .250	47 .250	48 .250
2 37	.492	1.0	39 .250	40 .250	48 .250	49 .250
2 38	.492	1.0	40 .250	41 .250	49 .250	50 .250
2 39	.492	1.0	41 .250	42 .250	50 .250	51 .250
2 40	.492	1.0	42 .250	43 .250	51 .250	52 .250
2 41	.492	1.0	44 .250	45 .250	53 .250	54 .250
2 42	.492	1.0	45 .250	46 .250	54 .250	55 .250
2 43	.492	1.0	46 .250	47 .250	55 .250	56 .250
2 44	.492	1.0	47 .250	48 .250	56 .250	57 .250
2 45	.492	1.0	48 .250	49 .250	57 .250	58 .250
2 46	.492	1.0	49 .250	50 .250	58 .250	59 .250
2 47	.492	1.0	50 .250	51 .250	59 .250	60 .250
2 48	.492	1.0	51 .250	52 .250	60 .250	61 .250
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2 50	.492	1.0	54 .250	55 .250	63 .250	64 .250

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2 52	492	1.0	56	250	57	250	65	250	66	250
2 53	492	1.0	57	250	58	250	66	250	67	250
2 54	492	1.0	58	250	59	250	67	250	68	250
2 55	492	1.0	59	250	60	250	68	250	69	250
2 56	492	1.0	60	250	61	250	69	250	70	250
2 57	492	1.0	62	375	63	250	71	375		
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2 59	492	1.0	64	250	65	250	72	250	73	250
2 60	492	1.0	65	250	66	250	73	250	74	250
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22	503	1.0	23	250	24	250	31	250	32	250
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45	503	1.0	49	250	50	250	56	250	57	250

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7	4	64	0								
8	6	64	0								
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2	18	.492	1.0	18	.250	19	.250	27	.250	28	.250
2	19	.492	1.0	19	.250	20	.250	28	.250	29	.250
2	20	.492	1.0	20	.250	21	.250	29	.250	30	.250
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2	52	.492	1.0	56	.250	57	.250	85	.250	86	.250
2	53	.492	1.0	57	.250	58	.250	86	.250	87	.250

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2 54 .492 1.0 58 .250 59 .250 67 .250 68 .250
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2 1496.
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11 114.2
12 261.4
13 233.1
14 122.9
15 110.1
16 123.5
17 172.2
18 87.52
19 140.1
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33 2993.
34 81391.
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		5	2	2	5	3	2	1	47	6	5	7	6
19	6	1	56	2	1	59	2	1	66	1	5	4	2
		5	5	2	5	6	1						
21	6	2	55	1	2	56	2	2	57	2	6	14	1
		6	22	2	6	36	2						
22	6	2	56	2	2	59	2	2	66	1	6	36	2
		6	46	2	6	54	1						
24	8	3	71	3	3	72	4	3	73	4	3	74	5
		7	62	3	7	53	4	7	44	4	7	35	5
25	8	3	74	5	3	75	4	3	76	4	3	77	3
		7	35	5	7	26	4	7	17	4	7	8	3
27	8	4	71	3	4	72	4	4	73	4	4	74	5
		8	4	5	8	3	4	8	2	4	8	1	3
28	10	4	74	5	4	75	4	4	76	4	4	77	3
		8	4	5	8	5	4	8	6	4	8	7	3
		4	78	6	8	16	6						
29	6	5	14	1	5	22	2	5	38	2	6	4	1
		6	5	2	6	6	2						
30	7	6	66	1	6	59	2	6	58	2	7	71	3
		7	72	4	7	73	4	7	74	5			
31	8	7	1	3	7	2	4	7	3	4	7	4	5
		8	8	3	8	17	4	8	26	4	8	35	5
32	8	5	38	2	5	46	2	5	54	1	6	1	1
		6	2	2	6	3	2	5	66	6	6	7	6
33	9	6	57	2	6	56	2	6	55	1	7	74	5
		7	75	4	7	76	4	7	77	3	6	47	6
		7	78	6									
34	10	7	4	5	7	5	4	7	6	4	7	7	3
		8	35	5	8	44	4	8	53	4	8	62	3
		7	16	6	8	71	6						
35	3	1	7	1	1	16	2	1	23	2			
36	3	1	31	2	1	39	2	1	47	1			
37	3	5	7	1	5	15	2	5	23	1			
38	3	5	31	2	5	39	2	5	47	1			
39	3	5	55	1	5	56	2	5	57	2			
40	3	5	58	2	5	59	2	5	60	1			
41	3	6	7	1	6	15	2	6	23	2			
42	3	6	31	2	6	39	2	6	47	1			
43	4	7	78	3	7	61	4	7	52	4	7	43	5
44	4	7	43	5	7	34	4	7	25	4	7	16	3
45	4	8	71	3	8	72	4	8	73	4	8	74	5
46	4	8	74	5	8	75	4	8	76	4	8	77	3
47	4	8	43	5	8	52	4	8	61	4	8	78	3
48	4	8	16	3	8	25	4	8	34	4	8	43	5
49	4	4	43	5	4	52	4	4	61	4	4	78	3
50	4	4	16	3	4	25	4	4	34	4	4	43	5
radg	8	6	8										
1	1	8	1	2	12	15	19	18	38	35			
2	2	6	4	5	13	16	22	21	15	12			
3	4	8	7	8	14	17	25	24	16	13			
4	5	8	10	11	58	49	28	27	17	14			
5	3	8	18	19	29	32	46	39	38	37			
6	1	8	32	29	21	22	36	33	42	41			
7	5	8	31	34	44	43	33	38	24	25			

	8	6	8	27	28	48	47	48	45	34	31
heat	1	0	1								
			3.88					3.88			
	1.	1.	1.	1.	1.	1.	1.	1.			
drag	2	0									
	100.	-1.0			100.	-1.0					
	84.	-1.0			84.	-1.0					
bdry	9	1	24	2							
	1	4.500e-06						.93			
	2	8.070e-05									
	3	3.287e-06					0.25	0.25			
	4	7.604e-05									
	5	3.816e-07				0.33	0.25				
	6	1.385e-04									
	7	1.143e-04									
	8	1.342e-04									
	9	3.442e-07				0.33	0.25				
	1	2	0.78.8	1.	78.8						
147	1	3.52	1								
	1	1.	1	1.	1						
148	1	3.52	1								
	1	1.	1	1.	1						
149	1	3.52	1								
	1	1.	1	1.	1						
150	1	4.95	1								
	1	1.	1	1.	1						
151	1	4.95	1								
	1	1.	1	1.	1						
152	1	4.95	1								
	1	1.	1	1.	1						
153	1	4.95	1								
	1	1.	1	1.	1						
154	1	4.95	1								
	1	1.	1	1.	1						
155	1	4.95	1								
	1	1.	1	1.	1						
156	1	3.52	1								
	1	1.	1	1.	1						
157	1	3.52	1								
	1	1.	1	1.	1						
158	1	3.52	1								
	1	1.	1	1.	1						
159	1	3.52	1								
	1	1.	1	1.	1						
160	1	3.52	1								
	1	1.	1	1.	1						
161	1	3.52	1								
	1	1.	1	1.	1						
162	1	4.95	1								
	1	1.	1	1.	1						
163	1	4.95	1								
	1	1.	1	1.	1						
164	1	4.95	1								
	1	1.	1	1.	1						
165	1	4.95	1								
	1	1.	1	1.	1						
166	1	4.95	1								
	1	1.	1	1.	1						
167	1	4.95	1								
	1	1.	1	1.	1						

```

168 1 3.52 1
1 1. 1 1. 1
169 1 3.52 1
1 1. 1 1. 1
170 1 3.52 1
1 1. 1 1. 1
1343.8 0. 6 0 78.8 0.
1 1.0 6 14 1 210.00 9.0 2 210.00 9.0 10 210.00 9.0
11 210.00 9.0 18 210.00 9.0 19 210.00 9.0
27 210.00 9.0 28 210.00 9.0 29 210.00 9.0
30 210.00 9.0 31 210.00 9.0 32 210.00 9.0
33 210.00 9.0 34 210.00 9.0
2 3.19 6 24 51 212.77 9.0 52 212.77 9.0 53 212.77 9.0
54 2 8.99 9.0 55 2 5.46 9.0 56 2 3.93 9.0
57 2 3.93 9.0 58 2 5.46 9.0 59 2 8.99 9.0
60 212.77 9.0 61 212.77 9.0 62 212.77 9.0
63 212.77 9.0 64 212.77 9.0 65 212.77 9.0
66 2 8.99 9.0 67 2 5.46 9.0 68 2 3.93 9.0
69 2 3.93 9.0 70 2 5.46 9.0 71 2 8.99 9.0
72 212.77 9.0 73 212.77 9.0 74 212.77 9.0
3 3.95 6 24 75 212.77 9.0 76 212.77 9.0 77 212.77 9.0
78 212.69 9.0 79 212.69 9.0 80 212.69 9.0
81 212.69 9.0 82 212.69 9.0 83 212.69 9.0
84 212.77 9.0 85 212.77 9.0 86 212.77 9.0
87 212.77 9.0 88 212.77 9.0 89 212.77 9.0
90 212.69 9.0 91 212.69 9.0 92 212.69 9.0
93 212.69 9.0 94 212.69 9.0 95 212.69 9.0
96 212.77 9.0 97 212.77 9.0 98 212.77 9.0
4 4.68 7 24 99 215.50 9.0 100 215.50 9.0 101 215.50 9.0
102 221.18 9.0 103 221.18 9.0 104 221.18 9.0
105 221.18 9.0 106 221.18 9.0 107 221.18 9.0
108 215.50 9.0 109 215.50 9.0 110 215.50 9.0
111 215.50 9.0 112 215.50 9.0 113 215.50 9.0
114 221.18 9.0 115 221.18 9.0 116 221.18 9.0
117 221.18 9.0 118 221.18 9.0 119 221.18 9.0
120 215.50 9.0 121 215.50 9.0 122 215.50 9.0
5 5.09 8 24 123 213.21 9.0 124 213.21 9.0 125 213.21 9.0
126 223.09 9.0 127 226.77 9.0 128 229.83 9.0
129 229.83 9.0 130 226.77 9.0 131 223.09 9.0
132 213.21 9.0 133 213.21 9.0 134 213.21 9.0
135 213.21 9.0 136 213.21 9.0 137 213.21 9.0
138 223.09 9.0 139 226.77 9.0 140 229.83 9.0
141 229.83 9.0 142 226.77 9.0 143 223.09 9.0
144 213.21 9.0 145 213.21 9.0 146 213.21 9.0

6 5.77 9 0
2 0. 549. 0 4 0. 78.8
1 1. 2
21.596 3
32.218 4
42.493 5
calc 1

20
oper 1 3 1 1
20.0 250. 000003 004060 500. 000000 0.0
.8483.8523.8375 8771.8436.8483.8771.7147
17
0. 0. 0468 0. 0469 0.61.0760 0.61.1345 0.61.1929 0.93
.3098 1.15.3882 1.18.4267 1.27.5436 1.22.6020 1.16.6684 1.14
.7773 0.81.8358 0.45.8852 0.45.8853 0. 1.0 0.

```

outp 1101
 endd

data from iterative solution using the recirculation module
 time = 0.0000 dt = ***** implicit dt = 0.0000 explicit dt = 0.6230 mode = 0

iteration no.	sweep no.	peak clad				total flow (lbm/s)	pressure drop(psi)	error			
		temp(f)	fluid	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	538.8	16	19	2	0.770e-11	0.0007559	0.0337	4.9984	0.0783	0.0023
	2	539.9	15	19	2			0.1763	4.9984	0.2045	0.0023
2	1	557.9	14	19	2	0.319e-11	0.0007792	0.1384	4.4702	0.0437	0.0110
	2	591.9	13	19	2			0.1308	4.4702	0.1276	0.0043
3	1	607.2	13	19	2	0.151e-11	0.0007769	0.1361	3.4860	0.0139	0.0023
	2	630.5	12	19	2			0.1365	3.4860	0.0454	0.0020
4	1	642.5	12	19	2	0.431e-12	0.0007684	0.0009	3.3572	0.0124	0.0010
	2	666.6	11	19	2			0.0093	3.3572	0.0237	0.0020
5	1	674.6	11	19	2	-0.155e-11	0.0007665	0.0147	1.3074	0.0104	0.0005
	2	683.1	11	19	2			0.0151	1.3074	0.0441	0.0006
6	1	687.4	11	19	2	0.957e-12	0.0007662	0.0169	4.9814	0.0105	0.0005
	2	692.2	11	13	2			0.0106	4.9814	0.0128	0.0004
7	1	694.6	11	13	2	0.667e-12	0.0007650	0.0042	1.0386	0.0102	0.0003
	2	697.4	11	13	2			0.0055	1.0386	0.0111	0.0004
8	1	698.5	11	13	2	0.244e-12	0.0007646	0.0059	0.9529	0.0105	0.0002
	2	699.0	11	13	2			0.0060	0.9529	0.0107	0.0003
9	1	700.4	11	13	2	-0.132e-11	0.0007643	0.0060	0.9960	0.0105	0.0002
	2	701.1	11	13	2			0.0059	0.9960	0.0128	0.0003
10	1	701.4	11	13	2	0.121e-11	0.0007640	0.0009	0.4374	0.0101	0.0002
	2	701.9	11	13	2			0.0013	0.4374	0.0099	0.0003
11	1	702.0	11	13	2	0.768e-12	0.0007639	0.0014	0.1101	0.0103	0.0002
	2	702.2	11	13	2			0.0014	0.1101	0.0098	0.0002
12	1	702.3	11	13	2	0.366e-12	0.0007639	0.0014	0.0631	0.0103	0.0002
	2	702.4	11	13	2			0.0014	0.0631	0.0099	0.0002
13	1	702.4	11	13	2	0.119e-12	0.0007638	0.0005	0.0393	0.0103	0.0002
	2	702.5	11	13	2			0.0005	0.0393	0.0100	0.0002
14	1	702.5	11	13	2	-0.230e-13	0.0007638	0.0005	0.0205	0.0103	0.0002
	2	702.6	11	13	2			0.0005	0.0205	0.0101	0.0002
15	1	702.6	11	13	2	-0.668e-13	0.0007637	0.0005	0.0129	0.0103	0.0002
	2	702.6	11	13	2			0.0005	0.0129	0.0101	0.0002

16	1	782.6	11	13	2	-0.689e-13	0.0007637	0.0003	0.0142	0.0103	0.0002
	2	782.6	11	13	2			0.0003	0.0142	0.0101	0.0002
17	1	782.6	11	13	2	-0.389e-13	0.0007637	0.0003	0.0038	0.0103	0.0002
	2	782.6	11	13	2			0.0003	0.0038	0.0101	0.0002

side boundary temperature summary time = 0.0000 seconds
 boundary slab node no. 147

axial zone (inches)	(1)	(2)	(
0.0 - 9.8	114.38	78.88	
9.8 - 19.6	116.74	78.88	
19.6 - 29.3	120.48	78.88	
29.3 - 39.1	124.81	78.88	
39.1 - 48.9	129.22	78.88	
48.9 - 58.7	133.38	78.88	
58.7 - 68.4	136.73	78.88	
68.4 - 78.2	139.31	78.88	
78.2 - 88.0	140.87	78.88	
88.0 - 97.8	141.33	78.88	
97.8 -107.6	140.71	78.88	
107.6 -117.3	139.08	78.88	
117.3 -127.1	136.46	78.88	
127.1 -136.9	133.12	78.88	
136.9 -146.7	129.38	78.88	
146.7 -156.4	125.75	78.88	
156.4 -166.2	122.81	78.88	
166.2 -176.0	121.28	78.88	

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

axial zone (inches)	(61)	(62)	(63)	(64)	(65)	(66)	(67)	(68)	(69)	(70)
0.0 - 9.8	120.36	120.34	120.31	120.26	120.16	119.77	119.61	119.54	119.54	119.60
9.8 - 19.6	125.25	125.42	125.46	125.16	124.88	123.67	123.28	123.14	123.13	123.26
19.6 - 29.3	131.43	131.85	131.82	131.34	130.28	128.82	128.20	127.98	127.95	128.17
29.3 - 39.1	138.18	138.74	138.71	137.99	136.46	134.51	133.68	133.35	133.33	133.64
39.1 - 48.9	144.88	145.53	145.49	144.54	142.58	140.18	139.16	138.75	138.72	139.10
48.9 - 58.7	150.68	151.72	151.68	150.52	148.17	145.37	144.18	143.78	143.68	144.11
58.7 - 68.4	155.62	156.85	156.79	155.47	152.88	149.78	148.37	147.82	147.78	148.28
68.4 - 78.2	159.41	160.77	160.71	159.25	156.31	152.95	151.51	150.91	150.87	151.42
78.2 - 88.0	161.88	163.11	163.05	161.49	158.38	154.87	153.36	152.73	152.68	153.26
88.0 - 97.8	162.33	163.85	163.79	162.18	158.98	155.41	153.87	153.22	153.17	153.76
97.8 -107.6	161.49	163.02	162.97	161.35	158.14	154.59	153.05	152.40	152.35	152.95
107.6 -117.3	159.23	160.76	160.71	159.11	155.94	152.48	150.98	150.34	150.29	150.87
117.3 -127.1	155.58	156.98	156.94	155.41	152.38	149.12	147.78	147.09	147.04	147.68
127.1 -136.9	150.47	151.85	151.82	150.42	147.66	144.72	143.44	142.88	142.84	143.35
136.9 -146.7	144.68	145.88	145.78	144.57	142.21	139.73	138.63	138.16	138.12	138.56
146.7 -156.4	138.78	139.88	139.67	138.89	136.79	134.82	133.95	133.56	133.53	133.86
156.4 -166.2	133.49	134.17	134.14	133.44	132.14	130.74	130.18	129.82	129.79	130.04
166.2 -176.0	130.77	131.24	131.21	130.69	129.75	128.83	128.13	127.98	127.88	128.07

calculated rod temperatures at time = 5.0000 seconds

rod no. 10

assembly 3 (fuel type 2 - cylinder)

rod o.d. = 0.492 (in.) zone-(fuel dia.(in.)) = 1-(0.417)

```

      * fuel temperatures(f.)
      *
axial zone heat flux type      hsurf * fluid clad
  (in.) (mbtu/hr-ft2)      (b/h-f-ft2) *
0.0 - 9.8  0.0000  2          7.1   149.7  149.0
9.8 - 19.6 0.0000  2          7.9   259.2  251.1
19.6 - 29.3 0.0000  2          8.6   361.0  363.7
29.3 - 39.1 0.0000  2          9.1   450.3  452.1
39.1 - 48.9 0.0000  2          9.5   524.8  526.6
48.9 - 58.7 0.0000  2          9.9   586.7  588.4
58.7 - 68.4 0.0000  2         10.1   631.7  633.3
68.4 - 78.2 0.0000  2         10.2   668.5  670.0
78.2 - 88.0 0.0000  2         10.3   698.2  691.7
88.0 - 97.8 0.0000  2         10.3   699.9  701.3
97.8 - 107.6 0.0000  2         10.3   699.4  700.7
107.6 - 117.3 0.0000  2         10.3   692.5  693.6
117.3 - 127.1 0.0000  2         10.2   672.4  673.5
127.1 - 136.9 0.0000  2         10.1   636.1  637.1
136.9 - 146.7 0.0000  2          9.8   578.5  579.2
146.7 - 156.4 0.0000  2          9.5   509.5  510.1
156.4 - 166.2 0.0000  2          8.9   408.9  408.7
166.2 - 176.0 0.0000  2          8.5   346.3  346.1

```

calculated rod temperatures at time = 8.0000 seconds

rod no. 28

assembly 3 (fuel type 2 - cylinder)

rod o.d. = 0.492 (in.) zone-(fuel dia.(in.)) = 1-(0.417)

```

      * fuel temperatures(f.)
      *
axial zone heat flux type      hsurf * fluid clad
  (in.) (mbtu/hr-ft2)      (b/h-f-ft2) *
0.0 - 9.8  0.0000  2          7.1   148.1  148.2
9.8 - 19.6 0.0000  2          7.9   269.3  271.0
19.6 - 29.3 0.0000  2          8.6   371.7  373.5
29.3 - 39.1 0.0000  2          9.2   457.5  459.3
39.1 - 48.9 0.0000  2          9.6   529.5  531.2
48.9 - 58.7 0.0000  2          9.9   589.4  591.1
58.7 - 68.4 0.0000  2         10.1   632.3  633.9
68.4 - 78.2 0.0000  2         10.2   668.0  669.6
78.2 - 88.0 0.0000  2         10.3   688.6  690.1
88.0 - 97.8 0.0000  2         10.3   697.4  698.8
97.8 - 107.6 0.0000  2         10.3   696.2  697.6
107.6 - 117.3 0.0000  2         10.3   689.1  690.4
117.3 - 127.1 0.0000  2         10.2   668.7  669.9
127.1 - 136.9 0.0000  2         10.1   631.9  633.0
136.9 - 146.7 0.0000  2          9.8   573.3  574.1
146.7 - 156.4 0.0000  2          9.4   504.4  505.0
156.4 - 166.2 0.0000  2          8.8   399.6  399.5
166.2 - 176.0 0.0000  2          8.4   338.0  337.9

```

calculated rod temperatures at time = 0.0000 seconds

rod no. 38

assembly 3 (fuel type 2 - cylinder)

rod o.d. - 0.492 (in.) zone-(fuel dia.(in.)) - 1-(0.417)

				* fuel temperatures(f.)		
				*		
axial zone	heat flux	type	hsurf	fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2)	*		*
0.0 - 9.8	0.0000	2	7.1	148.3	148.4	
9.8 - 19.6	0.0000	2	7.9	206.6	208.3	
19.6 - 29.3	0.0000	2	8.6	306.5	308.3	
29.3 - 39.1	0.0000	2	9.1	450.0	451.7	
39.1 - 48.9	0.0000	2	9.5	519.0	521.5	
48.9 - 58.7	0.0000	2	9.8	577.9	579.6	
58.7 - 68.4	0.0000	2	10.0	619.5	621.1	
68.4 - 78.2	0.0000	2	10.2	654.2	656.0	
78.2 - 88.0	0.0000	2	10.2	674.0	675.5	
88.0 - 97.8	0.0000	2	10.3	682.4	683.9	
97.8 - 107.6	0.0000	2	10.2	681.0	682.4	
107.6 - 117.3	0.0000	2	10.2	673.9	675.3	
117.3 - 127.1	0.0000	2	10.2	653.0	654.0	
127.1 - 136.9	0.0000	2	10.0	617.4	618.5	
136.9 - 146.7	0.0000	2	9.7	559.7	560.5	
146.7 - 156.4	0.0000	2	9.4	492.0	492.7	
156.4 - 166.2	0.0000	2	8.8	389.5	389.4	
166.2 - 176.0	0.0000	2	8.4	329.0	329.6	

calculated rod temperatures at time = 0.0000 seconds

rod no. 55

assembly 3 (fuel type 2 - cylinder)

rod o.d. - 0.492 (in.) zone-(fuel dia.(in.)) - 1-(0.417)

				* fuel temperatures(f.)		
				*		
axial zone	heat flux	type	hsurf	fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2)	*		*
0.0 - 9.8	0.0000	2	7.1	149.5	149.8	
9.8 - 19.6	0.0000	2	7.8	250.4	258.2	
19.6 - 29.3	0.0000	2	8.5	352.3	354.2	
29.3 - 39.1	0.0000	2	9.0	433.0	434.9	
39.1 - 48.9	0.0000	2	9.4	500.0	502.4	
48.9 - 58.7	0.0000	2	9.7	550.0	550.0	
58.7 - 68.4	0.0000	2	9.9	597.4	599.1	
68.4 - 78.2	0.0000	2	10.1	630.9	632.7	
78.2 - 88.0	0.0000	2	10.1	650.3	651.9	
88.0 - 97.8	0.0000	2	10.2	650.5	650.0	
97.8 - 107.6	0.0000	2	10.2	657.2	650.0	
107.6 - 117.3	0.0000	2	10.1	650.1	651.5	
117.3 - 127.1	0.0000	2	10.1	630.4	631.7	
127.1 - 136.9	0.0000	2	9.9	595.3	596.5	
136.9 - 146.7	0.0000	2	9.6	539.7	540.6	
146.7 - 156.4	0.0000	2	9.3	474.3	475.0	
156.4 - 166.2	0.0000	2	8.7	377.0	377.0	
166.2 - 176.0	0.0000	2	8.3	320.5	320.4	

calculated rod temperatures at time = 0.0000 seconds
 rod no. 28
 assembly 8 (fuel type 2 - cylinder)
 Rod o.d. - 0.492 (in.) zone-(fuel dia.(in.)) - 1-(0.417)

axial zone		heat flux	type	hsurf	fuel temperatures(f.)	
(in.)		(mbtu/hr-ft ²)		(b/h-f-ft ²)	fluid	clad
0.0 - 9.8	0.0000	2	7.1	153.2	153.2	
9.8 - 19.6	0.0000	2	7.7	242.5	243.9	
19.6 - 29.3	0.0000	2	8.2	302.3	303.9	
29.3 - 39.1	0.0000	2	8.5	349.4	351.1	
39.1 - 48.9	0.0000	2	8.8	389.8	390.8	
48.9 - 58.7	0.0000	2	9.0	422.5	424.4	
58.7 - 68.4	0.0000	2	9.1	445.2	447.1	
68.4 - 78.2	0.0000	2	9.2	465.2	467.2	
78.2 - 88.0	0.0000	2	9.3	474.5	470.5	
88.0 - 97.8	0.0000	2	9.3	476.6	470.6	
97.8 - 107.6	0.0000	2	9.3	472.3	474.3	
107.6 - 117.3	0.0000	2	9.2	464.7	466.6	
117.3 - 127.1	0.0000	2	9.1	446.6	446.7	
127.1 - 136.9	0.0000	2	9.0	417.9	419.6	
136.9 - 146.7	0.0000	2	8.7	374.4	375.7	
146.7 - 156.4	0.0000	2	8.3	327.8	320.7	
156.4 - 166.2	0.0000	2	7.8	257.3	257.3	
166.2 - 176.0	0.0000	2	7.7	230.9	230.9	

APPENDIX E

REA 2023 BWR CASK PERFORMANCE TEST SIMULATIONS
INPUT, OUTPUT, AND CONVERGENCE LISTS

APPENDIX E

REA 2023 BWR CASK PERFORMANCE TEST SIMULATIONS
INPUT, OUTPUT, AND CONVERGENCE LISTS

<u>Test Case</u>	<u>Input</u>	<u>Page Number Convergence List</u>	<u>Output</u>
Vertical, helium	E.2	E.13	E.15
Vertical, nitrogen	E.22	E.33	E.35
Vertical, vacuum	E.41	E.52	E.53

+8000

1 reload4n full load, helium, vertical validation runs.

prop	7	6					
1.	0.	100.0	.0760	1.24	50.30	.0410	
2.	200.	340.0	.0970	1.24	60.90	.0533	
3.	400.	500.0	.1150	1.24	105.00	.0641	
5.	600.	644.0	.1290	1.24	129.90	.0727	
10.	800.	1002.0	.1380	1.24	155.00	.0823	
15.	1000.	1340.0	.1380	1.24	179.20	.0907	
20.	1500.	1500.0	.1380	1.24	241.30	.1136	

1	can		14.8	
2	cu		215.	
3	ss		9.0	
4	pb		22.7	
5	lpr1		0.60	
6	lpr2		16.4	

chan 11 24 #

177.8												
1	1	25	0	0								
1	1	0	0	1								
11.	7365.8942.874	2	.175	.772	3	.175	.772	4	.175	.772	8.5245	2.62
2.	1470.8843.8843	3	.175	.738								
3.	29571.7691.769	4	.175	.738	9	.175	.738					
4.	29571.7691.769	5	.175	.738	10	.175	.738					
5.	29571.7691.769	6	.175	.738	8	.175	.772	11	.175	.738		
6.	29571.7691.769	7	.175	.738	8	.175	.772	12	.175	.738		
7.	29571.7691.769	14	.175	.772	8	.175	.772	13	.175	.738		
81.	7365.8942.874	14.	0584	2.62								
9.	1470.8843.8843	10	.175	.738								
10.	29571.7691.769	11	.175	.738	15	.175	.738					
11.	29571.7691.769	12	.175	.738	16	.175	.738					
12.	29571.7691.769	13	.175	.738	17	.175	.738					
13.	29571.7691.769	14	.175	.772	18	.175	.738					
141.	7365.8942.874	18	.175	.772	19.	5245	2.62					
15.	1470.8843.8843	16	.175	.738								
16.	29571.7691.769	17	.175	.738	20	.175	.738					
17.	29571.7691.769	18	.175	.738	21	.175	.738					
18.	29571.7691.769	22	.175	.738								
191.	7365.8942.874	22	.175	.772	24	.175	.772	25	.175	.772		
20.	1470.8843.8843	21	.175	.738								
21.	29571.7691.769	22	.175	.738	23	.175	.738					
22.	29571.7691.769	24	.175	.738								
23.	1470.8843.8843	24	.175	.738								
24.	29571.7691.769	25	.175	.738								
25.	1470.8843.8843											
2	2	44	0	0								
1	1	0	0	1								
11.	7365.8942.874	2	.175	.772	3	.175	.772	4	.175	.772	8.5245	2.62
2.	29571.7691.769	3	.175	.738	9	.175	.738	15	.175	.772		
3.	29571.7691.769	4	.175	.738	10	.175	.738					
4.	29571.7691.769	5	.175	.738	11	.175	.738					
5.	29571.7691.769	6	.175	.738	8	.175	.772	12	.175	.738		
6.	29571.7691.769	7	.175	.738	8	.175	.772	13	.175	.738		
7.	29571.7691.769	22	.175	.772	8	.175	.772	14	.175	.738		
81.	7365.8942.874	22.	0584	2.62								
9.	29571.7691.769	10	.175	.738	15	.175	.772	16	.175	.738		
10.	29571.7691.769	11	.175	.738	17	.175	.738					
11.	29571.7691.769	12	.175	.738	18	.175	.738					
12.	29571.7691.769	13	.175	.738	19	.175	.738					
13.	29571.7691.769	14	.175	.738	20	.175	.738					

14.29571.7691.769	22 .175 .772	21 .175 .738		
151.7365.8942.874	1.8584 2.82	16 .175 .772	23.5245 2.82	
16.29571.7691.769	17 .175 .738	24 .175 .738		
17.29571.7691.769	18 .175 .738	25 .175 .738		
18.29571.7691.769	19 .175 .738	26 .175 .738		
19.29571.7691.769	20 .175 .738	27 .175 .738		
20.29571.7691.769	21 .175 .738	28 .175 .738		
21.29571.7691.769	22 .175 .772	29 .175 .738		
221.7365.8942.874	30.5245 2.82			
231.7365.8942.874	24 .175 .772	31 .175 .772	37.8584 2.82	38 .175 .772
24.29571.7691.769	25 .175 .738	31 .175 .738		
25.29571.7691.769	26 .175 .738	32 .175 .738		
26.29571.7691.769	27 .175 .738	33 .175 .738		
27.29571.7691.769	28 .175 .738	34 .175 .738		
28.29571.7691.769	29 .175 .738	35 .175 .738		
29.29571.7691.769	30 .175 .772	38 .175 .738		
301.7365.8942.874	36 .175 .772	43 .175 .772	44.8584 2.82	
31.29571.7691.769	32 .175 .738	38 .175 .738		
32.29571.7691.769	33 .175 .738	39 .175 .738		
33.29571.7691.769	34 .175 .738	40 .175 .738		
34.29571.7691.769	35 .175 .738	41 .175 .738		
35.29571.7691.769	38 .175 .738	42 .175 .738		
36.29571.7691.769	43 .175 .738			
371.7365.8942.874	38 .175 .772	39 .175 .772	46 .175 .772	44.5245 2.82
38.29571.7691.769	39 .175 .738			
39.29571.7691.769	40 .175 .738			
40.29571.7691.769	41 .175 .738			
41.29571.7691.769	42 .175 .738	44 .175 .772		
42.29571.7691.769	43 .175 .738	44 .175 .772		
43.29571.7691.769	44 .175 .772			
441.7365.8942.874				
3	1	25	0	0
1	1	0	0	1
4	2	44	0	0
1	1	0	0	1
5	2	44	0	0
1	1	0	0	1
6	1	25	0	0
1	1	0	0	1
7	2	44	0	0
1	1	0	0	1
8	2	44	0	0
1	1	0	0	1
9	3	1	0	0
0	1	0	0	2
110.0710.11				
10	4	1	0	0
0	1	0	0	2
1	5.2413.78			
11	5	1	0	
0	1	0	0	2
122.1020.18				

rods	11	1	1	0	0	1		
1	1	28						
1	563	1.0	1	375	2	125		
2	563	1.0	1	500	2	250	3	250
3	563	1.0	1	500	3	250	4	250
4	563	1.0	1	250	4	250	5	250
5	563	1.0	5	250	6	250	8	250

6	.563	1.0	6	.250	7	.250	8	.500		
7	.563	1.0	7	.250	8	.375	14	.375		
8	.563	1.0	2	.125	3	.250	9	.125		
9	.563	1.0	3	.250	4	.250	9	.250	10	.250
10	.563	1.0	4	.250	5	.250	10	.250	11	.250
11	.563	1.0	5	.250	6	.250	11	.250	12	.250
12	.563	1.0	6	.250	7	.250	12	.250	13	.250
13	.563	1.0	7	.250	13	.250	14	.500		
14	.563	1.0	9	.125	10	.250	15	.125		
15	.563	1.0	10	.250	11	.250	15	.250	16	.250
16	.563	1.0	11	.250	12	.250	16	.250	17	.250
17	.563	1.0	12	.250	13	.250	17	.250	18	.250
18	.563	1.0	13	.250	14	.500	18	.250		
19	.563	1.0	15	.125	18	.250	20	.125		
20	.563	1.0	16	.250	17	.250	20	.250	21	.250
21	.563	1.0	17	.250	18	.250	21	.250	22	.250
22	.563	1.0	14	.250	18	.250	19	.250	22	.250
23	.563	1.0	20	.125	21	.250	23	.125		
24	.563	1.0	21	.250	22	.250	23	.250	24	.250
25	.563	1.0	19	.500	22	.250	24	.250		
26	.563	1.0	23	.125	24	.250	25	.125		
27	.563	1.0	19	.500	24	.250	25	.250		
28	.563	1.0	19	.375	25	.125				
2	2	49								
1	.563	1.0	1	.375	2	.250	15	.375		
2	.563	1.0	1	.500	2	.250	3	.250		
3	.563	1.0	1	.500	3	.250	4	.250		
4	.563	1.0	1	.250	4	.250	5	.250	8	.250
5	.563	1.0	5	.250	6	.250	8	.500		
6	.563	1.0	6	.250	7	.250	8	.500		
7	.563	1.0	7	.250	8	.375	22	.375		
8	.563	1.0	2	.250	9	.250	15	.500		
9	.563	1.0	2	.250	3	.250	9	.250	10	.250
10	.563	1.0	3	.250	4	.250	10	.250	11	.250
11	.563	1.0	4	.250	5	.250	11	.250	12	.250
12	.563	1.0	5	.250	6	.250	12	.250	13	.250
13	.563	1.0	6	.250	7	.250	13	.250	14	.250
14	.563	1.0	7	.250	14	.250	22	.500		
15	.563	1.0	9	.250	15	.500	16	.250		
16	.563	1.0	9	.250	18	.250	16	.250	17	.250
17	.563	1.0	10	.250	11	.250	17	.250	18	.250
18	.563	1.0	11	.250	12	.250	18	.250	19	.250
19	.563	1.0	12	.250	13	.250	19	.250	20	.250
20	.563	1.0	13	.250	14	.250	20	.250	21	.250
21	.563	1.0	14	.250	21	.250	22	.500		
22	.563	1.0	15	.250	16	.250	23	.250	24	.250
23	.563	1.0	18	.250	17	.250	24	.250	25	.250
24	.563	1.0	17	.250	18	.250	25	.250	26	.250
25	.563	1.0	18	.250	19	.250	26	.250	27	.250
26	.563	1.0	19	.250	20	.250	27	.250	28	.250
27	.563	1.0	20	.250	21	.250	28	.250	29	.250
28	.563	1.0	21	.250	22	.250	29	.250	30	.250
29	.563	1.0	23	.500	24	.250	31	.250		
30	.563	1.0	24	.250	25	.250	31	.250	32	.250
31	.563	1.0	25	.250	26	.250	32	.250	33	.250
32	.563	1.0	25	.250	27	.250	33	.250	34	.250
33	.563	1.0	27	.250	28	.250	34	.250	35	.250
34	.563	1.0	28	.250	29	.250	35	.250	36	.250
35	.563	1.0	29	.250	30	.500	36	.250		
36	.563	1.0	23	.500	31	.250	38	.250		

37	.563	1.0	31	.250	32	.250	38	.250	39	.250
38	.563	1.0	32	.250	33	.250	39	.250	40	.250
39	.563	1.0	33	.250	34	.250	40	.250	41	.250
40	.563	1.0	34	.250	35	.250	41	.250	42	.250
41	.563	1.0	35	.250	36	.250	42	.250	43	.250
42	.563	1.0	36	.500	38	.250	43	.250		
43	.563	1.0	23	.375	37	.375	38	.250		
44	.563	1.0	37	.500	38	.250	39	.250		
45	.563	1.0	37	.500	39	.250	40	.250		
46	.563	1.0	37	.250	40	.250	41	.250	44	.250
47	.563	1.0	41	.250	42	.250	44	.500		
48	.563	1.0	42	.250	43	.250	44	.500		
49	.563	1.0	36	.375	43	.250	44	.375		
3	1	28								
4	2	49								
5	2	49								
6	1	28								
7	2	49								
8	2	49								
9	0	0								
10	0	0								
11	0	0								
3.0	.059	655.	.477	18.	0.1	489.	.0321000.	.563		
slab	86	29	106							
1					16.78		520.	0.20	0.50	3.02
2					32.00		520.	0.20	0.20	3.02
3					30.02		520.	0.20	0.20	3.02
4					205.40		0.00			
5					3476.73		0.00			
6					195.51		0.00			
7					173.79		0.00			
8					1.00	130.3				
9					164.29	0.00				
10					145.44	0.00				
11					1.00	130.3				
12					169.10	0.00				
13					130.02	0.00				
14					150.61	0.00				
15					215.73	0.00				
16					211.44	0.00				
17					237.30	0.00				
18					220.26	0.00				
19					6572.72	0.00				
20					6017.34	0.00				
21					4102.12	0.00				
22					4592.99	0.00				
23					4171.11	0.00				
24					4400.98	0.00				
25					5028.79	0.00				
26					4925.00	0.00				
27					5019.14	0.00				
28					6041.59	0.00				
29					7001.62	0.00				
30					5880.39	0.00				
31					32.97	73.2				
32					51.01	55.6				
33					50.22	53.4				
34					52.68	58.3				
35					69.03	73.2				
36					130.66	146.4				

37		69.66	73.2						
38		38.13	520.	0.20	0.20	3.02			
39		975.50	13312.	0.20	0.20	.118			
40		51.58	704.	0.20	0.20	1.08			
41		55.25	390.91	0.50	0.20	3.18			
42		95.80	574.40	0.50	0.20	2.18			
43		106.71	638.79	0.50	0.20	1.94			
44		73.77	441.61	0.50	0.20	2.81			
45		51.95	310.13	0.50	0.20	4.00			
46		77.59	463.10	0.50	0.20	2.60			
47		43.18	257.20	0.50	0.20	4.83			
48		97.34	579.60	0.50	0.20	2.14			
49		102.46	0.00						
50		114.96	0.00						
51		81.04	0.00						
52		78.53	0.00						
53		146.95	110.15	0.20	0.60	0.23			
54		106.02	123.84	0.20	0.60	5.55			
55		117.47	87.96	0.20	0.60	7.00			
56		112.70	84.37	0.20	0.60	0.13			
57		0.00	0.00						
58		0.00	0.00						
59		0.00	0.00						
60		0.00	0.00						
61		3734.31	0.00						
62		4241.14	0.00						
63		5073.39	0.00						
64		217.00	0.00						
65		240.53	0.00						
66		294.06	0.00						
67		1693.87	0.00						
68		1921.92	0.00						
69		2290.33	0.00						
70		30.21	520.	0.20	0.20	3.02			
71		301.27	4101.	0.20	0.20	0.30			
72		43.54	593.	0.20	0.20	2.64			
73		44.87	614.	0.20	0.20	2.56			
74		248.74	3400.	0.20	0.20	0.46			
75		48.91	688.	0.20	0.20	2.35			
76		16.79	520.	0.20	0.50	3.02			
77		16.77	520.	0.20	0.50	3.02			
78		16.06	520.	0.20	0.50	3.02			
79		16.04	520.	0.20	0.50	3.02			
80		17.00	520.	0.20	0.50	3.02			
81		16.90	520.	0.20	0.50	3.02			
82		32.19	520.	0.20	0.20	3.02			
83		32.37	520.	0.20	0.20	3.02			
84		32.05	520.	0.20	0.20	3.02			
85		32.11	520.	0.20	0.20	3.02			
86		32.28	520.	0.20	0.20	3.02			
1	2 1.64	2	2	1	3	4			
2	1 .569	1	4	5					
3	2 1.64	2	4	1	9	4			
4	1 .569	1	5	5					
5	1 .569	2	6	2	7	5			
6	1 .569	2	8	5	10	5			
7	1 .569	1	8	2					
8	1 .569	1	13	5					
9	2 1.64	2	10	76	11	4			
10	1 .569	1	12	5					

11	2 1.64	2	12	76	27	4		
12	1 .569	1	19	5				
13	1 .569	2	14	76	16	5		
14	2 1.64	2	15	77	17	4		
15	1 .569	1	18	5				
16	1 .569	2	21	5	17	76		
17	2 1.64	2	32	4	18	77		
18	1 .569	1	23	5				
19	1 .569	2	21	5	20	82		
20	1 .569	2	28	5	22	5		
21	1 .569	1	22	82				
22	1 .569	1	31	5				
23	1 .569	2	25	5	24	84		
24	1 .569	2	33	5	26	5		
25	1 .569	1	26	84				
26	1 .569	1	37	5				
27	2 1.64	2	29	4	28	78		
28	1 .569	1	30	5				
29	2 1.64	2	53	4	30	78		
30	1 .569	1	41	5				
31	1 .569	2	34	5	32	78		
32	2 1.64	2	33	79	35	4		
33	1 .569	1	36	5				
34	1 .569	2	43	5	35	78		
35	2 1.64	2	38	79	50	4		
36	1 .569	1	45	5				
37	1 .569	2	38	85	39	5		
38	1 .569	1	46	5				
39	1 .569	2	47	5	40	85		
40	1 .569	1	49	5				
41	1 .569	2	43	5	42	83		
42	1 .569	2	54	5	44	5		
43	1 .569	1	44	83				
44	1 .569	1	57	5				
45	1 .569	2	47	5	46	88		
46	1 .569	2	59	5	48	5		
47	1 .569	1	48	86				
48	1 .569	1	63	5				
49	1 .569	2	51	5	50	3		
50	3 .807	2	64	28	52	29		
51	1 .569	1	52	3				
52	3 .874	1	92	30				
53	2 1.64	2	55	4	54	80		
54	1 .569	1	58	5				
55	2 1.64	2	75	6	56	80		
56	1 .569	1	67	5				
57	1 .569	2	68	5	58	80		
58	2 1.64	2	59	81	61	4		
59	1 .569	1	62	5				
60	1 .569	2	69	5	61	86		
61	2 1.64	2	82	81	76	9		
62	1 .569	1	71	5				
63	1 .569	3	65	5	64	73	66	74
64	3 .834	1	66	27				
65	1 .569	2	73	5	66	75		
66	3 .782	1	91	26				
67	1 .569	3	69	5	68	72	70	71
68	3 .711	2	78	19	80	31		
69	1 .569	1	78	78				
70	3 .846	1	82	28				

71	1 .569	2 73	5 72	36			
72	3 .779	3 86	24 74	25 73	39		
73	1 .569	1 74	48				
74	3 .588						
75	2 .729	2 79	32 77	7			
76	2 .485	3 86	36 87	18 82	34		
77	2 .634	2 78	33 83	8			
78	3 .477	1 79	22				
79	3 .594	1 88	23				
80	3 .384						
81	3 .367	2 82	21 85	35			
82	3 .576						
83	2 .792	2 84	12 95	41			
84	2 .539	2 85	13 95	42			
85	2 .485	2 88	14 96	43			
86	3 .384						
87	2 .857	1 88	11				
88	2 .701	2 89	15 98	44			
89	2 1.8	2 98	18 97	46			
90	2 .689	3 91	37 93	17 97	48		
91	3 .452						
92	3 .452	1 94	37				
93	2 1.28	2 98	47 94	18			
94	2 .534	1 98	48				
95	3 4.89	2 98	81 99	49			
96	3 3.86	2 97	82 100	50			
97	3 5.89	2 98	83 101	51			
98	3 5.33	1 102	52				
99	4 26.2	2 100	84 103	53			
100	4 23.3	2 101	85 104	54			
101	4 32.8	2 102	86 105	55			
102	4 34.2	1 106	56				
103	3 13.9	1 104	87				
104	3 12.4	1 105	88				
105	3 17.5	1 108	89				
106	3 18.2						
1	8.89	2.94					
2	31.59	2.12					
3	28.77	2.31					
4	38.56	1.71					
5	39.96	1.68					
6	32.54	2.84					
7	55.56	1.19					
8	19.75	3.34					
9	24.98	2.64					
10	24.23	2.71					
11	51.55	1.29					
12	28.31	3.21					
13	19.84	3.46					
14	25.67	2.56					
15	24.85	2.64					
16	48.78	1.86					
17	38.53	1.78					
18	3.33	8.68					
19	8.88	2.91					
20	8.88	2.58					
21	8.61	3.28					
22	8.39	5.82					
23	6.69	2.94					
24	6.68	2.94					

25	6.71	2.94
26	6.69	2.94
27	6.71	2.94
28	6.75	2.94
29	6.74	2.94
2	1 1 1	1 1
4	1 1 8	1
5	1 1 14	1
6	1 2 15	23
7	1 1 19	1
8	1 2 23	23
10	1 2 1	23
12	1 2 8	23
13	1 2 37	23
15	1 3 1	24
16	1 2 44	23
18	1 3 8	24
19	1 2 22	23
20	1 4 15	25
21	1 2 30	25
22	1 4 23	25
23	1 3 14	24
24	1 5 15	26
25	1 3 19	24
26	1 5 23	26
28	1 4 1	25
30	1 4 8	25
31	1 4 37	25
33	1 5 1	26
34	1 4 44	25
36	1 5 8	26
37	1 5 37	26
38	1 8 1	27
39	1 5 44	26
40	1 6 8	27
41	1 4 22	25
42	1 7 15	28
43	1 4 30	25
44	1 7 23	28
45	1 5 22	26
46	1 8 15	29
47	1 5 30	26
48	1 8 23	29
49	1 8 14	27
50	1 11 1	12
51	1 6 19	27
52	1 11 1	13
54	1 7 1	28
56	1 7 8	28
57	1 7 37	28
59	1 8 1	29
60	1 7 44	28
62	1 8 8	29
63	1 8 37	29
64	1 11 1	14
65	1 8 44	29
66	1 11 1	15
67	1 7 22	28
68	1 9 1	7
69	1 7 30	28

70 1 9 1 8
 71 1 8 22 29
 72 1 10 1 9
 73 1 8 30 29
 74 1 10 1 10
 77 1 9 1 18
 78 1 9 1 2
 79 1 9 1 3
 80 1 9 1 4
 81 1 9 1 5
 82 1 9 1 6
 84 1 9 1 20
 86 1 10 1 11
 87 1 10 1 19
 89 1 10 1 21
 91 1 11 1 16
 92 1 11 1 17
 93 1 11 1 22

radg 11 2 3
 1 9

1 .301	.2	1.0000	2.0000	3.0039	4.0050	5.2507	6.1132
		7.0095	8.0508	9.3137			
2 .846	.2	1.0000	2.0007	3.1962	4.2224	5.1247	6.0076
		7.0057	8.0442	9.3122			
3 .5178	.2	1.0000	2.0000	3.0355	4.1685	5.0764	6.1744
		7.0590	8.0320	9.1837			
4 .4249	.2	1.0000	2.0000	3.0000	4.0100	5.0170	6.1019
		7.0002	8.0109	9.0749			
5 .5350	.2	1.0000	2.0000	3.0000	4.0000	5.0200	6.2049
		7.2323	8.0304	9.0167			
6 .5859	.2	1.0000	2.0000	3.0000	4.0000	5.0000	6.0420
		7.1878	8.0029	9.1107			
7 .4334	.2	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000
		7.0287	8.0320	9.1873			
8 .1514	.2	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000
		7.0941	8.0493	9.2149			
9 .6332	.2	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000
		7.1282	8.0514	9.0031			
2 5							
1 .384	.2	1.0000	2.2872	3.0037	4.5031	5.1130	
2 .7850	.2	1.0000	2.0193	3.0004	4.0029	5.2370	
3 .6077	.2	1.0000	2.0000	3.0099	4.1124	5.0470	
4 .8650	.2	1.0000	2.0000	3.0000	4.0773	5.0400	
5 .9702	.2	1.0000	2.0000	3.0000	4.0000	5.0154	
3 7							
1 .3904	.2	1.0000	2.4404	3.1161	4.2547	5.1125	6.0115
		7.0002					
2 .6315	.2	1.0000	2.0329	3.0042	4.1467	5.1500	6.0505
		7.3333					
3 .6100	.2	1.0000	2.0000	3.0167	4.2734	5.1030	6.0093
		7.4271					
4 .7680	.2	1.0000	2.0000	3.0000	4.0104	5.0028	6.0475
		7.4099					
5 .8200	.2	1.0000	2.0000	3.0000	4.0000	5.0326	6.2904
		7.4292					
6 .4200	.2	1.0000	2.0000	3.0000	4.0000	5.0000	6.0025
		7.0205					
7 1.20	.2	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000
		7.0009					

```

1 1 4 2 4 5 7
2 2 8 10 12 19 21 16 13 6 6
3 1 4 15 18 23 25
4 2 8 28 30 41 43 34 31 22 20
5 2 8 33 36 46 47 39 37 26 24
6 1 4 38 40 49 51
7 2 8 54 56 67 69 60 57 44 42
8 2 8 59 62 71 73 65 63 48 46
9 -1 9 60 70 82 81 70 79 80 77 84
10 -2 5 66 72 74 87 89
11 -3 7 91 80 64 50 52 92 93
heat 1 1
      3.880      3.880
1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
drag 2 5
100. -1.0      100. -1.0
64. -1.0      64. -1.0
1 5 0
9 1 25 .01 2.2 .14 2.2 .25 2.2 .36 2.2 .47 2.2 .58 2.2
      .69 2.2 .80 2.2 .99 2.2
9 8 8 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
      .69 1.7 .80 1.7 .99 1.7
9 14 14 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
      .69 1.7 .80 1.7 .99 1.7
9 19 19 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
      .69 1.7 .80 1.7 .99 1.7
9 1 1 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
      .69 1.7 .80 1.7 .99 1.7
2 8 0
9 1 44 .01 2.2 .14 2.2 .25 2.2 .36 2.2 .47 2.2 .58 2.2
      .69 2.2 .80 2.2 .99 2.2
9 1 1 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
      .69 1.7 .80 1.7 .99 1.7
9 8 8 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
      .69 1.7 .80 1.7 .99 1.7
9 15 15 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
      .69 1.7 .80 1.7 .99 1.7
9 22 23 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
      .69 1.7 .80 1.7 .99 1.7
9 30 30 .01 2.2 .14 2.2 .25 2.2 .36 2.2 .47 2.2 .58 2.2
      .69 2.2 .80 2.2 .99 2.2
9 37 37 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
      .69 1.7 .80 1.7 .99 1.7
9 44 44 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
      .69 1.7 .80 1.7 .99 1.7
3 1 0
2 1 1 .01 7.5 .99 7.5
4 1 0
2 1 1 .01 7.5 .99 7.5
5 1 0
2 1 1 .01 4.0 .99 4.0
bdry 17 1 4 2
1 2.054e-04
2 1.173e-07 2.523e+00 .28
3 8.729e-04
4 1.17e-6      0.30 .78
5 6.75e-7
6 7.86e-5
7 2.47e-4      0.30
8 1.77e-7

```

```

9 1.877e-4
10 1.17e-6          0.30 0.3
11 3.60e-6
12 5.222e-5
13 3.723e-8
14 1.000e-4
15 8.72e-7          0.30 0.3
16 1.07e-4
17 1.17e-6          0.00 0.3
1 2 0. 0.0 1. 0.0
103 46.486 1
1 1. 1 1. 1
21.029 1 1. 2
31.103 1 1. 3
41.103 1 1. 4
104 45.777 1
1 1. 1 1. 1
21.029 1 1. 2
31.103 1 1. 3
41.103 1 1. 4
105 48.121 1
1 1. 1 1. 1
21.029 1 1. 2
31.103 1 1. 3
41.103 1 1. 4
106 48.209 1
1 1. 1 1. 1
21.029 1 1. 2
31.103 1 1. 3
41.103 1 1. 4
1 305. 0. 5 0 0.0 0.0
1 1.0 6 0
2 1.0 6 94 1 5 3.03 2 5 3.03 3 5 3.03
4 5 3.03 5 5 3.03 6 5 3.03
7 5 3.03 8 5 3.03 9 5 3.03
10 5 3.03 11 5 3.03 12 5 3.03
13 5 3.03 14 5 3.03 15 5 3.03
16 5 3.03 17 5 3.03 18 5 3.03
19 5 3.03 20 5 3.03 21 5 3.03
22 5 3.03 23 5 3.03 24 5 3.03
25 5 3.03 26 5 3.03 27 5 3.03
28 5 3.03 29 5 3.03 30 5 3.03
31 5 3.03 32 5 3.03 33 5 3.03
34 5 3.03 35 5 3.03 36 5 3.03
37 5 3.03 38 5 3.03 39 5 3.03
40 5 3.03 41 5 3.03 42 5 3.03
43 5 3.03 44 5 3.03 45 5 3.03
46 5 3.03 47 5 3.03 48 5 3.03
49 5 3.03 50 5 3.03 51 5 3.03
52 5 3.03 53 5 3.03 54 5 3.03
56 5 3.03 56 5 3.03 57 5 3.03
58 5 3.03 59 5 3.03 60 5 3.03
61 5 3.03 62 5 3.03 63 5 3.03
64 5 3.03 65 5 3.03 66 5 3.03
67 5 3.03 68 5 3.03 69 5 3.03
70 5 3.03 71 5 3.03 72 5 3.03
73 5 3.03 74 5 3.03 75 5 3.03
76 5 3.03 77 5 3.03 78 5 3.03
79 5 3.03 80 5 3.03 81 5 3.03
82 5 3.03 83 5 3.03 84 5 3.03

```



```

      85  5  3.63  86  5  3.63  87  5  3.63
      88  5  3.63  89  5  3.63  90  5  3.63
      91  5  3.63  92  5  3.63  93  5  3.63
      94  5  3.63
3  230  7  0
4  475  18  12  96  6  3.63  96  6  3.63  97  6  3.63
      98  6  3.63  99  6  3.63  100  6  3.63
      101  6  3.63  102  6  3.63  103  6  3.63
      104  6  3.63  105  6  3.63  106  6  3.63
5  589  17  0
21.963303.9  3  6  6.8  6.8
1  1.0  8  0
285.28  9  12  95  3  3.63  96  3  3.63  97  3  3.63
      98  3  3.63  99  3  3.63  100  3  3.63
      101  3  3.63  102  3  3.63  103  3  3.63
      104  3  3.63  105  3  3.63  106  3  3.63
3187.7  18  0
1  1.0  11  0
2  1.0  12  0
31.368  13  0
41.543  14  0
51.625  15  0
calc  1  0  0

```

```

      30
oper  1  3  1  1
      20.0  200.  .00001 .00184485  300.  .000000  0.0
.8781.7832.7679.7336.7000.6910.6713.5981
18
0. 0.0443 0.0444 .476.9780 .476.1470.9951.21541.163
.28391.173.35231.157.42071.145.48911.116.55761.117.82601.996
.69441.042.7629 .911.8313 .811.8055 .811.8056 0. 1.0 0.
outp 11011
endd

```

data from iterative solution using the recirculation module
time = 0.0000 dt = ***** implicit dt = 0.0000 explicit dt = 0.7463 mode = 0

iteration no.	sweep no.	peak clad				total flow (lb/s)	pressure drop(psi)	error			
		temp(f)	fluid	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	231.7	17	19	1	0.136e-10	0.0014122	-0.4747	1.1523	0.0848	0.0000
	2	231.7	16	19	1			-0.3491	1.1523	0.0157	0.0000
2	1	231.4	16	19	1	0.669e-11	0.0014416	-0.2082	3.3985	0.0457	0.0000
	2	230.9	16	19	1			-0.2379	3.3985	0.0085	0.0009
3	1	230.8	16	19	1	0.387e-11	0.0014425	-0.2294	0.2578	0.0096	0.0002
	2	230.4	16	19	1			-0.2279	0.2578	0.0063	0.0002
4	1	230.3	16	19	1	0.298e-11	0.0014697	-0.0006	1.4780	0.0138	0.0002
	2	218.4	16	19	1			-0.0332	1.4780	0.0091	0.0003
5	1	218.1	16	19	1	0.156e-11	0.0014828	-0.0417	0.3020	0.0069	0.0000
	2	217.6	16	19	1			-0.0451	0.3020	0.0039	0.0001
6	1	217.5	16	19	1	0.476e-12	0.0014640	-0.0492	0.1676	0.0032	0.0000

	2	217.8	16	19	1			-0.0518	0.1676	0.0030	0.0000
7	1	216.9	16	19	1	-0.462e-13	0.0014716	-0.0002	0.4479	0.0040	0.0001
	2	214.7	16	19	1			-0.0147	0.4479	0.0064	0.0001
8	1	214.6	16	19	1	-0.292e-12	0.0014711	-0.0106	0.1360	0.0021	0.0000
	2	214.0	16	19	1			-0.0215	0.1360	0.0019	0.0000
9	1	213.9	16	19	1	-0.336e-12	0.0014720	-0.0241	0.0760	0.0016	0.0000
	2	213.5	16	19	1			-0.0262	0.0760	0.0016	0.0000
10	1	213.4	16	19	1	-0.247e-12	0.0014774	0.0005	0.1521	0.0032	0.0000
	2	210.7	16	19	1			0.0005	0.1521	0.0056	0.0001
11	1	210.6	16	19	1	-0.193e-12	0.0014771	-0.0020	0.0580	0.0020	0.0000
	2	210.2	16	19	1			-0.0043	0.0580	0.0010	0.0000
12	1	210.2	16	19	1	-0.148e-12	0.0014770	-0.0001	0.0535	0.0015	0.0000
	2	209.8	16	19	1			-0.0070	0.0535	0.0015	0.0000
13	1	209.7	16	19	1	-0.086e-13	0.0014800	0.0005	0.0670	0.0026	0.0000
	2	200.4	16	19	1			0.0033	0.0670	0.0049	0.0000
14	1	208.3	16	19	1	-0.062e-13	0.0014804	0.0020	0.0441	0.0016	0.0000
	2	200.0	16	19	1			0.0005	0.0441	0.0014	0.0000
15	1	200.0	16	19	1	-0.571e-13	0.0014810	-0.0000	0.0409	0.0012	0.0000
	2	207.7	16	19	1			-0.0016	0.0409	0.0012	0.0000
16	1	207.7	16	19	1	-0.332e-13	0.0014820	0.0008	0.0402	0.0023	0.0000
	2	205.7	16	19	1			0.0049	0.0402	0.0042	0.0000
17	1	200.6	16	19	1	-0.206e-13	0.0014826	0.0042	0.0343	0.0014	0.0000
	2	200.4	16	19	1			0.0033	0.0343	0.0012	0.0000
18	1	200.4	16	19	1	-0.289e-13	0.0014830	0.0026	0.0324	0.0010	0.0000
	2	200.2	16	19	1			0.0019	0.0324	0.0010	0.0000
19	1	200.2	16	19	1	-0.200e-13	0.0014841	0.0000	0.0276	0.0019	0.0000
	2	205.5	16	19	1			0.0050	0.0276	0.0036	0.0000
20	1	205.5	16	19	1	-0.158e-13	0.0014840	0.0048	0.0260	0.0011	0.0000
	2	205.3	16	19	1			0.0042	0.0260	0.0010	0.0000
21	1	205.3	16	19	1	-0.213e-13	0.0014843	0.0038	0.0264	0.0009	0.0000
	2	205.2	16	19	1			0.0034	0.0264	0.0008	0.0000
22	1	205.1	16	19	1	-0.147e-13	0.0014850	0.0054	0.0195	0.0016	0.0000
	2	204.7	16	19	1			0.0049	0.0195	0.0030	0.0000
23	1	204.7	16	19	1	-0.104e-13	0.0014849	0.0040	0.0214	0.0010	0.0000
	2	204.6	16	19	1			0.0045	0.0214	0.0009	0.0000
24	1	204.6	16	19	1	-0.135e-13	0.0014851	0.0043	0.0216	0.0007	0.0000
	2	-204.5	16	19	1			0.0040	0.0216	0.0007	0.0000
25	1	204.5	16	19	1	-0.903e-14	0.0014850	0.0046	0.0161	0.0014	0.0000
	2	204.2	16	19	1			0.0045	0.0161	0.0020	0.0000
26	1	204.1	16	19	1	-0.521e-14	0.0014854	0.0046	0.0171	0.0000	0.0000

	2	284.1	16	19	1			0.0044	0.0171	0.0007	0.0000
27	1	284.1	16	19	1	-0.960e-14	0.0014857	0.0043	0.0176	0.0006	0.0000
	2	284.0	16	19	1			0.0041	0.0176	0.0006	0.0000
28	1	284.0	16	19	1	-0.750e-14	0.0014859	0.0040	0.0149	0.0012	0.0000
	2	283.8	16	19	1			0.0040	0.0149	0.0022	0.0000
29	1	283.8	16	19	1	-0.380e-14	0.0014858	0.0042	0.0138	0.0007	0.0000
	2	283.7	16	19	1			0.0040	0.0138	0.0006	0.0000
30	1	283.7	16	19	1	-0.733e-14	0.0014860	0.0040	0.0144	0.0005	0.0000
	2	283.7	16	19	1			0.0040	0.0144	0.0005	0.0000

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 - 7.4	106.18	106.68	106.58	104.77	101.63	101.54	100.47	100.45	104.44	103.55
7.4 - 14.8	108.71	108.74	108.13	108.17	107.20	107.00	106.49	106.30	106.95	106.87
14.8 - 22.2	112.74	113.21	112.17	112.90	114.00	113.92	113.98	113.83	110.95	111.52
22.2 - 29.6	117.77	118.74	117.23	118.74	122.39	122.18	123.01	122.49	115.95	117.20
29.6 - 37.0	123.17	124.61	122.65	124.78	130.53	130.28	131.85	131.18	121.29	123.24
37.0 - 44.4	128.54	130.15	128.02	130.64	138.05	137.70	139.98	139.18	126.57	129.00
44.4 - 51.9	133.55	135.34	133.02	135.98	144.57	144.27	146.94	146.00	131.49	134.24
51.9 - 59.3	138.07	139.98	137.52	140.09	150.12	149.81	152.84	151.93	135.98	138.07
59.3 - 66.7	142.00	143.97	141.43	144.76	154.80	154.47	157.77	156.83	139.73	142.06
66.7 - 74.1	145.34	147.36	144.74	148.20	158.70	158.38	161.87	160.90	142.97	146.22
74.1 - 81.5	148.05	150.12	147.43	150.99	161.00	161.52	165.19	164.21	145.61	148.96
81.5 - 88.9	150.14	152.25	149.51	153.15	164.32	163.97	167.78	166.78	147.64	151.06
88.9 - 96.3	151.60	153.76	150.96	154.68	168.16	168.01	169.75	168.74	149.05	152.57
96.3 - 103.7	152.41	154.62	151.78	155.59	167.40	167.06	171.12	170.09	149.84	153.45
103.7 - 111.1	152.50	154.78	151.86	155.77	167.92	167.58	171.76	170.72	149.93	153.63
111.1 - 118.5	151.81	154.11	151.19	155.10	167.81	167.25	171.58	170.52	149.27	153.05
118.5 - 125.9	150.24	152.57	149.65	153.66	168.30	168.01	170.43	169.30	147.77	151.60
125.9 - 133.3	147.73	150.04	147.10	151.19	163.93	163.59	168.07	167.02	145.35	149.18
133.3 - 140.8	144.12	148.37	148.60	147.56	160.15	159.82	164.30	163.29	141.90	146.66
140.8 - 148.2	139.41	141.51	138.98	142.09	154.77	154.47	158.86	157.92	137.45	141.00
148.2 - 155.6	133.36	135.36	133.11	136.00	148.14	147.89	152.17	151.35	131.91	135.27
155.6 - 163.0	125.81	127.26	125.98	128.83	138.38	138.21	142.14	141.60	125.48	128.04
163.0 - 170.4	115.82	117.21	117.51	119.71	129.21	129.22	133.18	132.94	118.55	120.79
170.4 - 177.8	99.72	102.53	100.36	110.25	121.88	122.19	126.80	126.84	112.86	115.04

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

axial zone (inches)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
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0.0 - 7.4	102.81	102.29	100.33	100.02	100.28	99.83	99.79	99.48	99.66	99.49
7.4 - 14.8	105.26	105.48	104.15	103.77	103.02	103.33	102.89	103.11	104.59	104.38
14.8 - 22.2	109.13	109.99	109.72	108.81	109.13	108.77	107.87	108.56	110.78	110.54
22.2 - 29.6	113.99	116.58	116.63	115.89	115.77	115.52	114.87	115.38	118.34	118.06
29.6 - 37.0	119.17	121.35	123.77	121.75	122.71	122.58	120.85	122.58	125.74	125.43
37.0 - 44.4	124.29	128.93	130.00	128.23	129.41	129.19	127.03	129.34	132.59	132.23
44.4 - 51.9	129.05	132.00	136.75	134.14	135.48	135.19	132.84	135.51	138.52	138.12
51.9 - 59.3	133.31	136.48	142.10	139.35	140.00	140.42	137.95	140.89	143.57	143.14
59.3 - 66.7	137.00	140.33	146.06	143.00	145.35	144.87	142.33	145.47	147.83	147.37
66.7 - 74.1	140.13	143.58	150.47	147.53	149.15	148.59	145.98	149.38	151.39	150.98
74.1 - 81.5	142.66	148.21	153.57	150.58	152.24	151.61	148.95	152.41	154.27	153.76
81.5 - 88.9	144.81	148.24	155.98	152.92	154.65	153.96	151.26	154.83	156.49	155.96
88.9 - 96.3	145.98	149.68	157.77	154.68	158.43	155.78	152.95	158.63	158.14	157.59
96.3 - 103.7	146.71	150.52	158.93	155.75	157.68	158.82	154.82	157.01	159.22	158.68
103.7 - 111.1	146.79	150.68	159.39	156.16	158.03	157.25	154.48	158.38	159.61	159.05
111.1 - 118.5	148.14	150.00	159.87	155.00	157.71	156.92	154.84	158.02	159.24	158.67
118.5 - 125.9	144.68	148.67	157.88	154.57	156.53	155.73	152.83	158.88	157.98	157.42
125.9 - 133.3	142.35	146.32	155.67	152.39	154.34	153.54	150.68	154.74	155.64	155.08
133.3 - 140.8	139.84	142.91	152.34	149.17	151.89	150.27	147.58	151.51	152.09	151.54
140.8 - 148.2	134.84	138.45	147.89	144.98	146.76	145.89	143.37	147.18	147.14	146.63
148.2 - 155.6	129.78	133.08	142.57	139.98	141.62	140.78	138.42	141.96	141.27	140.79
155.6 - 163.0	123.94	126.42	136.18	134.47	135.88	134.42	133.08	135.88	132.86	132.45
163.0 - 170.4	118.28	120.28	130.61	129.75	130.54	129.18	128.35	130.37	125.87	125.56
170.4 - 177.8	114.31	115.85	127.24	127.85	127.58	128.87	125.71	127.21	121.35	121.15

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

axial zone (inches)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)
0.0 - 7.4	98.92	98.78	97.88	97.52	96.96	96.85	100.58	99.97	97.81	97.74
7.4 - 14.8	103.95	103.78	102.75	102.58	102.56	102.42	102.98	102.98	100.00	100.59
14.8 - 22.2	110.41	110.20	109.77	109.58	110.38	110.14	106.61	107.26	103.58	104.67
22.2 - 29.6	118.32	118.08	118.67	118.44	120.28	120.84	111.28	112.59	107.88	109.76
29.6 - 37.0	126.11	125.89	127.74	127.48	130.28	130.12	116.21	118.87	112.53	114.98
37.0 - 44.4	133.31	132.99	136.29	136.00	139.73	139.58	121.89	123.34	117.11	119.94
44.4 - 51.9	139.55	139.18	143.79	143.48	147.97	147.82	125.81	128.12	121.34	124.43
51.9 - 59.3	144.86	144.45	150.19	149.85	154.94	154.79	129.65	132.32	125.12	128.37
59.3 - 66.7	149.32	148.88	155.58	155.28	160.75	160.58	133.15	135.94	128.39	131.76
66.7 - 74.1	153.83	152.57	160.81	159.63	165.54	165.36	136.11	138.98	131.15	134.68
74.1 - 81.5	158.84	155.55	163.62	163.22	169.42	169.22	138.58	141.44	133.38	136.98
81.5 - 88.9	158.36	157.88	166.44	166.83	172.45	172.24	140.34	143.33	135.88	138.85
88.9 - 96.3	168.11	159.59	168.62	168.28	174.83	174.61	141.61	144.68	138.24	139.87
96.3 - 103.7	181.29	168.75	178.19	169.76	176.88	176.37	142.38	145.42	136.88	140.56
103.7 - 111.1	161.77	161.23	171.86	170.62	177.67	177.43	142.35	145.54	136.88	140.63
111.1 - 118.5	161.48	160.93	171.14	170.78	177.94	177.71	141.71	144.95	136.26	140.83
118.5 - 125.9	168.29	159.74	178.31	169.87	177.28	177.85	148.38	143.57	134.92	138.78
125.9 - 133.3	158.81	157.48	166.31	167.88	175.37	175.16	138.88	141.33	132.83	136.54
133.3 - 140.8	154.48	153.94	164.98	164.54	171.99	171.79	134.97	138.12	129.93	133.49
140.8 - 148.2	149.58	149.84	160.88	159.88	166.76	166.58	131.85	133.97	126.33	129.59
148.2 - 155.6	143.72	143.22	153.87	153.49	168.17	159.97	126.37	129.88	122.18	125.85
155.6 - 163.0	135.38	134.92	144.81	144.46	149.87	149.68	121.28	123.14	117.62	119.61
163.0 - 170.4	128.88	128.18	137.18	136.76	148.92	148.67	116.57	117.99	113.85	115.88
170.4 - 177.8	124.35	123.98	132.82	131.78	134.84	134.58	113.64	114.79	111.35	112.44

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

axial zone (inches)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)	(40)
0.0 - 7.4	97.85	98.89	97.67	95.84	95.83	95.89	95.48	95.36	94.39	94.22
7.4 - 14.8	101.36	101.86	101.14	99.17	98.42	98.96	100.99	100.85	99.83	99.41
14.8 - 22.2	106.58	105.86	106.38	104.11	102.93	103.93	108.83	108.88	107.16	106.83
22.2 - 29.6	113.83	111.83	112.97	118.27	108.54	110.19	118.99	118.85	116.78	116.44
29.6 - 37.0	119.89	118.16	119.82	116.58	114.45	118.65	129.32	129.19	126.52	126.18
37.0 - 44.4	126.85	124.26	126.39	122.56	120.15	122.88	138.94	138.82	135.58	135.81
44.4 - 51.9	131.73	129.82	132.29	127.88	125.31	128.29	147.23	147.11	143.16	142.68
51.9 - 59.3	136.87	134.89	137.42	132.48	129.83	133.85	154.16	154.82	149.51	148.89
59.3 - 66.7	140.86	138.85	141.77	136.39	133.88	137.88	159.88	159.78	154.78	154.83
66.7 - 74.1	144.38	142.32	145.48	139.84	136.88	140.42	164.51	164.34	160.93	158.21
74.1 - 81.5	147.19	145.14	148.34	142.28	139.47	143.13	168.24	168.85	162.29	161.53
81.5 - 88.9	149.38	147.32	150.83	144.28	141.47	145.21	171.14	170.92	164.88	164.88
88.9 - 96.3	151.88	148.91	152.31	145.78	142.92	146.74	173.48	173.18	168.89	168.87
96.3 - 103.7	152.82	149.91	153.41	146.88	143.88	147.71	175.11	174.87	168.39	167.54
103.7 - 111.1	152.39	150.25	153.85	146.97	144.87	148.85	176.16	175.92	169.27	168.41
111.1 - 118.5	152.83	149.86	153.55	146.57	143.65	147.78	176.47	176.22	169.45	168.58
118.5 - 125.9	158.84	148.87	152.43	145.39	142.48	146.57	175.88	175.64	168.79	167.93
125.9 - 133.3	148.78	146.57	158.34	143.38	148.48	144.53	174.88	173.83	168.98	168.12
133.3 - 140.8	145.53	143.58	147.21	148.24	137.53	141.51	178.76	178.53	163.73	162.93
140.8 - 148.2	141.31	139.58	143.81	138.28	133.76	137.48	165.55	165.33	158.78	157.98
148.2 - 155.6	136.34	134.74	138.88	131.48	129.38	132.72	158.83	158.61	152.29	151.68
155.6 - 163.0	138.31	129.52	131.98	125.73	124.41	126.91	148.87	147.82	142.88	141.48
163.0 - 170.4	125.37	125.89	126.81	121.14	128.33	122.18	138.68	138.39	133.22	132.69
170.4 - 177.8	122.51	122.88	123.88	118.55	118.87	119.44	132.24	131.95	127.37	126.98

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

axial zone (inches)	(51)	(52)	(53)	(54)	(55)	(56)	(57)	(58)	(59)	(60)
0.0 - 7.4	87.88	88.94	94.34	94.85	98.29	98.78	92.18	92.18	91.92	88.64
7.4 - 14.8	91.86	98.48	98.38	98.87	92.14	93.17	95.12	94.84	94.87	91.37
14.8 - 22.2	96.94	95.48	99.88	108.42	95.88	96.58	99.58	98.73	99.37	95.35
22.2 - 29.6	103.83	101.58	103.84	105.11	98.73	108.88	105.15	103.82	105.81	108.28
29.6 - 37.0	118.14	107.84	107.93	109.83	102.88	105.84	118.77	109.14	118.75	105.28
37.0 - 44.4	116.83	113.13	112.13	114.34	108.39	109.88	116.85	114.24	116.17	109.83
44.4 - 51.9	128.98	117.74	116.81	118.38	109.98	112.71	128.72	118.86	128.97	113.92
51.9 - 59.3	124.99	121.53	119.48	121.93	113.84	115.91	124.75	122.89	125.11	117.48
59.3 - 66.7	128.25	124.59	122.48	124.98	115.75	118.65	128.17	126.32	128.81	128.46
66.7 - 74.1	138.88	127.85	125.88	127.53	118.83	128.95	131.81	129.18	131.51	122.95
74.1 - 81.5	132.89	128.95	127.84	129.58	119.87	122.79	133.29	131.48	133.84	124.94
81.5 - 88.9	134.39	138.36	128.58	131.13	121.25	124.17	135.83	133.24	135.82	126.44
88.9 - 96.3	135.51	131.48	129.83	132.28	122.18	125.18	136.27	134.49	136.98	127.58

96.3 -183.7	136.20	132.00	130.17	132.78	122.64	125.58	137.02	135.23	137.60	120.10
103.7 -111.1	130.50	132.35	130.16	132.79	122.00	125.54	137.19	135.41	137.89	120.18
111.1 -118.5	136.41	132.15	129.55	132.20	122.02	124.95	136.74	134.96	137.48	127.69
118.5 -125.9	135.67	131.42	126.29	130.93	120.80	123.76	135.58	133.83	136.36	126.58
125.9 -133.3	134.16	129.00	126.30	128.93	119.12	121.92	133.62	131.93	134.43	124.76
133.3 -140.8	131.75	127.71	123.72	120.10	118.77	119.41	130.79	129.23	131.63	122.21
140.8 -148.2	128.21	124.43	120.49	122.65	113.92	118.29	127.12	125.79	127.96	118.94
148.2 -155.6	123.86	120.38	116.75	118.67	110.69	112.82	122.89	121.77	123.70	115.27
155.6 -163.0	117.00	114.25	112.87	113.89	107.40	100.69	117.71	117.40	118.48	110.78
163.0 -170.4	111.72	109.40	106.55	110.16	104.06	105.62	113.70	113.85	114.43	107.54
170.4 -177.8	100.49	106.49	107.72	100.12	103.18	104.01	111.06	111.93	112.21	105.89

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

axial zone (inches)	(01)	(02)	(03)	(04)	(05)	(06)	(07)	(08)	(09)	(100)
0.0 - 7.4	70.06	66.60	67.94	67.95	69.26	68.28	66.15	64.76	66.63	65.91
7.4 - 14.8	71.17	69.50	68.77	68.60	70.91	69.73	67.14	65.30	66.24	67.20
14.8 - 22.2	72.93	71.07	70.23	70.28	72.75	71.49	68.62	66.60	69.97	68.69
22.2 - 29.6	75.13	73.00	72.11	72.19	74.89	73.58	70.46	68.23	71.94	70.79
29.6 - 37.0	77.49	75.28	74.17	74.20	77.19	75.84	72.49	70.07	74.06	72.85
37.0 - 44.4	79.83	77.48	76.25	76.40	79.49	78.10	74.53	71.94	76.19	74.93
44.4 - 51.9	82.01	79.51	78.22	78.39	81.67	80.24	76.49	73.74	78.22	76.91
51.9 - 59.3	83.97	81.35	79.99	80.10	83.06	82.19	78.26	75.30	80.08	78.72
59.3 - 66.7	85.00	82.94	81.55	81.74	85.40	83.89	79.82	76.82	81.71	80.31
66.7 - 74.1	87.00	84.20	82.65	83.04	86.06	85.32	81.13	78.03	83.09	81.65
74.1 - 81.5	88.21	85.32	83.89	84.00	88.04	86.47	82.18	79.00	84.19	82.73
81.5 - 88.9	89.06	86.10	84.66	84.85	89.91	87.33	82.96	79.72	85.02	83.53
88.9 - 96.3	89.60	86.62	85.16	85.36	89.49	87.90	83.40	80.20	85.56	84.07
96.3 -103.7	89.87	86.86	85.39	85.59	89.76	88.17	83.72	80.42	85.82	84.31
103.7 -111.1	89.83	86.83	85.35	85.50	89.72	88.13	83.68	80.30	85.77	84.20
111.1 -118.5	89.49	86.52	85.03	85.25	89.35	87.78	83.36	80.09	85.43	83.95
118.5 -125.9	88.83	85.93	84.44	84.60	88.66	87.11	82.76	79.54	84.78	83.33
125.9 -133.3	87.87	85.06	83.50	83.81	87.65	86.14	81.89	78.76	83.66	82.43
133.3 -140.8	86.63	83.96	82.50	82.73	86.36	84.91	80.66	77.78	82.68	81.30
140.8 -148.2	85.18	82.65	81.25	81.47	84.89	83.49	79.55	78.67	81.35	80.02
148.2 -155.6	83.62	81.25	79.93	80.13	83.31	81.96	78.23	75.51	79.92	78.66
155.6 -163.0	82.07	79.84	78.60	78.83	81.80	80.58	77.02	74.44	78.62	77.42
163.0 -170.4	80.86	78.69	77.67	77.77	80.61	79.39	76.07	73.57	77.51	76.38
170.4 -177.8	80.24	78.04	77.11	77.16	79.63	78.54	75.57	72.97	76.77	75.76

side boundary temperature summary time = 0.0000 seconds
boundary slab node no. 100

axial zone (inches)	(1)	(2)	(3)	(4)	(5)
0.0 - 7.4	59.39	58.12	52.26	52.01	6.00

7.4 - 14.8	59.23	57.97	52.12	51.87	5.86
14.8 - 22.2	60.15	58.85	52.91	52.65	5.88
22.2 - 29.6	61.58	60.18	54.07	53.80	6.00
29.6 - 37.0	63.03	61.65	55.39	55.11	6.00
37.0 - 44.4	64.82	63.19	56.78	56.47	6.00
44.4 - 51.9	66.15	64.67	58.07	57.77	6.00
51.9 - 59.3	67.58	66.03	59.28	58.97	6.00
59.3 - 66.7	68.79	67.23	60.34	60.03	6.00
66.7 - 74.1	69.84	68.24	61.24	60.92	6.00
74.1 - 81.5	70.67	69.05	61.96	61.63	6.00
81.5 - 88.9	71.38	69.68	62.49	62.17	6.00
88.9 - 96.3	71.71	70.05	62.84	62.52	6.00
96.3 - 103.7	71.90	70.24	63.01	62.60	6.00
103.7 - 111.1	71.87	70.21	62.98	62.55	6.00
111.1 - 118.5	71.82	69.96	62.77	62.44	6.00
118.5 - 125.9	71.15	69.51	62.36	62.04	6.00
125.9 - 133.3	70.49	68.87	61.80	61.48	6.00
133.3 - 140.8	69.66	68.07	61.09	60.77	6.00
140.8 - 148.2	68.74	67.18	60.29	59.90	6.00
148.2 - 155.6	67.80	66.26	59.48	59.10	6.00
155.6 - 163.0	66.91	65.41	58.73	58.43	6.00
163.0 - 170.4	66.25	64.77	58.17	57.87	6.00
170.4 - 177.8	65.82	64.35	57.80	57.51	6.00

calculated rod temperatures at time = 0.0000 seconds

rod no. 25

assembly 1 (fuel type 1 - cylinder)

rod o.d. - 0.563 (in.) zone-(fuel dia.(in.)) - 1-(0.477)

						* fuel temperatures(f.)		
						*		
axial zone	heat flux	type	surf	fluid	clad			
(in.)	(mbtu/hr-ft ²)		(b/h-f-ft ²) *					
0.0 - 7.4	0.0000	1	4.4	98.5	98.6			
7.4 - 14.8	0.0000	1	4.5	100.9	110.5			
14.8 - 22.2	0.0000	1	4.6	119.7	121.9			
22.2 - 29.6	0.0000	1	4.6	132.9	138.0			
29.6 - 37.0	0.0000	1	4.7	144.4	147.8			
37.0 - 44.4	0.0000	1	4.7	154.4	158.0			
44.4 - 51.9	0.0000	1	4.8	162.5	165.9			
51.9 - 59.3	0.0000	1	4.8	169.8	172.4			
59.3 - 66.7	0.0000	1	4.8	174.2	177.6			
66.7 - 74.1	0.0000	1	4.8	178.6	181.9			
74.1 - 81.5	0.0000	1	4.9	182.1	185.4			
81.5 - 88.9	0.0000	1	4.9	184.8	188.0			
88.9 - 96.3	0.0000	1	4.9	186.9	190.1			
96.3 - 103.7	0.0000	1	4.9	188.6	191.7			
103.7 - 111.1	0.0000	1	4.9	189.4	192.5			
111.1 - 118.5	0.0000	1	4.9	189.4	192.4			
118.5 - 125.9	0.0000	1	4.9	188.3	191.2			
125.9 - 133.3	0.0000	1	4.9	185.7	188.4			
133.3 - 140.8	0.0000	1	4.9	181.4	183.8			
140.8 - 148.2	0.0000	1	4.8	174.6	178.4			
148.2 - 155.6	0.0000	1	4.8	167.1	168.7			
155.6 - 163.0	0.0000	1	4.7	151.4	151.2			
163.0 - 170.4	0.0000	1	4.6	139.6	139.4			
170.4 - 177.8	0.0000	1	4.5	130.5	130.3			

calculated rod temperatures at time = 0.0000 seconds

rod no. 25

assembly 3 (fuel type 1 - cylinder)

rod o.d. - 0.563 (in.) zone-(fuel dia.(in.)) - 1-(0.477)

```

* fuel temperatures(f.)
*
axial zone heat flux type hsurf * fluid clad
(in.) (mbtu/hr-ft2) (b/h-f-ft2) *
0.0 - 7.4 0.0000 1 4.4 90.5 90.5
7.4 - 14.8 0.0000 1 4.5 105.0 100.3
14.8 - 22.2 0.0000 1 4.5 114.8 116.7
22.2 - 29.6 0.0000 1 4.6 127.5 130.3
29.6 - 37.0 0.0000 1 4.7 139.4 142.4
37.0 - 44.4 0.0000 1 4.7 150.2 153.3
44.4 - 51.9 0.0000 1 4.8 159.2 162.3
51.9 - 59.3 0.0000 1 4.8 166.7 169.7
59.3 - 66.7 0.0000 1 4.8 172.9 175.0
66.7 - 74.1 0.0000 1 4.8 176.0 180.9
74.1 - 81.5 0.0000 1 4.9 182.2 185.0
81.5 - 88.9 0.0000 1 4.9 185.4 188.1
88.9 - 96.3 0.0000 1 4.9 188.0 190.6
96.3 - 103.7 0.0000 1 4.9 190.0 192.6
103.7 - 111.1 0.0000 1 4.9 191.2 193.6
111.1 - 118.5 0.0000 1 4.9 191.7 194.2
118.5 - 125.9 0.0000 1 4.9 191.1 193.5
125.9 - 133.3 0.0000 1 4.9 189.6 191.3
133.3 - 140.8 0.0000 1 4.9 185.3 187.3
140.8 - 148.2 0.0000 1 4.8 179.1 180.7
148.2 - 155.6 0.0000 1 4.8 172.2 173.5
155.6 - 163.0 0.0000 1 4.7 157.7 167.4
163.0 - 170.4 0.0000 1 4.7 146.9 146.6
170.4 - 177.8 0.0000 1 4.6 139.1 130.9
```

calculated rod temperatures at time = 0.0000 seconds

rod no. 25

assembly 6 (fuel type 1 - cylinder)

rod o.d. - 0.563 (in.) zone-(fuel dia.(in.)) - 1-(0.477)

```

* fuel temperatures(f.)
*
axial zone heat flux type hsurf * fluid clad
(in.) (mbtu/hr-ft2) (b/h-f-ft2) *
0.0 - 7.4 0.0000 1 4.4 91.3 91.4
7.4 - 14.8 0.0000 1 4.5 98.1 99.3
14.8 - 22.2 0.0000 1 4.5 106.3 100.1
22.2 - 29.6 0.0000 1 4.5 117.3 119.9
29.6 - 37.0 0.0000 1 4.6 126.9 129.0
37.0 - 44.4 0.0000 1 4.6 135.3 130.3
44.4 - 51.9 0.0000 1 4.7 141.0 144.9
51.9 - 59.3 0.0000 1 4.7 146.9 150.1
59.3 - 66.7 0.0000 1 4.7 151.0 154.1
66.7 - 74.1 0.0000 1 4.7 154.3 157.4
74.1 - 81.5 0.0000 1 4.7 156.0 160.6
81.5 - 88.9 0.0000 1 4.8 158.7 161.0
```


88.9 - 96.3	0.0000	1	4.8	188.1	183.2
96.3 - 103.7	0.0000	1	4.8	181.2	184.3
103.7 - 111.1	0.0000	1	4.8	181.8	184.9
111.1 - 118.5	0.0000	1	4.8	181.7	184.7
118.5 - 125.9	0.0000	1	4.8	188.9	183.8
125.9 - 133.3	0.0000	1	4.8	158.9	161.7
133.3 - 140.8	0.0000	1	4.7	155.5	158.1
140.8 - 148.2	0.0000	1	4.7	158.8	152.1
148.2 - 155.6	0.0000	1	4.7	144.2	148.1
155.6 - 163.0	0.0000	1	4.8	138.7	131.1
163.0 - 170.4	0.0000	1	4.6	122.1	122.4
170.4 - 177.8	0.0000	1	4.5	118.8	118.9

calculated rod temperatures at time = 0.0000 seconds
rod no. 25
assembly 7 (fuel type 1 - cylinder)
rod o.d. = 0.563 (in.) zone-(fuel dia.(in.)) = 1-(0.477)

						* fuel temperatures(f.)		
						*		
axial zone	heat flux	type	hsurf	fluid	clad			
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2)					
0.0 - 7.4	0.0000	1	5.8	93.2	93.2			
7.4 - 14.8	0.0000	1	5.7	105.4	105.2			
14.8 - 22.2	0.0000	1	5.8	118.1	117.1			
22.2 - 29.6	0.0000	1	5.9	129.8	131.2			
29.6 - 37.0	0.0000	1	5.9	139.5	140.9			
37.0 - 44.4	0.0000	1	6.0	147.8	148.5			
44.4 - 51.9	0.0000	1	6.0	152.1	163.8			
51.9 - 59.3	0.0000	1	6.0	158.8	157.4			
59.3 - 66.7	0.0000	1	6.1	159.8	168.4			
66.7 - 74.1	0.0000	1	6.1	161.4	162.9			
74.1 - 81.5	0.0000	1	6.1	163.3	164.7			
81.5 - 88.9	0.0000	1	6.1	164.5	165.9			
88.9 - 96.3	0.0000	1	6.1	165.8	167.8			
96.3 - 103.7	0.0000	1	6.1	168.3	167.7			
103.7 - 111.1	0.0000	1	6.1	168.4	167.7			
111.1 - 118.5	0.0000	1	6.1	165.8	168.9			
118.5 - 125.9	0.0000	1	6.1	163.9	165.2			
125.9 - 133.3	0.0000	1	6.1	168.8	161.8			
133.3 - 140.8	0.0000	1	6.0	155.8	160.9			
140.8 - 148.2	0.0000	1	6.0	148.1	148.9			
148.2 - 155.6	0.0000	1	5.9	141.4	142.2			
155.6 - 163.0	0.0000	1	6.0	122.2	122.1			
163.0 - 170.4	0.0000	1	5.8	114.1	114.8			
170.4 - 177.8	0.0000	1	5.7	118.2	118.2			

-6000

```
1      reload2ann full load, nitrogen, vertical validation run.
prop  5      8
      1.      1.      114.8      .0128      .249      8.4137      .0373
      2.      81.      134.8      .0154      .249      10.09      .0432
      3.      261.      179.8      .0193      .250      13.496      .0532
      4.      441.      225.0      .0230      .252      16.89      .0622
      20.      1500.      1588.0      .1300      1.24      241.30      .1138
1 can      14.8
2 cu      215.
3 ss      9.8
4 pb      22.7
5 lpr1      0.00
6 lpr2      16.4
chan  11  24  0
      177.8
1  1  25  0  0
1  1  0  0  1
11.7365.8942.874  2 .175 .772  3 .175 .772  4 .175 .772  8.5245 2.82
2.1478.8843.8843  3 .175 .738
3.29571.7691.769  4 .175 .738  9 .175 .738
4.29571.7691.769  5 .175 .738  10 .175 .738
5.29571.7691.769  8 .175 .738  8 .175 .772  11 .175 .738
6.29571.7691.769  7 .175 .738  8 .175 .772  12 .175 .738
7.29571.7691.769  14 .175 .772  8 .175 .772  13 .175 .738
81.7365.8942.874  14.8584 2.82
9.1478.8843.8843  10 .175 .738
10.29571.7691.769  11 .175 .738  15 .175 .738
11.29571.7691.769  12 .175 .738  16 .175 .738
12.29571.7691.769  13 .175 .738  17 .175 .738
13.29571.7691.769  14 .175 .772  18 .175 .738
141.7365.8942.874  10 .175 .772  19.5245 2.82
15.1478.8843.8843  16 .175 .738
16.29571.7691.769  17 .175 .738  20 .175 .738
17.29571.7691.769  18 .175 .738  21 .175 .738
18.29571.7691.769  22 .175 .738
191.7365.8942.874  22 .175 .772  24 .175 .772  25 .175 .772
20.1478.8843.8843  21 .175 .738
21.29571.7691.769  22 .175 .738  23 .175 .738
22.29571.7691.769  24 .175 .738
23.1478.8843.8843  24 .175 .738
24.29571.7691.769  25 .175 .738
25.1478.8843.8843
2  2  44  0  0
1  1  0  0  1
11.7365.8942.874  2 .175 .772  3 .175 .772  4 .175 .772  8.5245 2.82
2.29571.7691.769  3 .175 .738  9 .175 .738  15 .175 .772
3.29571.7691.769  4 .175 .738  10 .175 .738
4.29571.7691.769  5 .175 .738  11 .175 .738
5.29571.7691.769  8 .175 .738  8 .175 .772  12 .175 .738
6.29571.7691.769  7 .175 .738  8 .175 .772  13 .175 .738
7.29571.7691.769  22 .175 .772  8 .175 .772  14 .175 .738
81.7365.8942.874  22.8584 2.82
9.29571.7691.769  10 .175 .738  15 .175 .772  16 .175 .738
10.29571.7691.769  11 .175 .738  17 .175 .738
11.29571.7691.769  12 .175 .738  18 .175 .738
12.29571.7691.769  13 .175 .738  19 .175 .738
13.29571.7691.769  14 .175 .738  20 .175 .738
14.29571.7691.769  22 .175 .772  21 .175 .738
151.7365.8942.874  1.8584 2.82  16 .175 .772  23.5245 2.82
```

16.29571.7691.769	17	.175	.738	24	.175	.738		
17.29571.7691.769	18	.175	.738	25	.175	.738		
18.29571.7691.769	19	.175	.738	26	.175	.738		
19.29571.7691.769	20	.175	.738	27	.175	.738		
20.29571.7691.769	21	.175	.738	28	.175	.738		
21.29571.7691.769	22	.175	.772	29	.175	.738		
221.7385.8942.874	30	.5245	2.82					
231.7385.8942.874	24	.175	.772	31	.175	.772	37.8584	2.82
24.29571.7691.769	25	.175	.738	31	.175	.738		
25.29571.7691.769	26	.175	.738	32	.175	.738		
26.29571.7691.769	27	.175	.738	33	.175	.738		
27.29571.7691.769	28	.175	.738	34	.175	.738		
28.29571.7691.769	29	.175	.738	35	.175	.738		
29.29571.7691.769	30	.175	.772	36	.175	.738		
301.7385.8942.874	36	.175	.772	43	.175	.772	44.8584	2.82
31.29571.7691.769	32	.175	.738	38	.175	.738		
32.29571.7691.769	33	.175	.738	39	.175	.738		
33.29571.7691.769	34	.175	.738	40	.175	.738		
34.29571.7691.769	35	.175	.738	41	.175	.738		
35.29571.7691.769	36	.175	.738	42	.175	.738		
36.29571.7691.769	43	.175	.738					
371.7385.8942.874	38	.175	.772	39	.175	.772	40	.175
38.29571.7691.769	39	.175	.738				44.5245	2.82
39.29571.7691.769	40	.175	.738					
40.29571.7691.769	41	.175	.738					
41.29571.7691.769	42	.175	.738	44	.175	.772		
42.29571.7691.769	43	.175	.738	44	.175	.772		
43.29571.7691.769	44	.175	.772					

441.7385.8942.874

3	1	25	0	0
1	1	0	0	1
4	2	44	0	0
1	1	0	0	1
5	2	44	0	0
1	1	0	0	1
6	1	25	0	0
1	1	0	0	1
7	2	44	0	0
1	1	0	0	1
8	2	44	0	0
1	1	0	0	1
9	3	1	0	0
0	1	0	0	2

118.0718.11

10	4	1	0	0
0	1	0	0	2

1 5.2413.78

11	5	1	0	
0	1	0	0	2

122.1820.18

rods	11	1	1	0	0	1		
1	1	28						
1	.583	1.0	1	.375	2	.125		
2	.583	1.0	1	.500	2	.250	3	.250
3	.583	1.0	1	.500	3	.250	4	.250
4	.583	1.0	1	.250	4	.250	5	.250
5	.583	1.0	5	.250	6	.250	8	.500
6	.583	1.0	8	.250	7	.250	8	.500
7	.583	1.0	7	.250	8	.375	14	.375

8	.563	1.0	2	.125	3	.250	9	.125		
9	.563	1.0	3	.250	4	.250	9	.250	10	.250
10	.563	1.0	4	.250	5	.250	10	.250	11	.250
11	.563	1.0	5	.250	6	.250	11	.250	12	.250
12	.563	1.0	6	.250	7	.250	12	.250	13	.250
13	.563	1.0	7	.250	13	.250	14	.500		
14	.563	1.0	9	.125	10	.250	15	.125		
15	.563	1.0	10	.250	11	.250	15	.250	16	.250
16	.563	1.0	11	.250	12	.250	16	.250	17	.250
17	.563	1.0	12	.250	13	.250	17	.250	18	.250
18	.563	1.0	13	.250	14	.500	18	.250		
19	.563	1.0	15	.125	16	.250	20	.125		
20	.563	1.0	16	.250	17	.250	20	.250	21	.250
21	.563	1.0	17	.250	18	.250	21	.250	22	.250
22	.563	1.0	14	.250	18	.250	19	.250	22	.250
23	.563	1.0	20	.125	21	.250	23	.125		
24	.563	1.0	21	.250	22	.250	23	.250	24	.250
25	.563	1.0	19	.500	22	.250	24	.250		
26	.563	1.0	23	.125	24	.250	25	.125		
27	.563	1.0	19	.500	24	.250	25	.250		
28	.563	1.0	19	.375	25	.125				
2	2	49								
1	.563	1.0	1	.375	2	.250	15	.375		
2	.563	1.0	1	.500	2	.250	3	.250		
3	.563	1.0	1	.500	3	.250	4	.250		
4	.563	1.0	1	.250	4	.250	5	.250	8	.250
5	.563	1.0	5	.250	6	.250	8	.500		
6	.563	1.0	6	.250	7	.250	8	.500		
7	.563	1.0	7	.250	8	.375	22	.375		
8	.563	1.0	2	.250	9	.250	15	.500		
9	.563	1.0	2	.250	3	.250	9	.250	10	.250
10	.563	1.0	3	.250	4	.250	10	.250	11	.250
11	.563	1.0	4	.250	5	.250	11	.250	12	.250
12	.563	1.0	5	.250	6	.250	12	.250	13	.250
13	.563	1.0	6	.250	7	.250	13	.250	14	.250
14	.563	1.0	7	.250	14	.250	22	.500		
15	.563	1.0	9	.250	15	.500	16	.250		
16	.563	1.0	9	.250	16	.250	16	.250	17	.250
17	.563	1.0	10	.250	11	.250	17	.250	18	.250
18	.563	1.0	11	.250	12	.250	18	.250	19	.250
19	.563	1.0	12	.250	13	.250	19	.250	20	.250
20	.563	1.0	13	.250	14	.250	20	.250	21	.250
21	.563	1.0	14	.250	21	.250	22	.500		
22	.563	1.0	15	.250	16	.250	23	.250	24	.250
23	.563	1.0	16	.250	17	.250	24	.250	25	.250
24	.563	1.0	17	.250	18	.250	25	.250	26	.250
25	.563	1.0	18	.250	19	.250	26	.250	27	.250
26	.563	1.0	19	.250	20	.250	27	.250	28	.250
27	.563	1.0	20	.250	21	.250	28	.250	29	.250
28	.563	1.0	21	.250	22	.250	29	.250	30	.250
29	.563	1.0	23	.500	24	.250	31	.250		
30	.563	1.0	24	.250	25	.250	31	.250	32	.250
31	.563	1.0	25	.250	26	.250	32	.250	33	.250
32	.563	1.0	26	.250	27	.250	33	.250	34	.250
33	.563	1.0	27	.250	28	.250	34	.250	35	.250
34	.563	1.0	28	.250	29	.250	35	.250	36	.250
35	.563	1.0	29	.250	30	.500	36	.250		
36	.563	1.0	23	.500	31	.250	38	.250		
37	.563	1.0	31	.250	32	.250	38	.250	39	.250
38	.563	1.0	32	.250	33	.250	39	.250	40	.250

39	.563	1.0	33	.250	34	.250	40	.250	41	.250
40	.563	1.0	34	.250	35	.250	41	.250	42	.250
41	.563	1.0	35	.250	36	.250	42	.250	43	.250
42	.563	1.0	36	.500	36	.250	43	.250		
43	.563	1.0	23	.375	37	.375	38	.250		
44	.563	1.0	37	.500	38	.250	39	.250		
45	.563	1.0	37	.500	39	.250	40	.250		
46	.563	1.0	37	.250	40	.250	41	.250	44	.250
47	.563	1.0	41	.250	42	.250	44	.500		
48	.563	1.0	42	.250	43	.250	44	.500		
49	.563	1.0	30	.375	43	.250	44	.375		
3	1	28								
4	2	49								
5	2	49								
6	1	28								
7	2	49								
8	2	49								
9	0	0								
10	0	0								
11	0	0								
3	0	.069	655	.477	10	0.1	400	.0321000	.563	
slab	06	29	106							
1				16.78		2860	0.20	0.50	3.02	
2				32.09		2860	0.20	0.20	3.02	
3				38.02		2860	0.20	0.20	3.02	
4				205.40		0.00				
5				3476.73		0.00				
6				195.51		0.00				
7				173.79		0.00				
8				1.99		142	0.50	0.50	1.40	
9				164.29		0.00				
10				145.44		0.00				
11				1.99		142	0.50	0.50	1.40	
12				169.10		0.00				
13				130.02		0.00				
14				150.81		0.00				
15				215.73		0.00				
16				211.44		0.00				
17				237.30		0.00				
18				220.26		0.00				
19				6572.72		0.00				
20				6017.34		0.00				
21				4102.12		0.00				
22				4692.99		0.00				
23				4171.11		0.00				
24				4400.98		0.00				
25				5828.79		0.00				
26				4925.06		0.00				
27				5619.14		0.00				
28				8041.59		0.00				
29				7061.62		0.00				
30				5680.39		0.00				
31				32.97		73.2				
32				51.81		55.5				
33				50.22		53.4				
34				52.88		56.3				
35				69.03		73.2				
36				136.86		146.4				
37				69.60		73.2				
38				38.13		2860	0.20	0.20	3.02	

39		975.50	73220.	0.20	0.20	.118
40		51.58	3724.	0.20	0.20	1.68
41		65.25	2126.7	0.50	0.20	3.10
42		95.88	3124.94	0.50	0.20	2.16
43		100.71	3475.2	0.50	0.20	1.94
44		73.77	2402.54	0.50	0.20	2.81
45		51.95	1887.27	0.50	0.20	4.00
46		77.59	2519.84	0.50	0.20	2.68
47		43.18	1399.31	0.50	0.20	4.03
48		97.34	3154.34	0.50	0.20	2.14
49		102.40	0.00			
50		114.96	0.00			
51		81.84	0.00			
52		70.63	0.00			
53		146.96	509.25	0.20	0.60	6.23
54		165.02	672.65	0.20	0.60	5.55
55		117.47	478.55	0.20	0.60	7.80
56		112.70	459.00	0.20	0.60	8.13
57		0.00	0.00			
58		0.00	0.00			
59		0.00	0.00			
60		0.00	0.00			
61		3734.31	0.00			
62		4241.14	0.00			
63		5073.39	0.00			
64		217.60	0.00			
65		246.53	0.00			
66		294.00	0.00			
67		1693.87	0.00			
68		1921.92	0.00			
69		2290.33	0.00			
70		30.21	2000.	0.20	0.20	3.02
71		301.27	22559.	0.20	0.20	0.38
72		43.54	3260.	0.20	0.20	2.64
73		44.87	3375.	0.20	0.20	2.50
74		248.74	16701.	0.20	0.20	0.46
75		48.91	3077.	0.20	0.20	2.35
76		16.79	2000.	0.20	0.50	3.02
77		16.77	2000.	0.20	0.50	3.02
78		16.86	2000.	0.20	0.50	3.02
79		16.84	2000.	0.20	0.50	3.02
80		17.00	2000.	0.20	0.50	3.02
81		16.99	2000.	0.20	0.50	3.02
82		32.19	2000.	0.20	0.20	3.02
83		32.37	2000.	0.20	0.20	3.02
84		32.05	2000.	0.20	0.20	3.02
85		32.11	2000.	0.20	0.20	3.02
86		32.20	2000.	0.20	0.20	3.02
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21	1 .569	1	22	82				
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25	1 .569	1	26	84				
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67	1 .569	3	89	5	68	72	78	71
68	3 .711	2	78	19	80	31		
69	1 .569	1	76	78				
70	3 .846	1	82	20				
71	1 .569	2	73	5	72	38		
72	3 .779	3	86	24	74	25	73	39

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77	2	.834	2	78	33	83	8		
78	3	.477	1	79	22				
79	3	.594	1	88	23				
80	3	.384							
81	3	.387	2	82	21	85	35		
82	3	.576							
83	2	.792	2	84	12	95	41		
84	2	.539	2	85	13	96	42		
85	2	.485	2	88	14	98	43		
86	3	.384							
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90	2	.689	3	91	37	93	17	97	46
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92	3	.452	1	94	37				
93	2	1.20	2	98	47	94	18		
94	2	.534	1	98	48				
95	3	4.89	2	98	61	99	49		
96	3	3.86	2	97	82	100	50		
97	3	5.89	2	98	83	101	51		
98	3	5.33	1	102	52				
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100	4	23.3	2	101	66	104	54		
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105	3	17.5	1	108	89				
106	3	18.2							
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2		31.59	2.12						
3		28.77	2.31						
4		38.56	1.71						
5		39.98	1.68						
6		32.54	2.84						
7		55.58	1.19						
8		19.76	3.34						
9		24.96	2.84						
10		24.23	2.71						
11		51.55	1.29						
12		20.31	3.21						
13		19.84	3.48						
14		25.87	2.58						
15		24.85	2.84						
16		48.78	1.66						
17		38.53	1.78						
18		3.33	0.60						
19		0.68	2.91						
20		0.88	2.58						
21		0.81	3.28						
22		0.39	5.82						
23		6.89	2.94						
24		6.68	2.94						
25		6.71	2.94						
26		6.89	2.94						

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28	6.75	2	94
29	6.74	2	94
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67	1	7	22
68	1	9	1
69	1	7	30
70	1	9	1
71	1	8	22

72 1 10 1 9
 73 1 8 30 29
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 91 1 11 1 16
 92 1 11 1 17
 93 1 11 1 22

radg	11	2	3						
1	9								
1	.301	.2	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000
			7.0000	8.0000	9.0000	10.0000	11.0000	12.0000	13.0000
2	.840	.2	1.0000	2.0000	3.1902	4.2224	5.1247	6.0076	7.0000
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3	5.170	.2	1.0000	2.0000	3.0355	4.1605	5.0764	6.1744	7.0000
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4	4.249	.2	1.0000	2.0000	3.0000	4.0160	5.0178	6.1019	7.0000
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5	5.5350	.2	1.0000	2.0000	3.0000	4.0000	5.0208	6.2649	7.0000
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2	7.850	.2	1.0000	2.0193	3.0000	4.5029	5.2370	6.0000	7.0000
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3	6.077	.2	1.0000	2.0000	3.0000	4.1124	5.0470	6.0000	7.0000
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4	8.650	.2	1.0000	2.0000	3.0000	4.0773	5.0450	6.0000	7.0000
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1	3.904	.2	1.0000	2.4404	3.1101	4.2547	5.1125	6.0115	7.0000
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6  1  4  38  40  49  51
7  2  8  54  50  67  69  60  57  44  42
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9  -1  9  68  70  82  81  78  79  66  77  84
10 -2  5  66  72  74  87  89
11 -3  7  91  86  64  50  52  92  93
heat  1  1
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64. -1.0      64. -1.0
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      .69 2.2 .80 2.2 .90 2.2
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      .69 1.7 .80 1.7 .90 1.7
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      .69 1.7 .80 1.7 .90 1.7
  9 19 19 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
      .69 1.7 .80 1.7 .90 1.7
  9  1  1 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
      .69 1.7 .80 1.7 .90 1.7
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      .69 2.2 .80 2.2 .90 2.2
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  9 22 23 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
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  9 30 30 .01 2.2 .14 2.2 .25 2.2 .36 2.2 .47 2.2 .58 2.2
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  9 44 44 .01 1.7 .14 1.7 .25 1.7 .36 1.7 .47 1.7 .58 1.7
      .69 1.7 .80 1.7 .90 1.7
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  4  1  0
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bdry 17  1  4  2
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  2 1.173e-07 2.523e-00      .20
  3 8.729e-04
  4 3.22e-6      6.20 .70
  5 5.40e-7
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  8 1.33e-7
  9 1.877e-4
10 3.22e-6      6.20 .30

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12 5.222e-5
13 3.723e-6
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16 1.87e-4
17 3.22e-8      0.20  .30
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106 40.289  1
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 41.103  1  1.  4
  1 305.  0.  5  0 25. 25.
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          104 6   3.63 105  6   3.63 106  6   3.63
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21.963363.9 3 5 25. 25.
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285.28 9 12  95  3   3.63  96  3   3.63  97  3   3.63
          98  3   3.63  99  3   3.63 100  3   3.63
          101 3   3.63 102  3   3.63 103  3   3.63
          104 3   3.63 105  3   3.63 106  3   3.63
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2 1.0 12 0
31.366 13 0
41.543 14 0
51.825 15 0
calc 1 0 0

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0.4

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18
0. 0.8443 0.08444 .476.8786 .476.1478.9951.21541.163
.28391.173.35231.157.42871.146.48911.116.56781.117.82881.896
.89441.842.7829 .911.8313 .811.8855 .811.8856 0. 1.0 0.
outp 11011
endd

```

data from iterative solution using the recirculation module

time = 0.8888 dt = ***** implicit dt = 0.0000 explicit dt = 0.0750 mode = 0

iteration no.	sweep no.	peak clad				total flow (lbw/s)	pressure drop (psi)	error			
		temp(f)	fluid	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	348.4	18	19	1	0.889e-10	0.0080424	-0.3473	1.0051	0.1189	0.0171
	2	348.5	15	19	1			-0.1069	1.0051	0.0240	0.0160
2	1	348.2	18	19	1	0.487e-10	0.0093990	-0.1235	2.0100	0.0621	0.0115
	2	282.5	20	19	1			-0.1291	2.0100	0.0853	0.0472
3	1	281.6	22	19	1	0.290e-10	0.0093313	-0.1458	0.8532	0.0139	0.0082
	2	242.1	20	19	1			-0.1374	0.8532	0.0026	0.0095
4	1	241.8	20	19	1	-0.148e-11	0.0090818	0.7881	0.9176	0.0883	0.0132
	2	260.5	18	19	1			0.6566	0.9176	0.0038	0.0092
5	1	260.2	18	19	1	-0.138e-10	0.0089958	0.5961	1.1285	0.0133	0.0024
	2	241.8	18	19	1			0.5632	1.1285	0.0018	0.0059
6	1	241.8	18	19	1	-0.214e-10	0.0088224	0.5304	2.7887	0.0032	0.0011
	2	241.9	19	19	1			0.5099	2.7887	0.0026	0.0018

7	1	242.7	19	19	1	-0.256e-10	0.0000269	-0.3207	0.3501	0.0191	0.0009
	2	259.0	20	19	1			-0.1878	0.3501	0.0071	0.0048
8	1	259.4	20	19	1	-0.284e-10	0.0007706	-0.1191	3.5106	0.0109	0.0019
	2	271.4	19	19	1			-0.0952	3.5106	0.0193	0.0005
9	1	271.5	19	19	1	-0.290e-10	0.0000713	-0.0000	2.5009	0.0048	0.0049
	2	273.0	19	19	1			-0.0725	2.5009	0.0195	0.0023
10	1	273.7	19	19	1	-0.222e-10	0.0000427	0.0300	3.3555	0.0064	0.0045
	2	272.1	19	19	1			0.0157	3.3555	0.0123	0.0010
11	1	272.2	19	19	1	-0.166e-10	0.0000438	0.0107	3.7002	0.0054	0.0026
	2	272.6	19	19	1			0.0091	3.7002	0.0071	0.0025
12	1	272.7	19	19	1	-0.114e-10	0.0000466	0.0000	3.1113	0.0032	0.0017
	2	273.3	19	19	1			0.0000	3.1113	0.0029	0.0010
13	1	273.3	19	19	1	-0.749e-11	0.0000490	-0.0004	2.4162	0.0019	0.0007
	2	273.9	19	19	1			0.0015	2.4162	0.0010	0.0005
14	1	273.9	19	19	1	-0.483e-11	0.0000505	0.0035	1.5409	0.0008	0.0005
	2	274.5	19	19	1			0.0042	1.5409	0.0007	0.0003
15	1	274.5	19	19	1	-0.366e-11	0.0000524	0.0050	0.5309	0.0009	0.0002
	2	274.7	19	19	1			0.0053	0.5309	0.0007	0.0003
16	1	274.7	19	19	1	-0.207e-11	0.0000509	0.0110	0.5077	0.0010	0.0005
	2	274.2	19	19	1			0.0109	0.5077	0.0014	0.0005
17	1	274.2	19	19	1	-0.860e-12	0.0000592	0.0111	0.4431	0.0005	0.0004
	2	274.2	19	19	1			0.0109	0.4431	0.0005	0.0002
18	1	274.2	19	19	1	-0.246e-12	0.0000000	0.0110	0.2744	0.0005	0.0001
	2	274.1	19	19	1			0.0110	0.2744	0.0005	0.0001
19	1	274.1	19	19	1	-0.022e-14	0.0000030	0.0124	0.2466	0.0015	0.0004
	2	273.8	19	19	1			0.0122	0.2466	0.0012	0.0005
20	1	273.0	19	19	1	0.356e-13	0.0000041	0.0120	0.2010	0.0004	0.0003
	2	273.0	19	19	1			0.0124	0.2010	0.0004	0.0002
21	1	273.0	19	19	1	0.116e-13	0.0000051	0.0125	0.1940	0.0005	0.0001
	2	273.7	19	19	1			0.0124	0.1940	0.0005	0.0001
22	1	273.7	19	19	1	-0.451e-13	0.0000005	0.0115	0.1631	0.0013	0.0003
	2	273.5	19	19	1			0.0117	0.1631	0.0011	0.0004
23	1	273.5	19	19	1	-0.113e-12	0.0000073	0.0123	0.1504	0.0004	0.0003
	2	273.5	19	19	1			0.0122	0.1504	0.0004	0.0002
24	1	273.5	19	19	1	-0.112e-12	0.0000001	0.0123	0.1040	0.0005	0.0001
	2	273.5	19	19	1			0.0123	0.1040	0.0005	0.0001
25	1	273.5	19	19	1	-0.944e-13	0.0000003	0.0100	0.1325	0.0012	0.0003
	2	273.3	19	19	1			0.0111	0.1325	0.0010	0.0004
26	1	273.3	19	19	1	-0.647e-13	0.0000000	0.0117	0.1124	0.0004	0.0003
	2	273.3	19	19	1			0.0110	0.1124	0.0004	0.0002

27	1	273.3	19	19	1	-0.495e-13	0.0006705	0.0110	0.1455	0.0005	0.0001
	2	273.3	19	19	1			0.0110	0.1455	0.0005	0.0001
28	1	273.3	19	19	1	-0.502e-13	0.0006714	0.0099	0.0985	0.0011	0.0003
	2	273.2	19	19	1			0.0104	0.0985	0.0009	0.0003
29	1	273.2	19	19	1	-0.730e-13	0.0006717	0.0110	0.0032	0.0004	0.0002
	2	273.2	19	19	1			0.0110	0.0032	0.0004	0.0001
30	1	273.2	19	19	1	-0.493e-13	0.0006724	0.0112	0.1185	0.0005	0.0001
	2	273.1	19	19	1			0.0113	0.1185	0.0005	0.0001

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 - 7.4	134.77	136.93	134.25	137.48	140.08	139.62	140.94	139.87	133.13	136.40
7.4 - 14.8	136.04	138.84	135.53	139.58	142.78	142.26	143.84	142.61	134.41	138.47
14.8 - 22.2	137.97	141.10	137.46	141.93	145.50	145.03	146.78	145.47	136.35	140.67
22.2 - 29.6	140.50	144.20	140.01	145.23	149.47	148.92	150.89	149.48	138.90	144.23
29.6 - 37.0	143.43	147.79	142.94	148.93	153.81	153.25	155.46	153.94	141.83	147.99
37.0 - 44.4	146.03	151.00	146.14	152.90	158.45	157.87	160.32	158.70	145.01	152.00
44.4 - 51.9	149.93	155.43	149.44	156.90	163.00	162.47	165.18	163.46	148.20	156.02
51.9 - 59.3	153.23	159.21	152.73	160.03	167.62	166.99	169.95	168.12	151.54	159.96
59.3 - 66.7	156.42	162.83	155.91	164.62	171.90	171.32	174.53	172.59	154.69	163.73
66.7 - 74.1	159.43	166.25	158.90	168.19	176.12	175.42	178.80	176.83	157.65	167.20
74.1 - 81.5	162.10	169.39	161.65	171.48	179.95	179.21	182.92	180.77	160.35	170.53
81.5 - 88.9	164.63	172.19	164.08	174.43	183.42	182.65	186.61	184.35	162.74	173.45
88.9 - 96.3	166.70	174.62	166.14	177.01	186.55	185.73	189.95	187.50	164.77	176.01
96.3 - 103.7	168.34	176.83	167.78	179.18	189.27	188.42	192.91	190.43	166.37	178.15
103.7 - 111.1	169.47	178.13	168.90	180.84	191.50	190.61	195.30	192.70	167.40	179.80
111.1 - 118.5	170.02	179.03	169.45	181.92	193.14	192.21	197.25	194.57	168.02	180.87
118.5 - 125.9	169.06	179.22	169.31	182.20	194.07	193.12	198.43	195.60	167.80	181.26
125.9 - 133.3	168.91	178.50	168.39	181.00	194.11	193.16	198.73	195.94	167.00	180.62
133.3 - 140.8	168.95	178.03	168.40	180.25	193.00	192.12	197.94	195.16	165.19	179.38
140.8 - 148.2	163.07	173.03	163.51	177.46	190.00	189.79	195.03	193.15	162.40	175.79
148.2 - 155.6	159.12	169.24	159.02	173.14	188.90	188.14	192.40	189.94	158.31	172.94
155.6 - 163.0	152.21	161.00	152.76	166.33	180.48	180.04	186.30	184.43	152.90	167.14
163.0 - 170.4	141.02	151.00	143.78	157.55	173.42	173.00	180.20	178.90	148.19	160.77
170.4 - 177.8	119.00	136.58	132.52	147.14	150.73	148.03	174.93	174.39	139.78	155.30

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 - 7.4	131.39	135.24	136.34	132.00	135.00	135.41	131.65	135.79	136.87	136.01
7.4 - 14.8	132.07	137.27	138.55	134.11	137.00	137.56	133.17	137.97	139.36	138.51

14.8 - 22.2	134.82	139.88	141.18	136.45	139.83	148.18	135.51	148.61	142.12	141.32
22.2 - 29.6	137.16	143.06	144.82	139.51	143.15	149.83	138.57	144.25	146.88	145.35
29.6 - 37.8	148.88	146.83	148.91	143.83	147.11	147.93	142.87	148.34	158.46	149.77
37.8 - 44.4	143.23	158.84	153.28	148.81	151.35	152.29	145.83	152.72	155.88	154.41
44.4 - 51.9	146.46	154.84	157.67	158.87	155.62	158.65	149.85	157.11	159.64	158.96
51.9 - 59.3	149.88	158.74	161.97	154.48	159.88	168.91	153.42	161.42	164.84	163.33
59.3 - 68.7	152.73	162.45	168.89	158.14	163.81	164.97	157.83	165.55	168.22	167.46
68.7 - 74.1	155.82	165.94	169.98	161.59	167.59	168.88	168.43	169.46	172.12	171.31
74.1 - 81.5	158.26	169.12	173.57	164.77	171.88	172.32	163.56	173.89	175.69	174.82
81.5 - 88.9	168.58	171.98	176.82	167.84	174.25	175.49	168.39	178.38	178.89	177.96
88.9 - 98.3	162.55	174.44	179.73	178.17	177.88	178.32	168.87	179.35	181.72	180.72
98.3 -103.7	164.18	176.51	182.25	172.31	179.53	188.76	178.98	181.95	184.15	183.89
103.7 -111.1	165.16	178.89	184.31	174.81	181.53	182.74	172.61	184.18	186.89	184.95
111.1 -118.5	165.88	179.18	185.84	175.28	183.88	184.19	173.77	185.74	187.45	186.25
118.5 -125.9	165.54	179.43	186.75	175.84	183.94	185.83	174.38	186.88	188.13	186.86
125.9 -133.3	164.89	178.98	188.93	175.87	184.19	185.15	174.38	187.17	187.98	186.84
133.3 -148.8	162.98	177.51	186.27	175.25	183.88	184.44	173.74	186.78	186.82	185.42
148.8 -148.2	168.42	174.99	184.78	174.85	182.48	182.87	172.53	185.52	184.58	183.88
148.2 -155.8	158.78	171.33	182.38	172.27	188.47	188.58	178.74	183.55	181.12	179.71
155.8 -163.8	152.32	165.95	178.55	178.26	177.58	178.88	168.73	188.45	175.71	174.36
163.8 -178.4	147.28	168.39	175.82	188.38	175.81	173.88	168.88	177.71	178.88	169.53
178.4 -177.8	143.21	158.85	172.49	167.22	173.48	171.38	165.74	175.95	168.99	168.14

slab temperature summary time = 8.8888 seconds
 (assembly no. - channel no.)

axial zone (inches)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)
8.8 - 7.4	138.97	138.28	139.58	139.11	141.58	141.28	128.98	132.84	125.97	129.89
7.4 - 14.8	139.49	138.78	142.39	141.93	144.85	144.46	138.27	134.21	127.27	132.28
14.8 - 22.2	142.38	141.55	145.39	144.95	147.85	147.78	132.23	136.81	129.23	135.87
22.2 - 29.6	146.33	145.82	149.55	149.12	152.23	152.13	134.77	148.39	131.74	138.81
29.6 - 37.8	158.88	158.13	154.19	153.78	157.12	157.88	137.65	144.25	134.57	142.73
37.8 - 44.4	155.53	154.87	159.13	158.74	162.33	162.38	148.75	148.27	137.58	146.73
44.4 - 51.9	168.28	159.52	164.88	163.68	167.54	167.54	143.98	152.19	148.83	158.58
51.9 - 59.3	164.71	164.81	168.93	168.52	172.65	172.65	147.81	155.97	143.82	154.25
59.3 - 68.7	169.88	168.28	173.88	173.17	177.59	177.88	149.99	159.52	148.48	157.67
68.7 - 74.1	173.81	172.22	178.85	177.59	182.38	182.32	152.78	162.83	149.15	168.83
74.1 - 81.5	178.89	175.84	182.28	181.71	188.72	188.74	155.32	165.82	151.58	163.88
81.5 - 88.9	188.88	179.88	188.83	185.51	198.82	198.84	157.55	168.46	153.88	168.17
88.9 - 98.3	182.95	181.97	189.54	188.99	194.82	194.83	159.43	178.74	155.45	168.38
98.3 -103.7	185.51	184.45	192.78	192.12	198.88	198.89	168.98	172.62	158.83	178.84
103.7 -111.1	187.58	186.45	195.42	194.82	201.18	201.12	161.98	174.81	157.78	171.28
111.1 -118.5	189.89	187.88	197.62	197.88	203.61	203.63	162.37	174.84	158.16	171.98
118.5 -125.9	189.93	188.85	199.22	198.57	205.49	205.51	162.22	175.81	158.82	172.82
125.9 -133.3	189.97	188.81	208.83	199.38	208.58	208.57	161.41	174.48	157.24	171.29
133.3 -148.8	189.84	187.82	199.93	199.23	208.83	208.84	159.81	172.89	155.75	169.89
148.8 -148.2	187.83	185.54	198.74	198.81	205.52	205.49	157.48	178.48	153.84	167.15
148.2 -155.8	184.85	182.51	196.81	195.83	203.32	203.23	154.27	167.81	158.83	163.82
155.8 -163.8	179.17	177.81	192.88	191.79	198.96	198.79	158.57	162.14	147.75	159.88
163.8 -178.4	174.79	173.28	189.11	188.28	195.14	194.89	148.84	157.73	144.88	155.11
178.4 -177.8	171.78	178.25	186.78	185.82	192.45	192.14	144.88	154.77	142.79	152.82

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

axial zone (inches)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)	(40)
0.0 - 7.4	132.86	129.80	133.66	136.58	126.50	131.72	140.93	140.49	138.85	137.48
7.4 - 14.8	134.82	131.13	136.88	132.86	128.84	133.94	144.31	143.91	142.22	140.90
14.8 - 22.2	137.55	133.48	138.79	135.73	130.39	136.73	147.73	147.38	145.71	144.41
22.2 - 29.6	141.32	136.52	142.52	139.65	133.39	140.52	152.36	152.05	150.42	149.09
29.6 - 37.0	145.49	139.99	146.67	143.87	136.77	144.78	157.48	157.21	155.56	154.20
37.0 - 44.4	149.85	143.67	151.06	148.22	140.33	149.05	162.87	162.63	160.94	159.51
44.4 - 51.9	154.14	147.40	155.42	152.43	143.91	153.34	168.23	168.00	166.22	164.72
51.9 - 59.3	158.28	151.06	159.66	156.44	147.40	157.47	173.45	173.23	171.31	169.75
59.3 - 66.7	162.18	154.57	163.71	160.20	150.73	161.37	178.48	178.25	176.17	174.54
66.7 - 74.1	165.82	157.85	167.52	163.68	153.83	165.02	183.23	183.02	180.77	179.06
74.1 - 81.5	169.14	160.87	171.03	166.84	156.67	168.36	187.70	187.48	185.04	183.28
81.5 - 88.9	172.11	163.58	174.22	169.63	159.21	171.37	191.84	191.62	188.98	187.16
88.9 - 96.3	174.72	165.95	177.08	172.08	161.42	174.05	195.69	195.47	192.61	190.75
96.3 - 103.7	178.95	167.94	179.58	174.15	163.26	176.38	199.20	198.98	195.90	194.01
103.7 - 111.1	178.71	169.50	181.63	175.74	164.68	178.24	202.28	202.07	198.77	196.85
111.1 - 118.5	179.95	170.57	183.19	176.81	165.62	179.61	204.65	204.65	201.11	199.18
118.5 - 125.9	180.58	171.09	184.18	177.28	166.04	180.41	206.79	206.59	202.82	200.89
125.9 - 133.3	180.49	171.03	184.44	177.03	165.89	180.51	207.87	207.68	203.68	201.75
133.3 - 140.8	179.59	170.34	183.94	175.97	165.13	179.83	207.91	207.71	203.49	201.58
140.8 - 148.2	177.84	169.10	182.60	174.08	163.85	178.34	206.87	206.44	202.84	200.13
148.2 - 155.6	175.38	167.30	180.52	171.53	162.06	176.13	204.22	203.93	199.48	197.50
155.6 - 163.0	171.67	165.31	177.28	167.77	160.11	172.00	199.44	199.06	194.50	192.58
163.0 - 170.4	168.48	163.42	174.47	164.71	158.30	169.98	195.24	194.77	190.26	188.32
170.4 - 177.8	166.45	162.40	172.67	162.87	157.35	168.23	192.29	191.76	187.34	185.38

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

axial zone (inches)	(51)	(52)	(53)	(54)	(55)	(56)	(57)	(58)	(59)	(60)
0.0 - 7.4	123.31	116.32	122.27	125.64	117.91	122.96	125.34	122.10	126.27	122.37
7.4 - 14.8	127.02	119.53	123.57	128.37	119.22	125.64	128.22	123.74	128.99	125.21
14.8 - 22.2	130.63	122.65	125.52	131.37	121.13	128.55	131.45	126.07	132.14	128.33
22.2 - 29.6	135.09	126.35	127.98	135.07	123.50	131.99	135.43	128.98	136.08	132.05
29.6 - 37.0	139.63	130.17	130.72	138.81	126.12	135.45	139.49	132.20	140.18	135.79
37.0 - 44.4	144.16	133.99	133.61	142.53	128.86	138.86	143.51	135.56	144.30	139.46
44.4 - 51.9	148.44	137.63	136.52	146.05	131.60	142.12	147.32	138.91	148.24	142.96
51.9 - 59.3	152.47	141.00	139.38	149.36	134.20	145.17	150.89	142.15	151.96	146.22
59.3 - 66.7	156.24	144.31	142.00	152.42	136.82	147.98	154.19	145.23	155.43	149.23
66.7 - 74.1	159.74	147.30	144.58	155.20	139.17	150.53	157.21	148.09	158.61	151.97
74.1 - 81.5	162.95	150.05	146.85	157.67	141.29	152.78	159.89	150.69	161.48	154.40
81.5 - 88.9	165.85	152.54	148.83	159.79	143.15	154.71	162.23	153.00	164.02	156.50
88.9 - 96.3	168.50	154.78	150.48	161.57	144.89	156.29	164.23	155.00	166.23	158.27
96.3 - 103.7	170.86	156.75	151.77	162.94	145.88	157.49	165.85	156.64	168.06	159.67
103.7 - 111.1	172.85	158.39	152.81	163.82	146.68	158.21	167.00	157.88	169.46	160.61
111.1 - 118.5	174.39	159.63	152.99	164.18	147.00	158.42	167.61	158.66	170.34	161.05
118.5 - 125.9	175.38	160.39	152.81	163.87	146.84	158.04	167.63	158.94	170.64	160.92

125.9 -133.3	175.63	160.52	152.07	162.87	146.17	157.01	166.95	158.68	170.26	160.16
133.3 -140.8	174.98	159.92	150.70	161.10	144.93	155.32	165.53	157.66	169.12	158.74
140.8 -148.2	173.25	158.48	148.81	158.68	143.26	153.05	163.39	156.56	167.25	156.75
148.2 -155.6	170.58	156.14	146.36	155.54	141.12	150.38	160.73	154.81	164.79	154.37
155.6 -163.0	165.88	152.54	143.79	151.80	138.96	147.33	157.31	152.97	161.51	151.57
163.0 -170.4	162.16	149.47	141.32	149.15	136.91	145.32	155.03	151.29	159.16	149.83
170.4 -177.8	159.82	147.53	139.95	148.05	135.83	144.66	154.12	150.45	158.07	149.33

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

axial zone (inches)	(91)	(92)	(93)	(94)	(95)	(96)	(97)	(98)	(99)	(100)
0.0 - 7.4	92.69	89.78	89.14	89.03	73.21	72.61	71.38	70.27	70.76	70.31
7.4 - 14.8	94.67	91.12	90.39	90.32	75.88	75.13	73.52	72.23	73.41	72.88
14.8 - 22.2	95.84	92.83	92.05	91.99	77.75	76.94	75.21	73.88	75.27	74.59
22.2 - 29.6	97.82	94.74	93.89	93.86	79.38	78.54	76.74	75.27	76.86	76.15
29.6 - 37.0	99.89	96.72	95.81	95.86	80.92	80.06	78.21	76.68	78.34	77.68
37.0 - 44.4	101.97	98.71	97.74	97.74	82.41	81.54	79.62	78.05	79.76	79.08
44.4 - 51.9	104.00	100.66	99.63	99.65	83.86	82.97	81.08	79.38	81.13	80.36
51.9 - 59.3	105.95	102.52	101.44	101.47	85.24	84.33	82.31	80.64	82.43	81.64
59.3 - 66.7	107.79	104.28	103.15	103.19	86.55	85.62	83.54	81.83	83.66	82.86
66.7 - 74.1	109.48	105.98	104.73	104.78	87.75	86.88	84.67	82.92	84.80	83.98
74.1 - 81.5	111.02	107.37	106.15	106.22	88.83	87.87	85.78	83.91	85.82	84.98
81.5 - 88.9	112.37	108.67	107.41	107.49	89.78	88.88	86.59	84.77	86.71	85.85
88.9 - 96.3	113.52	109.78	108.48	108.57	90.57	89.59	87.34	85.58	87.46	86.60
96.3 -103.7	114.44	110.68	109.34	109.44	91.18	90.20	87.93	86.07	88.04	87.18
103.7 -111.1	115.10	111.34	109.98	110.08	91.61	90.62	88.35	86.47	88.44	87.57
111.1 -118.5	115.49	111.74	110.32	110.46	91.82	90.84	88.56	86.68	88.63	87.77
118.5 -125.9	115.57	111.85	110.39	110.55	91.88	90.84	88.56	86.69	88.62	87.76
125.9 -133.3	115.31	111.64	110.18	110.33	91.54	90.59	88.33	86.47	88.37	87.53
133.3 -140.8	114.70	111.08	109.59	109.77	91.01	90.09	87.85	86.08	87.87	87.04
140.8 -148.2	113.77	110.19	108.72	108.98	90.23	89.32	87.09	85.26	87.12	86.30
148.2 -155.6	112.46	108.91	107.46	107.63	89.12	88.19	85.94	84.14	86.05	85.19
155.6 -163.0	110.93	107.36	106.02	106.14	87.75	86.72	84.31	82.64	84.78	83.73
163.0 -170.4	109.20	105.63	104.34	104.44	86.01	84.61	81.51	80.52	82.95	81.59
170.4 -177.8	107.79	104.36	103.07	103.18	84.19	81.92	79.90	78.09	81.29	78.95

side boundary temperature summary time = 0.0000 seconds
boundary slab node no. 106

axial zone (inches)	(1)	(2)	(3)	(4)	(5)	(
0.0 - 7.4	59.08	57.91	52.39	52.16	25.00	
7.4 - 14.8	58.52	57.37	51.94	51.71	25.00	
14.8 - 22.2	59.23	58.05	52.52	52.28	25.00	
22.2 - 29.6	60.16	58.94	53.26	53.02	25.00	
29.6 - 37.0	61.09	59.83	54.01	53.76	25.00	
37.0 - 44.4	61.99	60.70	54.75	54.49	25.00	
44.4 - 51.9	62.86	61.53	55.45	55.19	25.00	

51.9 - 59.3	63.78	62.33	56.13	55.85	25.00
59.3 - 66.7	64.47	63.07	56.76	56.48	25.00
66.7 - 74.1	65.19	63.78	57.34	57.05	25.00
74.1 - 81.5	65.83	64.38	57.86	57.57	25.00
81.5 - 88.9	66.46	64.92	58.31	58.02	25.00
88.9 - 96.3	66.87	65.37	58.69	58.40	25.00
96.3 - 103.7	67.24	65.72	58.99	58.69	25.00
103.7 - 111.1	67.49	65.97	59.20	58.90	25.00
111.1 - 118.5	67.63	66.09	59.31	59.00	25.00
118.5 - 125.9	67.62	66.09	59.30	59.00	25.00
125.9 - 133.3	67.47	65.94	59.18	58.88	25.00
133.3 - 140.8	67.16	65.64	58.93	58.63	25.00
140.8 - 148.2	66.85	65.18	58.52	58.23	25.00
148.2 - 155.6	66.91	64.45	57.93	57.64	25.00
155.6 - 163.0	64.83	63.42	57.06	56.78	25.00
163.0 - 170.4	63.48	62.12	55.96	55.69	25.00
170.4 - 177.8	62.02	60.73	54.79	54.53	25.00

calculated rod temperatures at time = 0.0000 seconds
rod no. 25
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.563 (in.) zone-(fuel dia.(in.)) - 1-(0.477)

						* fuel temperatures(f.)	
						*	
axial zone	heat flux	type	hsurf	fluid	clad		
(in.)	(mbtu/hr-ft ²)		(b/h-f-ft ²)				
0.0 - 7.4	0.0000	1	0.9	155.2	154.0		
7.4 - 14.8	0.0000	1	0.9	157.4	163.3		
14.8 - 22.2	0.0000	1	0.9	161.4	170.3		
22.2 - 29.6	0.0000	1	0.9	167.8	181.3		
29.6 - 37.0	0.0000	1	0.9	174.9	190.1		
37.0 - 44.4	0.0000	1	0.9	182.3	198.5		
44.4 - 51.9	0.0000	1	0.9	189.5	205.8		
51.9 - 59.3	0.0000	1	0.9	196.3	212.5		
59.3 - 66.7	0.0000	1	0.9	202.7	218.6		
66.7 - 74.1	0.0000	1	0.9	208.7	224.4		
74.1 - 81.5	0.0000	1	0.9	214.4	229.7		
81.5 - 88.9	0.0000	1	0.9	219.6	234.5		
88.9 - 96.3	0.0000	1	0.9	224.4	239.0		
96.3 - 103.7	0.0000	1	1.0	228.9	243.2		
103.7 - 111.1	0.0000	1	1.0	232.9	246.9		
111.1 - 118.5	0.0000	1	1.0	236.4	249.8		
118.5 - 125.9	0.0000	1	1.0	239.2	252.0		
125.9 - 133.3	0.0000	1	1.0	241.1	252.7		
133.3 - 140.8	0.0000	1	1.0	241.8	251.9		
140.8 - 148.2	0.0000	1	1.0	240.7	248.3		
148.2 - 155.6	0.0000	1	1.0	238.6	244.9		
155.6 - 163.0	0.0000	1	1.0	231.3	229.7		
163.0 - 170.4	0.0000	1	0.9	224.1	222.1		
170.4 - 177.8	0.0000	1	0.9	217.1	214.9		

calculated rod temperatures at time = 0.0000 seconds
rod no. 25

assembly 3 (fuel type 1 - cylinder)
 Ørod o.d. - Ø.563 (in.) zone-(fuel dia.(in.)) - 1-(Ø.477)

* fuel temperatures(f.)

*

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2) *	fluid	clad
0.0 - 7.4	0.0000	1	0.9	155.2	154.0
7.4 - 14.8	0.0000	1	0.9	157.2	162.3
14.8 - 22.2	0.0000	1	0.9	160.7	168.5
22.2 - 29.6	0.0000	1	0.9	166.7	178.6
29.6 - 37.0	0.0000	1	0.9	173.3	186.7
37.0 - 44.4	0.0000	1	0.9	180.2	194.8
44.4 - 51.9	0.0000	1	0.9	187.0	201.5
51.9 - 59.3	0.0000	1	0.9	193.5	207.9
59.3 - 66.7	0.0000	1	0.9	199.6	213.9
66.7 - 74.1	0.0000	1	0.9	205.6	219.6
74.1 - 81.5	0.0000	1	0.9	211.1	224.8
81.5 - 88.9	0.0000	1	0.9	216.3	229.6
88.9 - 96.3	0.0000	1	0.9	221.2	234.2
96.3 - 103.7	0.0000	1	0.9	225.8	238.6
103.7 - 111.1	0.0000	1	1.0	230.0	242.4
111.1 - 118.5	0.0000	1	1.0	233.7	245.7
118.5 - 125.9	0.0000	1	1.0	236.9	248.2
125.9 - 133.3	0.0000	1	1.0	239.1	249.4
133.3 - 140.8	0.0000	1	1.0	240.3	249.3
140.8 - 148.2	0.0000	1	1.0	239.9	248.6
148.2 - 155.6	0.0000	1	1.0	238.6	244.2
155.6 - 163.0	0.0000	1	1.0	232.7	231.3
163.0 - 170.4	0.0000	1	0.9	227.0	225.3
170.4 - 177.8	0.0000	1	0.9	221.8	220.0

calculated rod temperatures at time = 0.0000 seconds

rod no. 25

assembly 6 (fuel type 1 - cylinder)
 Ørod o.d. - Ø.563 (in.) zone-(fuel dia.(in.)) - 1-(Ø.477)

* fuel temperatures(f.)

*

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2) *	fluid	clad
0.0 - 7.4	0.0000	1	0.9	143.6	144.5
7.4 - 14.8	0.0000	1	0.9	148.3	153.7
14.8 - 22.2	0.0000	1	0.9	153.9	161.0
22.2 - 29.6	0.0000	1	0.9	162.7	172.5
29.6 - 37.0	0.0000	1	0.9	170.9	181.6
37.0 - 44.4	0.0000	1	0.9	178.8	190.0
44.4 - 51.9	0.0000	1	0.9	185.7	196.9
51.9 - 59.3	0.0000	1	0.9	191.8	203.0
59.3 - 66.7	0.0000	1	0.9	197.3	208.4
66.7 - 74.1	0.0000	1	0.9	202.3	213.3
74.1 - 81.5	0.0000	1	0.9	206.7	217.7
81.5 - 88.9	0.0000	1	0.9	210.7	221.5
88.9 - 96.3	0.0000	1	0.9	214.3	225.1
96.3 - 103.7	0.0000	1	0.9	217.7	228.5
103.7 - 111.1	0.0000	1	0.9	220.5	231.3
111.1 - 118.5	0.0000	1	0.9	222.9	233.5

-5880

```
1      reload2ann  fuil load, vaccum, vertical validation run.
prop   5      6
1.      1.      114.8      .0128      .249      8.4137      .0373
2.      81.      134.6      .0154      .249      18.89      .0432
3.      261.      179.6      .0193      .250      13.498      .0532
4.      441.      225.0      .0230      .252      16.89      .0622
20.     1500.     1588.0      .1380      1.24      241.30     .1130
1 can
2 cu
3 ss
4 pb
5 lpr1
6 lor2
chan  11  24  0
177.8  90.0
1  1  25  0
1  1  0  0
11.7365.8942.874  2 .175 .772  3 .175 .772  4 .175 .772  8.5245 2.62
2.1478.8843.8843  3 .175 .738
3.29571.7691.769  4 .175 .738  9 .175 .738
4.29571.7691.769  5 .175 .738 10 .175 .738
5.29571.7691.769  6 .175 .738  8 .175 .772 11 .175 .738
6.29571.7691.769  7 .175 .738  8 .175 .772 12 .175 .738
7.29571.7691.769 14 .175 .772  8 .175 .772 13 .175 .738
81.7365.8942.874 14.8584 2.62
9.1478.8843.8843 10 .175 .738
10.29571.7691.769 11 .175 .738 15 .175 .738
11.29571.7691.769 12 .175 .738 16 .175 .738
12.29571.7691.769 13 .175 .738 17 .175 .738
13.29571.7691.769 14 .175 .772 18 .175 .738
141.7365.8942.874 18 .175 .772 19.5245 2.62
15.1478.8843.8843 16 .175 .738
16.29571.7691.769 17 .175 .738 20 .175 .738
17.29571.7691.769 18 .175 .738 21 .175 .738
18.29571.7691.769 22 .175 .738
191.7365.8942.874 22 .175 .772 24 .175 .772 25 .175 .772
20.1478.8843.8843 21 .175 .738
21.29571.7691.769 22 .175 .738 23 .175 .738
22.29571.7691.769 24 .175 .738
23.1478.8843.8843 24 .175 .738
24.29571.7691.769 25 .175 .738
25.1478.8843.8843
2  2  44  0
1  1  0  0
11.7365.8942.874  2 .175 .772  3 .175 .772  4 .175 .772  8.5245 2.62
2.29571.7691.769  3 .175 .738  9 .175 .738 15 .175 .772
3.29571.7691.769  4 .175 .738 10 .175 .738
4.29571.7691.769  5 .175 .738 11 .175 .738
5.29571.7691.769  6 .175 .738  8 .175 .772 12 .175 .738
6.29571.7691.769  7 .175 .738  8 .175 .772 13 .175 .738
7.29571.7691.769 22 .175 .772  8 .175 .772 14 .175 .738
81.7365.8942.874 22.8584 2.62
9.29571.7691.769 10 .175 .738 15 .175 .772 16 .175 .738
10.29571.7691.769 11 .175 .738 17 .175 .738
11.29571.7691.769 12 .175 .738 18 .175 .738
12.29571.7691.769 13 .175 .738 19 .175 .738
13.29571.7691.769 14 .175 .738 20 .175 .738
14.29571.7691.769 22 .175 .772 21 .175 .738
151.7365.8942.874  1.8584 2.62 16 .175 .772 23.5245 2.62
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16. 29571.7691.769 17 .175 .738 24 .175 .738
 17. 29571.7691.769 18 .175 .738 25 .175 .738
 18. 29571.7691.769 19 .175 .738 26 .175 .738
 19. 29571.7691.769 20 .175 .738 27 .175 .738
 20. 29571.7691.769 21 .175 .738 28 .175 .738
 21. 29571.7691.769 22 .175 .772 29 .175 .738
 221. 7365.8942.874 30.5245 2.62
 231. 7365.8942.874 24 .175 .772 31 .175 .772 37.8584 2.62 38 .175 .772
 24. 29571.7691.769 25 .175 .738 31 .175 .738
 25. 29571.7691.769 26 .175 .738 32 .175 .738
 26. 29571.7691.769 27 .175 .738 33 .175 .738
 27. 29571.7691.769 28 .175 .738 34 .175 .738
 28. 29571.7691.769 29 .175 .738 35 .175 .738
 29. 29571.7691.769 30 .175 .772 36 .175 .738
 301. 7365.8942.874 36 .175 .772 43 .175 .772 44.8584 2.62
 31. 29571.7691.769 32 .175 .738 38 .175 .738
 32. 29571.7691.769 33 .175 .738 39 .175 .738
 33. 29571.7691.769 34 .175 .738 40 .175 .738
 34. 29571.7691.769 35 .175 .738 41 .175 .738
 35. 29571.7691.769 36 .175 .738 42 .175 .738
 36. 29571.7691.769 43 .175 .738
 371. 7365.8942.874 38 .175 .772 39 .175 .772 40 .175 .772 44.5245 2.62
 38. 29571.7691.769 39 .175 .738
 39. 29571.7691.769 40 .175 .738
 40. 29571.7691.769 41 .175 .738
 41. 29571.7691.769 42 .175 .738 44 .175 .772
 42. 29571.7691.769 43 .175 .738 44 .175 .772
 43. 29571.7691.769 44 .175 .772
 441. 7365.8942.874

3 1 25 0 0
 1 1 0 0 1
 4 2 44 0 0
 1 1 0 0 1
 5 2 44 0 0
 1 1 0 0 1
 0 1 25 0 0
 1 1 0 0 1
 7 2 44 0 0
 1 1 0 0 1
 0 2 44 0 0
 1 1 0 0 1
 9 3 1 0 0
 0 1 0 0 2
 110.0718.11
 10 4 1 0 0
 0 1 0 0 2
 1 5.2413.70
 11 5 1 0
 0 1 0 0 2
 122.1820.18

rods 11 1 1 0 0 1
 1 1 26
 1 .563 1.0 1 375 2 .125
 2 .563 1.0 1 .500 2 .250 3 .250
 3 .563 1.0 1 .500 3 .250 4 .250
 4 .563 1.0 1 .250 4 .250 5 .250 8 .250
 5 .563 1.0 5 .250 6 .250 8 .500
 6 .563 1.0 6 .250 7 .250 8 .500
 7 .563 1.0 7 .250 8 .375 14 .375

8	.563	1.0	2 .125	3 .250	9 .125		
9	.563	1.0	3 .250	4 .250	9 .250	10 .250	
10	.563	1.0	4 .250	5 .250	10 .250	11 .250	
11	.563	1.0	5 .250	6 .250	11 .250	12 .250	
12	.563	1.0	6 .250	7 .250	12 .250	13 .250	
13	.563	1.0	7 .250	13 .250	14 .500		
14	.563	1.0	9 .125	10 .250	15 .125		
15	.563	1.0	10 .250	11 .250	15 .250	16 .250	
16	.563	1.0	11 .250	12 .250	16 .250	17 .250	
17	.563	1.0	12 .250	13 .250	17 .250	18 .250	
18	.563	1.0	13 .250	14 .500	18 .250		
19	.563	1.0	15 .125	16 .250	20 .125		
20	.563	1.0	16 .250	17 .250	20 .250	21 .250	
21	.563	1.0	17 .250	18 .250	21 .250	22 .250	
22	.563	1.0	14 .250	18 .250	19 .250	22 .250	
23	.563	1.0	20 .125	21 .250	23 .125		
24	.563	1.0	21 .250	22 .250	23 .250	24 .250	
25	.563	1.0	19 .500	22 .250	24 .250		
26	.563	1.0	23 .125	24 .250	25 .125		
27	.563	1.0	19 .500	24 .250	25 .250		
28	.563	1.0	19 .375	25 .125			
2	2	40					
1	.563	1.0	1 .375	2 .250	15 .375		
2	.563	1.0	1 .500	2 .250	3 .250		
3	.563	1.0	1 .500	3 .250	4 .250		
4	.563	1.0	1 .250	4 .250	5 .250	8 .250	
5	.563	1.0	5 .250	8 .250	8 .500		
6	.563	1.0	6 .250	7 .250	8 .500		
7	.563	1.0	7 .250	8 .375	22 .375		
8	.563	1.0	2 .250	9 .250	15 .500		
9	.563	1.0	2 .250	3 .250	9 .250	10 .250	
10	.563	1.0	3 .250	4 .250	10 .250	11 .250	
11	.563	1.0	4 .250	5 .250	11 .250	12 .250	
12	.563	1.0	5 .250	6 .250	12 .250	13 .250	
13	.563	1.0	6 .250	7 .250	13 .250	14 .250	
14	.563	1.0	7 .250	14 .250	22 .500		
15	.563	1.0	9 .250	15 .500	16 .250		
16	.563	1.0	9 .250	16 .250	16 .250	17 .250	
17	.563	1.0	10 .250	11 .250	17 .250	18 .250	
18	.563	1.0	11 .250	12 .250	18 .250	19 .250	
19	.563	1.0	12 .250	13 .250	19 .250	20 .250	
20	.563	1.0	13 .250	14 .250	20 .250	21 .250	
21	.563	1.0	14 .250	21 .250	22 .500		
22	.563	1.0	15 .250	16 .250	23 .250	24 .250	
23	.563	1.0	16 .250	17 .250	24 .250	25 .250	
24	.563	1.0	17 .250	18 .250	25 .250	26 .250	
25	.563	1.0	18 .250	19 .250	26 .250	27 .250	
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28	.563	1.0	21 .250	22 .250	29 .250	30 .250	
29	.563	1.0	23 .500	24 .250	31 .250		
30	.563	1.0	24 .250	25 .250	31 .250	32 .250	
31	.563	1.0	25 .250	26 .250	32 .250	33 .250	
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38	.563	1.0	32 .250	33 .250	39 .250	40 .250	

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1				16.78		2660.	0.20	0.50	3.02	
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4				205.40		0.00				
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35				69.03		73.2				
36				136.86		146.4				
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38				38.13		2660.	0.20	0.20	3.02	

39		975.50	73220	0.20	0.20	.110
40		51.58	3724	0.20	0.20	1.88
41		85.25	2128.7	0.50	0.20	3.18
42		95.88	3124.94	0.50	0.20	2.18
43		100.71	3475.2	0.50	0.20	1.94
44		73.77	2402.54	0.50	0.20	2.81
45		51.95	1887.27	0.50	0.20	4.00
46		77.59	2519.84	0.50	0.20	2.68
47		43.18	1399.31	0.50	0.20	4.83
48		97.34	3154.34	0.50	0.20	2.14
49		102.40	0.00			
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54		165.02	872.85	0.20	0.60	5.55
55		117.47	478.55	0.20	0.60	7.80
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69		2290.33	0.00			
70		38.21	2860	0.20	0.20	3.02
71		301.27	22559	0.20	0.20	0.38
72		43.54	3280	0.20	0.20	2.64
73		44.87	3375	0.20	0.20	2.56
74		248.74	18701	0.20	0.20	0.46
75		48.91	3877	0.20	0.20	2.35
76		16.79	2860	0.20	0.50	3.02
77		16.77	2850	0.20	0.50	3.02
78		16.86	2860	0.20	0.50	3.02
79		16.84	2860	0.20	0.50	3.02
80		17.00	2860	0.20	0.50	3.02
81		16.99	2860	0.20	0.50	3.02
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92	3	.452	1	94	37					
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25		6.71	2.94							
26		6.89	2.94							

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70	5	3.63	71	5	3.63	72	5	3.63
73	5	3.63	74	5	3.63	75	5	3.63
76	5	3.63	77	5	3.63	78	5	3.63
79	5	3.63	80	5	3.63	81	5	3.63
82	5	3.63	83	5	3.63	84	5	3.63
85	5	3.63	86	5	3.63	87	5	3.63
88	5	3.63	89	5	3.63	90	5	3.63

```

          91  5   3.63  92  5   3.63  93  5   3.63
          94  5   3.63
3 .238  7  0
4 .475 16 12  95  6   3.63  96  6   3.63  97  6   3.63
          98  6   3.63  99  6   3.63 100  6   3.63
          101 6   3.63 102 6   3.63 103 6   3.63
          104 6   3.63 105 6   3.63 106 6   3.63
5 .589 17  0
21.963363.9 3 5 14. 14.
1 1.0  8  0
285.28  9 12  95  3   3.63  96  3   3.63  97  3   3.63
          98  3   3.63  99  3   3.63 100  3   3.63
          101 3   3.63 102 3   3.63 103 3   3.63
          104 3   3.63 105 3   3.63 106 3   3.63
3107.7 10  0
1 1.0 11  0
2 1.0 12  0
31.366 13  0
41.543 14  0
51.825 15  0
calc  1  0  0

```

0.1

```

      30
oper  1      3  1
      20.0  200.  .00001 .00184485  300.  .000000  0.0
.8960.7998.7658.7479.7143.7010.6809.6879
18
0. 0.0443 0.00444 .476.6786 .476.1470.9951.21541.163
.28391.173.35231.157.42071.145.48011.116.55761.117.62601.096
69441.042.7829 .911.8313 .811.8655 .811.8656 0. 1.0 0.
outp 11011
endd

```

data from iterative solution using the recirculation module
time = 0.0000 dt = ***** implicit dt = 0.0000 explicit dt = ***** mode = 0

iteration no.	sweep no.	peak clad				total flow (lbs/s)	pressure drop(psi)	error			
		temp(f)	fluid	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	451.1	18	19	1	0.783e-10	-0.0000005	-0.3142	0.6645	0.1149	0.0194
	2	461.6	17	19	1			-0.1106	0.6645	0.0458	0.0225
2	1	453.5	18	19	1	0.457e-10	0.0000000	-0.0088	0.2839	0.0858	0.0278
	2	454.7	18	19	1			-0.0404	0.2839	0.0384	0.0133
3	1	455.4	15	19	1	0.259e-10	0.0000000	-0.0342	0.0547	0.0338	0.0079
	2	455.8	15	19	1			-0.0453	0.0547	0.0282	0.0062
4	1	454.5	15	19	1	0.178e-10	0.0000000	0.1442	0.0089	0.0212	0.0082
	2	441.3	14	19	1			0.1113	0.0089	0.0182	0.0053
5	1	438.8	14	19	1	0.928e-11	0.0000000	0.0930	0.0026	0.0112	0.0019
	2	436.8	14	19	1			0.0807	0.0026	0.0035	0.0012
6	1	435.6	14	19	1	0.346e-11	0.0000000	0.0722	0.0007	0.0030	0.0010
	2	434.7	14	19	1			0.0677	0.0007	0.0026	0.0007

7	1	433.9	14	19	1	0.179e-12	0.0000000	0.0236	0.0004	0.0000	0.0010
	2	431.3	13	19	1			0.0271	0.0004	0.0022	0.0014
8	1	436.8	12	19	1	-0.767e-12	0.0000000	0.0279	0.0004	0.0022	0.0009
	2	436.3	12	19	1			0.0250	0.0004	0.0022	0.0005
9	1	429.9	12	19	1	-0.804e-12	0.0000000	0.0235	0.0003	0.0022	0.0006
	2	429.4	12	19	1			0.0218	0.0003	0.0022	0.0004
10	1	429.0	12	19	1	-0.626e-12	0.0000000	0.0168	0.0002	0.0031	0.0009
	2	427.9	12	19	1			0.0154	0.0002	0.0021	0.0007
11	1	427.5	12	19	1	-0.326e-12	0.0000000	0.0142	0.0001	0.0022	0.0005
	2	427.1	12	19	1			0.0124	0.0001	0.0022	0.0003
12	1	426.9	12	19	1	-0.132e-12	0.0000000	0.0105	0.0001	0.0022	0.0004
	2	426.5	12	19	1			0.0093	0.0001	0.0022	0.0003
13	1	426.2	12	19	1	-0.074e-13	0.0000000	0.0107	0.0001	0.0025	0.0005
	2	425.3	12	19	1			0.0086	0.0001	0.0021	0.0004
14	1	425.2	12	19	1	-0.144e-13	0.0000000	0.0073	0.0000	0.0021	0.0003
	2	424.8	12	19	1			0.0057	0.0000	0.0021	0.0002
15	1	424.7	12	19	1	0.297e-14	0.0000000	0.0042	0.0000	0.0021	0.0002
	2	424.4	11	19	1			0.0031	0.0000	0.0021	0.0002
16	1	424.2	12	19	1	-0.093e-14	0.0000000	0.0077	0.0000	0.0025	0.0004
	2	423.9	11	19	1			0.0053	0.0000	0.0021	0.0003
17	1	423.7	11	19	1	-0.399e-14	0.0000000	0.0039	0.0000	0.0021	0.0002
	2	423.7	11	19	1			0.0025	0.0000	0.0021	0.0001
18	1	423.4	11	19	1	-0.323e-14	0.0000000	0.0012	0.0000	0.0021	0.0002
	2	423.4	11	19	1			0.0003	0.0000	0.0021	0.0002

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 - 7.4	252.24	251.00	251.42	250.03	247.57	246.04	240.05	244.45	249.77	247.47
7.4 - 14.8	255.85	259.79	255.10	260.44	264.04	262.74	264.54	261.52	253.47	250.02
14.8 - 22.2	262.10	268.51	261.39	270.30	277.95	276.47	279.90	276.14	259.75	260.04
22.2 - 29.6	260.57	277.04	267.91	280.72	292.39	290.72	295.92	291.31	266.26	278.57
29.6 - 37.0	275.76	280.25	275.11	289.71	303.52	301.77	307.09	302.95	273.41	287.62
37.0 - 44.4	281.83	292.99	281.18	296.76	311.70	310.00	316.64	311.58	279.45	294.70
44.4 - 51.9	287.59	298.83	286.92	302.07	318.00	316.22	323.01	317.94	285.14	300.50
51.9 - 59.3	291.00	303.02	291.10	306.85	322.20	320.42	327.23	322.20	289.36	304.73
59.3 - 66.7	295.43	306.45	294.72	310.22	325.39	323.00	330.34	325.32	292.00	300.03
66.7 - 74.1	297.37	308.20	296.85	311.99	326.90	325.19	331.06	326.06	294.76	309.75
74.1 - 81.5	290.40	309.10	297.67	312.81	327.55	325.74	332.30	327.20	295.75	310.52
81.5 - 88.9	297.62	300.24	296.00	311.81	326.30	324.51	330.96	325.95	294.97	309.50
88.9 - 96.3	295.00	300.40	295.14	309.99	324.33	322.52	328.90	323.07	293.22	307.60

96.3 -103.7	292.00	302.65	291.33	306.17	320.44	318.64	324.98	319.93	289.45	303.67
103.7 -111.1	287.27	297.70	286.55	301.26	315.34	313.53	319.76	314.74	284.70	299.00
111.1 -118.5	280.10	290.47	279.42	293.90	307.89	305.93	312.04	307.08	277.65	291.73
118.5 -125.9	272.00	282.10	271.36	285.43	298.70	296.98	302.87	298.02	269.60	283.35
125.9 -133.3	261.30	270.90	260.01	274.03	286.42	284.81	290.30	285.74	259.30	272.15
133.3 -140.8	249.00	256.40	249.41	261.31	272.35	270.91	275.00	271.60	246.12	259.60
140.8 -148.2	235.99	243.00	235.71	245.47	254.60	253.47	257.48	254.13	234.83	244.34
148.2 -155.6	221.00	226.04	221.11	220.92	236.22	235.51	238.59	236.21	220.94	220.63
155.6 -163.0	203.21	204.51	204.33	200.01	209.29	209.02	210.67	210.49	205.66	207.73
163.0 -170.4	181.65	183.75	186.14	187.31	192.39	193.97	194.76	196.01	190.89	193.20
170.4 -177.8	146.97	157.73	166.00	168.75	179.89	183.51	184.55	187.20	178.77	182.98

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 - 7.4	247.37	245.52	239.66	237.75	235.02	237.04	235.96	233.55	241.45	240.19
7.4 - 14.8	251.03	255.78	251.77	243.62	246.48	249.50	241.65	246.02	256.21	254.76
14.8 - 22.2	257.22	265.55	263.54	252.34	257.64	261.05	250.56	250.60	268.89	267.28
22.2 - 29.6	263.65	275.00	278.05	261.69	269.69	273.30	259.00	271.95	282.21	280.45
29.6 - 37.0	270.71	284.75	286.48	270.79	279.99	283.54	268.93	282.95	292.69	290.83
37.0 - 44.4	276.67	291.75	294.60	278.37	280.20	291.59	276.47	291.50	300.64	298.72
44.4 - 51.9	282.27	297.50	300.00	284.65	294.55	297.02	282.69	297.90	306.69	304.73
51.9 - 59.3	286.44	301.60	305.24	289.10	290.99	302.18	287.17	302.28	310.64	308.06
59.3 - 66.7	289.67	304.94	308.37	292.41	302.00	305.26	290.36	305.27	313.94	311.93
66.7 - 74.1	291.74	306.65	309.91	294.05	303.60	306.78	291.97	306.70	315.60	313.48
74.1 - 81.5	292.70	307.39	310.31	294.49	303.91	307.16	292.40	306.93	316.00	313.97
81.5 - 88.9	291.92	306.30	309.05	293.35	302.63	305.91	291.25	305.59	314.76	312.76
88.9 - 96.3	290.10	304.54	306.00	291.12	300.30	303.74	289.03	303.32	312.79	310.77
96.3 -103.7	266.40	300.70	302.95	287.15	296.43	299.84	285.09	299.39	300.97	300.98
103.7 -111.1	261.77	295.95	297.02	282.03	291.26	294.74	280.01	294.21	303.96	301.99
111.1 -118.5	274.03	280.77	290.40	274.06	283.99	287.47	272.93	286.92	296.61	294.70
118.5 -125.9	267.01	280.51	281.00	266.61	275.40	278.96	264.72	278.26	287.99	286.15
125.9 -133.3	258.00	269.52	270.64	256.25	264.52	267.90	254.45	267.06	276.45	274.73
133.3 -140.8	246.01	257.35	250.11	245.00	252.42	255.62	243.37	254.40	263.41	261.00
140.8 -148.2	233.25	242.50	243.15	232.53	230.29	241.03	230.92	239.61	247.39	246.10
148.2 -155.6	220.22	227.51	228.39	220.33	224.64	226.77	218.82	225.00	231.42	230.45
155.6 -163.0	206.46	207.00	209.51	200.57	200.32	200.75	207.17	207.00	209.06	208.73
163.0 -170.4	194.33	195.04	198.09	200.39	199.42	198.90	199.00	197.50	197.12	197.10
170.4 -177.8	106.00	106.00	193.12	198.16	195.00	193.85	194.93	193.01	190.66	191.49

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

axial zone (inches)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)
0.0 - 7.4	238.93	237.02	227.07	225.00	224.18	220.24	244.17	241.14	240.32	238.27
7.4 - 14.8	254.10	252.64	247.10	245.00	246.60	243.13	247.70	250.90	243.01	247.89
14.8 - 22.2	267.30	265.71	264.90	262.90	267.16	264.09	253.01	260.35	249.69	257.04

22.2 - 29.6	281.33	279.49	283.14	281.29	287.98	285.19	288.11	278.27	255.81	266.74
29.6 - 37.0	292.25	290.30	296.81	295.01	302.99	300.48	287.01	278.07	262.52	275.15
37.0 - 44.4	300.54	298.53	306.76	304.96	313.66	311.23	272.86	285.68	268.23	281.82
44.4 - 51.9	306.73	304.88	313.47	311.64	320.53	318.08	278.34	291.33	273.56	287.36
51.9 - 59.3	310.95	308.87	317.75	315.88	324.78	322.24	282.43	295.37	277.55	291.33
59.3 - 66.7	314.00	311.90	320.47	318.56	327.31	324.70	285.78	298.53	280.81	294.43
66.7 - 74.1	315.49	313.38	321.64	319.69	328.33	325.86	287.81	300.20	282.59	296.06
74.1 - 81.5	315.88	313.76	321.57	319.59	328.10	325.37	288.53	300.89	283.46	296.73
81.5 - 88.9	314.58	312.47	319.99	318.02	328.40	323.68	287.75	299.98	282.69	295.74
88.9 - 96.3	312.48	310.38	317.81	315.83	323.96	321.21	286.02	298.07	280.98	293.93
96.3 - 103.7	308.62	306.53	313.68	311.74	320.05	317.35	282.36	294.39	277.48	290.31
103.7 - 111.1	303.52	301.46	308.36	306.44	314.86	312.00	277.75	289.65	272.88	285.64
111.1 - 118.5	296.14	294.13	300.81	298.94	307.88	304.41	270.97	282.89	268.29	278.81
118.5 - 125.9	287.44	285.50	291.53	289.78	297.42	294.84	263.33	274.87	258.85	270.96
125.9 - 133.3	275.86	274.03	279.18	277.39	284.49	281.93	253.49	264.11	249.35	260.68
133.3 - 140.8	262.78	261.09	264.64	262.87	268.95	266.31	243.83	252.51	239.31	249.36
140.8 - 148.2	248.82	245.34	248.86	245.18	249.87	246.92	230.89	238.55	227.79	235.87
148.2 - 155.6	231.86	229.88	228.74	226.91	229.84	226.81	218.74	224.79	216.48	222.89
155.6 - 163.0	209.15	208.36	204.25	202.48	202.84	198.78	206.38	207.22	205.25	205.98
163.0 - 170.4	198.86	197.57	192.83	190.79	189.28	185.72	196.28	198.78	196.45	196.35
170.4 - 177.8	192.44	192.22	187.59	185.74	183.82	180.28	189.97	191.83	191.43	191.26

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

axial zone (inches)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)	(40)
0.0 - 7.4	233.12	232.41	227.60	229.82	227.48	222.81	208.80	202.36	201.44	193.33
7.4 - 14.8	244.37	238.23	240.42	240.83	233.11	235.09	232.55	227.28	225.05	216.93
14.8 - 22.2	255.42	248.88	253.33	251.88	241.39	247.52	255.17	250.41	246.87	238.87
22.2 - 29.6	267.24	255.97	268.88	263.15	250.27	260.57	277.78	273.35	268.68	260.66
29.6 - 37.0	277.15	264.85	277.91	272.83	258.88	271.24	293.72	289.57	284.84	276.85
37.0 - 44.4	284.99	272.25	286.42	288.51	268.84	279.49	304.75	300.67	294.69	286.62
44.4 - 51.9	291.88	278.34	292.68	286.43	271.93	285.58	311.47	307.32	301.15	292.93
51.9 - 59.3	295.29	282.72	298.92	290.58	276.18	289.78	315.48	311.16	304.93	296.58
59.3 - 66.7	298.29	285.83	299.77	293.58	279.18	292.46	317.57	313.28	308.99	298.48
66.7 - 74.1	299.78	287.48	301.12	294.95	288.69	293.76	318.31	313.86	307.68	299.88
74.1 - 81.5	300.12	287.79	301.27	295.27	281.86	293.89	317.82	313.29	307.17	298.49
81.5 - 88.9	298.89	286.86	299.93	294.86	279.94	292.58	318.85	311.52	305.45	296.77
88.9 - 96.3	298.74	284.48	297.87	291.93	277.77	298.34	313.68	309.86	303.84	294.38
96.3 - 103.7	292.92	288.59	293.84	288.18	274.88	286.61	309.98	305.43	299.46	290.91
103.7 - 111.1	287.92	275.59	288.75	283.28	269.12	281.83	304.67	300.28	294.38	285.93
111.1 - 118.5	288.84	268.85	281.64	276.34	262.38	274.71	297.31	293.81	287.29	279.84
118.5 - 125.9	272.55	268.59	273.12	268.21	254.53	266.41	287.82	283.57	278.11	270.82
125.9 - 133.3	261.85	258.53	262.12	257.75	244.88	255.75	274.94	270.78	265.71	257.87
133.3 - 140.8	249.97	239.88	249.64	246.18	234.28	243.85	259.88	254.77	250.35	242.67
140.8 - 148.2	235.98	227.49	234.88	232.55	222.51	229.42	239.88	234.78	231.19	223.74
148.2 - 155.6	222.38	215.85	220.23	219.38	211.89	215.27	217.88	213.22	210.78	203.33
155.6 - 163.0	205.42	204.28	202.22	202.98	200.16	198.87	188.67	183.88	182.74	175.64
163.0 - 170.4	196.35	196.42	192.73	194.33	192.61	188.91	174.97	169.91	169.57	162.58
170.4 - 177.8	191.88	192.48	188.38	190.14	188.78	184.64	169.36	164.25	164.17	157.13

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

axial zone (inches)	(51)	(52)	(53)	(54)	(55)	(56)	(57)	(58)	(59)	(60)
0.0 - 7.4	158.79	143.71	235.73	232.00	230.01	228.09	221.78	220.99	213.74	216.91
7.4 - 14.8	174.46	157.46	239.12	240.95	233.89	236.39	231.99	228.37	225.20	226.42
14.8 - 22.2	191.06	170.91	244.77	249.47	239.32	244.32	241.97	234.24	238.65	235.72
22.2 - 29.6	207.83	184.22	250.88	258.53	245.00	252.77	252.70	242.69	248.77	245.76
29.6 - 37.0	219.35	193.95	257.15	260.46	251.22	260.20	261.74	250.87	258.67	254.31
37.0 - 44.4	227.53	200.90	262.89	272.82	256.58	266.39	268.97	257.73	266.39	261.22
44.4 - 51.9	232.33	205.07	267.86	278.12	261.56	271.52	274.57	263.36	272.09	266.60
51.9 - 59.3	235.14	207.59	271.73	281.95	265.31	275.27	278.53	267.44	276.00	270.44
59.3 - 66.7	238.46	208.75	274.88	284.92	268.34	278.17	281.30	270.30	278.59	273.12
66.7 - 74.1	236.82	209.09	276.60	286.50	270.00	279.72	282.68	271.74	279.82	274.47
74.1 - 81.5	236.18	208.48	277.43	287.12	270.78	280.33	282.96	272.05	279.91	274.74
81.5 - 88.9	234.74	207.21	278.66	286.17	270.02	279.42	281.80	270.97	278.65	273.61
88.9 - 96.3	232.63	205.24	274.97	284.39	268.36	277.66	279.72	268.85	276.49	271.58
96.3 -103.7	229.86	202.72	271.49	280.89	264.97	274.25	276.14	265.22	272.93	266.10
103.7 -111.1	225.77	199.00	267.00	276.37	260.88	269.82	271.40	260.49	268.16	263.49
111.1 -118.5	220.45	194.33	260.69	269.83	254.50	263.47	264.82	254.02	261.62	257.14
118.5 -125.9	213.29	186.02	253.49	262.30	247.54	256.18	257.00	246.47	253.76	246.66
125.9 -133.3	204.06	180.10	244.35	252.55	238.77	246.79	247.23	237.16	243.76	240.23
133.3 -140.8	192.32	170.22	234.73	241.92	229.55	236.61	236.31	227.07	232.42	229.00
140.8 -148.2	178.10	158.50	223.83	229.42	219.21	224.76	223.63	215.90	219.19	217.00
148.2 -155.6	162.61	145.65	213.25	217.38	209.25	213.43	211.40	205.03	206.13	200.27
155.6 -163.0	142.41	130.31	203.02	202.45	199.79	199.70	196.41	194.71	190.22	192.40
163.0 -170.4	132.46	121.94	195.21	194.14	192.67	191.98	188.49	187.55	181.83	184.96
170.4 -177.8	128.31	118.39	190.95	189.96	188.06	188.09	184.67	183.92	177.91	181.35

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

axial zone (inches)	(91)	(92)	(93)	(94)	(95)	(96)	(97)	(98)	(99)	(100)
0.0 - 7.4	99.97	96.82	95.27	95.62	74.21	73.55	72.14	71.12	71.25	70.76
7.4 - 14.8	102.94	99.94	97.88	98.47	78.03	77.21	75.52	74.26	75.01	74.36
14.8 - 22.2	106.28	103.45	100.90	101.71	80.59	79.72	77.93	76.58	77.52	76.81
22.2 - 29.6	109.95	107.28	104.27	105.30	82.99	82.11	80.27	78.90	79.84	79.10
29.6 - 37.0	112.85	110.23	106.91	108.09	84.68	83.78	81.90	80.50	81.42	80.67
37.0 - 44.4	115.43	112.82	109.30	110.56	86.20	85.37	83.45	82.03	82.93	82.17
44.4 - 51.9	117.00	114.40	110.70	112.00	87.20	86.28	84.30	82.84	83.77	82.99
51.9 - 59.3	118.35	115.61	111.93	113.25	87.99	87.04	85.03	83.53	84.50	83.70
59.3 - 66.7	118.84	116.02	112.32	113.64	88.19	87.21	85.15	83.62	84.64	83.82
66.7 - 74.1	119.03	116.16	112.46	113.77	88.25	87.28	85.17	83.62	84.68	83.85
74.1 - 81.5	118.53	115.61	111.92	113.23	87.76	86.76	84.65	83.08	84.19	83.35
81.5 - 88.9	117.83	114.90	111.25	112.54	87.23	86.23	84.11	82.54	83.67	82.82
88.9 - 96.3	116.43	113.51	109.88	111.16	86.12	85.12	83.01	81.44	82.58	81.74
96.3 -103.7	114.96	112.09	108.50	109.76	85.07	84.09	82.01	80.47	81.60	80.77
103.7 -111.1	112.66	109.84	106.31	107.56	83.38	82.41	80.36	78.84	79.97	79.16
111.1 -118.5	110.30	107.65	104.22	105.43	81.89	80.95	78.97	77.50	78.59	77.80

118.5	-125.9	107.20	104.52	101.22	102.38	79.70	78.78	76.85	75.41	76.50	75.73
125.9	-133.3	104.12	101.53	98.44	99.51	77.87	78.90	75.13	73.75	74.81	74.07
133.3	-140.8	100.22	97.63	94.82	95.77	75.40	74.54	72.74	71.40	72.49	71.76
140.8	-148.2	96.60	94.02	91.57	92.37	73.44	72.60	70.87	69.57	70.68	69.98
148.2	-155.6	92.60	89.94	87.91	88.52	71.14	70.30	68.60	67.32	68.53	67.83
155.6	-163.0	89.17	86.41	84.92	85.29	69.44	68.58	66.85	65.64	66.97	66.23
163.0	-170.4	86.58	83.78	82.56	82.80	67.97	68.97	65.01	64.00	65.59	64.71
170.4	-177.8	85.20	82.49	81.36	81.57	67.36	68.06	63.02	63.35	64.90	63.85

side boundary temperature summary time = 0.0000 seconds
boundary slab node no. 100

axial zone (inches)	(1)	(2)	(3)	(4)	(5)	(
0.0 - 7.4	56.74	55.22	48.47	48.17	14.00	
7.4 - 14.8	56.32	54.81	48.13	47.83	14.00	
14.8 - 22.2	57.60	56.10	49.21	48.90	14.00	
22.2 - 29.6	58.80	57.18	50.14	49.82	14.00	
29.6 - 37.0	60.04	58.37	51.13	50.80	14.00	
37.0 - 44.4	60.73	59.03	51.71	51.37	14.00	
44.4 - 51.9	61.40	59.60	52.24	51.89	14.00	
51.9 - 59.3	61.80	59.87	52.41	52.07	14.00	
59.3 - 66.7	61.77	60.03	52.53	52.19	14.00	
66.7 - 74.1	61.53	59.80	52.36	52.02	14.00	
74.1 - 81.5	61.31	59.59	52.17	51.82	14.00	
81.5 - 88.9	60.70	59.01	51.87	51.34	14.00	
88.9 - 96.3	60.20	58.53	51.26	50.93	14.00	
96.3 - 103.7	59.24	57.61	50.49	50.17	14.00	
103.7 - 111.1	58.52	56.92	49.90	49.58	14.00	
111.1 - 118.5	57.25	55.70	48.89	48.58	14.00	
118.5 - 125.9	56.34	54.83	48.13	47.83	14.00	
125.9 - 133.3	54.84	53.39	46.93	46.65	14.00	
133.3 - 140.8	53.79	52.39	46.07	45.79	14.00	
140.8 - 148.2	52.26	50.92	44.84	44.57	14.00	
148.2 - 155.6	51.20	49.91	43.96	43.71	14.00	
155.6 - 163.0	49.94	48.70	42.95	42.70	14.00	
163.0 - 170.4	49.00	47.87	42.25	42.01	14.00	
170.4 - 177.8	48.45	47.27	41.74	41.51	14.00	

calculated rod temperatures at time = 0.0000 seconds
rod no. 25
assembly 1 (fuel type 1 - cylinder)
rod o.d. - 0.563 (in.) zone-(fuel dia.(in.)) - 1-(0.477)

axial zone (in.)	heat flux (mbtu/hr-ft2)	type	hsurf (b/h-f-ft2) *	fluid	clad
0.0 - 7.4	0.0000	1	0.3	247.4	247.2
7.4 - 14.8	0.0000	1	0.3	298.9	300.6
14.8 - 22.2	0.0000	1	0.3	323.8	333.4
22.2 - 29.6	0.0000	1	0.3	354.8	368.1
29.6 - 37.0	0.0000	1	0.3	370.0	383.7

37.0 - 44.4	0.0000	1	0.3	380.4	394.8
44.4 - 51.9	0.0000	1	0.3	385.9	399.8
51.9 - 59.3	0.0000	1	0.3	389.0	402.9
59.3 - 66.7	0.0000	1	0.3	391.2	404.7
66.7 - 74.1	0.0000	1	0.3	392.0	405.6
74.1 - 81.5	0.0000	1	0.3	392.0	405.3
81.5 - 88.9	0.0000	1	0.3	390.0	403.4
88.9 - 96.3	0.0000	1	0.3	388.3	401.5
96.3 - 103.7	0.0000	1	0.3	385.0	398.6
103.7 - 111.1	0.0000	1	0.3	380.3	393.7
111.1 - 118.5	0.0000	1	0.3	372.8	386.6
118.5 - 125.9	0.0000	1	0.3	363.9	377.3
125.9 - 133.3	0.0000	1	0.3	349.9	363.2
133.3 - 140.8	0.0000	1	0.3	332.8	344.9
140.8 - 148.2	0.0000	1	0.3	306.2	316.9
148.2 - 155.6	0.0000	1	0.3	285.9	295.3
155.6 - 163.0	0.0000	1	0.3	269.2	269.1
163.0 - 170.4	0.0000	1	0.2	192.2	192.0
170.4 - 177.8	0.0000	1	0.2	179.0	178.3

calculated rod temperatures at time = 0.0000 seconds

rod no. 25

assembly 3

(fuel type 1 - cylinder)

rod o.d. - 0.563 (in.) zone-(fuel dia.(in.)) - 1-(0.477)

						* fuel temperatures(f.)	
						*	
axial zone	heat flux	type	hsurf	fluid	clad		
(in.)	(mbtu/hr-ft ²)		(b/h-f-ft ²)				
0.0 - 7.4	0.0000	1	0.3	227.3	227.6		
7.4 - 14.8	0.0000	1	0.3	279.8	287.1		
14.8 - 22.2	0.0000	1	0.3	307.6	316.6		
22.2 - 29.6	0.0000	1	0.3	340.9	352.9		
29.6 - 37.0	0.0000	1	0.3	358.0	370.3		
37.0 - 44.4	0.0000	1	0.3	369.7	382.3		
44.4 - 51.9	0.0000	1	0.3	375.8	387.9		
51.9 - 59.3	0.0000	1	0.3	378.9	391.1		
59.3 - 66.7	0.0000	1	0.3	380.7	392.7		
66.7 - 74.1	0.0000	1	0.3	381.3	393.3		
74.1 - 81.5	0.0000	1	0.3	380.0	392.5		
81.5 - 88.9	0.0000	1	0.3	378.8	390.4		
88.9 - 96.3	0.0000	1	0.3	378.5	388.2		
96.3 - 103.7	0.0000	1	0.3	373.2	385.1		
103.7 - 111.1	0.0000	1	0.3	368.2	380.0		
111.1 - 118.5	0.0000	1	0.3	360.9	372.9		
118.5 - 125.9	0.0000	1	0.3	351.7	363.5		
125.9 - 133.3	0.0000	1	0.3	337.6	349.4		
133.3 - 140.8	0.0000	1	0.3	320.2	331.1		
140.8 - 148.2	0.0000	1	0.3	294.2	303.8		
148.2 - 155.6	0.0000	1	0.3	273.9	282.7		
155.6 - 163.0	0.0000	1	0.3	203.8	204.1		
163.0 - 170.4	0.0000	1	0.2	192.0	192.5		
170.4 - 177.8	0.0000	1	0.2	186.9	187.5		

calculated rod temperatures at time = 0.0000 seconds

rod no. 25

assembly 6 (fuel type 1 - cylinder)

#rod o.d. - 0.563 (in.) zone-(fuel dia.(in.)) - 1-(0.477)

* fuel temperatures(f.)						
*						
axial zone	heat flux	type	hsurf	* fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2) *			
0.0 - 7.4	0.0000	1	0.2	169.5	171.4	
7.4 - 14.8	0.0000	1	0.3	224.8	235.4	
14.8 - 22.2	0.0000	1	0.3	253.5	260.7	
22.2 - 29.6	0.0000	1	0.3	287.4	304.3	
29.6 - 37.0	0.0000	1	0.3	303.9	321.7	
37.0 - 44.4	0.0000	1	0.3	314.8	333.2	
44.4 - 51.9	0.0000	1	0.3	319.5	337.7	
51.9 - 59.3	0.0000	1	0.3	321.8	339.9	
59.3 - 66.7	0.0000	1	0.3	322.7	340.6	
66.7 - 74.1	0.0000	1	0.3	322.7	340.5	
74.1 - 81.5	0.0000	1	0.3	321.6	339.3	
81.5 - 88.9	0.0000	1	0.3	319.5	337.0	
88.9 - 96.3	0.0000	1	0.3	317.6	335.1	
96.3 - 103.7	0.0000	1	0.3	315.0	332.6	
103.7 - 111.1	0.0000	1	0.3	310.9	328.4	
111.1 - 118.5	0.0000	1	0.3	305.0	322.4	
118.5 - 125.9	0.0000	1	0.3	297.1	314.2	
125.9 - 133.3	0.0000	1	0.3	284.9	301.3	
133.3 - 140.8	0.0000	1	0.3	268.9	284.2	
140.8 - 148.2	0.0000	1	0.3	244.3	257.5	
148.2 - 155.6	0.0000	1	0.3	225.2	237.0	
155.6 - 163.0	0.0000	1	0.2	154.0	156.7	
163.0 - 170.4	0.0000	1	0.2	142.8	144.5	
170.4 - 177.8	0.0000	1	0.2	130.2	139.8	

calculated rod temperatures at time = 0.0000 seconds

rod no. 25

assembly 7 (fuel type 1 - cylinder)

#rod o.d. - 0.563 (in.) zone-(fuel dia.(in.)) - 1-(0.477)

* fuel temperatures(f.)						
*						
axial zone	heat flux	type	hsurf	* fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2) *			
0.0 - 7.4	0.0000	1	0.3	224.5	224.3	
7.4 - 14.8	0.0000	1	0.4	281.5	283.0	
14.8 - 22.2	0.0000	1	0.4	306.2	308.0	
22.2 - 29.6	0.0000	1	0.4	330.8	341.3	
29.6 - 37.0	0.0000	1	0.4	353.2	355.6	
37.0 - 44.4	0.0000	1	0.4	363.1	365.7	
44.4 - 51.9	0.0000	1	0.4	367.5	370.0	
51.9 - 59.3	0.0000	1	0.4	370.0	372.6	
59.3 - 66.7	0.0000	1	0.4	371.5	374.0	
66.7 - 74.1	0.0000	1	0.4	372.1	374.7	
74.1 - 81.5	0.0000	1	0.4	371.7	374.2	
81.5 - 88.9	0.0000	1	0.4	369.7	372.2	
88.9 - 96.3	0.0000	1	0.4	368.0	370.5	
96.3 - 103.7	0.0000	1	0.4	365.3	367.9	

103.7 - 111.1	0.0000	1	0.4	361.8	363.5
111.1 - 118.5	0.0000	1	0.4	354.8	357.2
118.5 - 125.9	0.0000	1	0.4	348.7	349.0
125.9 - 133.3	0.0000	1	0.4	334.8	336.5
133.3 - 140.8	0.0000	1	0.4	318.3	320.4
140.8 - 148.2	0.0000	1	0.4	293.3	295.3
148.2 - 155.6	0.0000	1	0.3	276.5	278.2
155.6 - 163.0	0.0000	1	0.3	198.2	198.3
163.0 - 170.4	0.0000	1	0.3	190.1	190.2
170.4 - 177.8	0.0000	1	0.3	186.2	186.2

APPENDIX F

TN-24P PWR CASK PERFORMANCE TEST SIMULATIONS
INPUT, OUTPUT, AND CONVERGENCE LISTS

APPENDIX F

TN-24P PWR CASK PERFORMANCE TEST SIMULATIONS
INPUT, OUTPUT, AND CONVERGENCE LISTS

<u>Test Case</u>	<u>Input</u>	<u>Page Number Convergence List</u>	<u>Output</u>
Vertical, helium	F.2	F.14	F.16
Horizontal, helium	F.20	F.32	F.34


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-0000
  1  1  tn-24 vertical helium full-load validation analyses
prop  7  5
    1.  0.  100.0  .0780  1.24  83.33  .0410
    2.  200.  348.0  .0970  1.24  119.76  .0533
    3.  400.  596.0  .1150  1.24  156.25  .0641
    5.  600.  844.0  .1290  1.24  192.31  .0727
   10.  800.  1092.0  .1380  1.24  229.36  .0823
   15.  1000.  1340.0  .1380  1.24  265.25  .0907
   20.  1500.  1588.0  .1380  1.24  357.14  .1130
  1 alum  50.88
  2 steel  24.
  3 rescu  10.69
  4 radme  4.0000
  5 stilt  119.0
chan  7  16
    159.5  0.0
  1  1  136  0  0
  1  1  0  0  1
  1.0663.5750.1657  2.1984  486
  2.30041.226.6629  3.1410  486  4.1984  563
  3.0805.6630.6630  5.1410  563
  4.30041.226.6629  5.1410  486  7.1984  563
  5.17701.3261.326  6.1410  563  8.1410  563
  6.0768.7115.4972  9.0790  563
  7.30041.226.6629  8.1410  486  11.1984  563
  8.17701.3261.326  9.1410  563  12.1410  563
  9.15351.423.9943  10.0790  563  13.1410  563
 10.0768.7115.4972  14.1410  563
 11.30041.226.6629  12.1410  486  16.1984  563
 12.17701.3261.326  13.1410  563  17.1410  563
 13.17701.3261.326  14.1410  563  18.1410  563
 14.17701.3261.326  15.1410  563  19.1410  563
 15.0768.7115.4972  20.0790  563
 16.30041.226.6629  17.1410  486  22.1984  563
 17.17701.3261.326  18.1410  563  23.1410  563
 18.15351.423.9943  19.0790  563  24.0790  563
 19.15351.423.9943  20.1410  563  25.0790  563
 20.15351.423.9943  21.0790  563  26.1410  563
 21.0768.7115.4972  27.1410  563
 22.30041.226.6629  23.1410  486  29.1984  563
 23.17701.3261.326  24.1410  563  30.1410  563
 24.15351.423.9943  25.0790  563  31.1410  563
 25.15351.423.9943  26.1410  563  32.1410  563
 26.17701.3261.326  27.1410  563  33.1410  563
 27.17701.3261.326  28.1410  563  34.1410  563
 28.0805.6630.6630  35.1410  563
 29.30041.226.6629  30.1410  486  37.1984  563
 30.17701.3261.326  31.1410  563  36.1410  563
 31.17701.3261.326  32.1410  563  39.1410  563
 32.15351.423.9943  33.0790  563  40.0790  563
 33.15351.423.9943  34.1410  563  41.0790  563
 34.17701.3261.326  35.1410  563  42.1410  563
 35.17701.3261.326  36.1410  563  43.1410  563
 36.0768.7115.4972  44.0790  563
 37.30041.226.6629  38.1410  486  46.1984  563
 38.17701.3261.326  39.1410  563  47.1410  563
 39.17701.3261.326  40.1410  563  48.1410  563
 40.15351.423.9943  41.0790  563  49.1410  563
 41.15351.423.9943  42.1410  563  50.1410  563

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42.17701.3261.326	43.1410 .563	51.1410 .563
43.17701.3261.326	44.1410 .563	52.1410 .563
44.15351.423.9943	45.0790 .563	53.1410 .563
45.0768.7115.4972	54.1410 .563	
46.30041.226.6829	47.1410 .486	56.1984 .563
47.17701.3261.326	48.1410 .563	57.1410 .563
48.15351.423.9943	49.0790 .563	58.0790 .563
49.15351.423.9943	50.1410 .563	59.0790 .563
50.17701.3261.326	51.1410 .563	60.1410 .563
51.17701.3261.326	52.1410 .563	61.1410 .563
52.17701.3261.326	53.1410 .563	62.1410 .563
53.17701.3261.326	54.1410 .563	63.1410 .563
54.17701.3261.326	55.1410 .563	64.1410 .563
55.0885.6830.6830	65.1410 .563	
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58.15351.423.9943	59.0790 .563	69.1410 .563
59.15351.423.9943	60.1410 .563	70.1410 .563
60.15351.423.9943	61.0790 .563	71.0790 .563
61.15351.423.9943	62.1410 .563	72.0790 .563
62.17701.3261.326	63.1410 .563	73.1410 .563
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64.17701.3261.326	65.1410 .563	75.1410 .563
65.17701.3261.326	66.1410 .563	76.1410 .563
66.0768.7115.4972	77.0790 .563	
67.30041.226.6829	68.1410 .486	79.1984 .563
68.17701.3261.326	69.1410 .563	80.1410 .563
69.17701.3261.326	70.1410 .563	81.1410 .563
70.17701.3261.326	71.1410 .563	82.1410 .563
71.15351.423.9943	72.1410 .563	83.0790 .563
72.15351.423.9943	73.1410 .563	84.1410 .563
73.17701.3261.326	74.1410 .563	85.1410 .563
74.15351.423.9943	75.0790 .563	86.0790 .563
75.15351.423.9943	76.1410 .563	87.0790 .563
76.17701.3261.326	77.1410 .563	88.1410 .563
77.15351.423.9943	78.0790 .563	89.1410 .563
78.0768.7115.4972	90.1410 .563	
79.30041.226.6829	80.1410 .486	92.1984 .563
80.17701.3261.326	81.1410 .563	93.1410 .563
81.15351.423.9943	82.0790 .563	94.0790 .563
82.15351.423.9943	83.1410 .563	95.0790 .563
83.17701.3261.326	84.1410 .563	96.1410 .563
84.15351.423.9943	85.0790 .563	97.0790 .563
85.15351.423.9943	86.1410 .563	98.0790 .563
86.15351.423.9943	87.0790 .563	99.1410 .563
87.15351.423.9943	88.1410 .563	100.1410 .563
88.15351.423.9943	89.0790 .563	101.0790 .563
89.15351.423.9943	90.1410 .563	102.0790 .563
90.17701.3261.326	91.1410 .563	103.1410 .563
91.0768.7115.4972	104.0790 .563	
92.30041.226.6829	93.1410 .486	106.1984 .563
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95.15351.423.9943	96.1410 .563	109.1410 .563
96.17701.3261.326	97.1410 .563	110.1410 .563
97.15351.423.9943	98.0790 .563	111.1410 .563
98.15351.423.9943	99.1410 .563	112.1410 .563
99.17701.3261.326	100.1410 .563	113.1410 .563
100.17701.3261.326	101.1410 .563	114.1410 .563
101.15351.423.9943	102.0790 .563	115.1410 .563

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72.1699.1574.006	8.19844.427	15.141	486		
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18.09137.6336.132	19.0793.097	26.519	563		
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23.09137.6336.132	24.0793.097	31.519	563		

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25.71436.3074.806	28.0792.534	32.0792.534	33.502.563		
26.71436.3074.806	27.0792.534	34.502.563			
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33.56084.8843.812	34.0791.971	40.07901.971	41.361.563		
34.56084.8843.812	35.0791.971	42.361.563			
35.56084.8843.812	36.0791.971	43.361.563			
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37.56084.8843.812	38.0791.971	45.361.563			
38.56084.8843.812	39.0791.971	46.361.563			
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41.43083.3643.149	42.0791.400	40.0791.400	49.282.563		
42.43083.3643.149	43.0791.400	50.282.563			
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44.43083.3643.149	46.0791.400	52.282.563			
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47.43083.3643.149	48.0791.400	55.282.563			
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49.28551.9891.989	50.141.8445	56.1410.8445	57.1410.563		
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7 5 1 0 0					
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3	.422	1.	3	.125	5	.25	6	.125		
4	.422	1.	4	.25	5	.25	7	.25	8	.25
5	.422	1.	5	.25	6	.25	8	.25	9	.25
6	.422	0.	6	.125	9	.25	10	.125		
7	.422	1.	7	.25	8	.25	11	.25	12	.25
8	.422	1.	8	.25	9	.25	12	.25	13	.25
9	.422	1.	9	.25	10	.25	13	.25	14	.25
10	.422	1.	10	.125	14	.25	15	.125		

11	.422	1.	11	.25	12	.25	16	.25	17	.25
12	.422	1.	12	.25	13	.25	17	.25	18	.25
13	.422	1.	13	.25	14	.25	18	.25	19	.25
14	.422	1.	14	.25	15	.25	19	.25	20	.25
15	.422	0.	15	.125	20	.25	21	.125		
16	.422	1.	16	.25	17	.25	22	.25	23	.25
17	.422	1.	17	.25	18	.25	23	.25	24	.25
18	.422	0.	18	.25	19	.25	24	.25	25	.25
19	.422	1.	19	.25	20	.25	25	.25	26	.25
20	.422	1.	20	.25	21	.25	26	.25	27	.25
21	.422	1.	21	.125	27	.25	28	.125		
22	.422	1.	22	.25	23	.25	29	.25	30	.25
23	.422	1.	23	.25	24	.25	30	.25	31	.25
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27	.422	1.	27	.25	28	.25	34	.25	35	.25
28	.422	1.	28	.125	35	.25	36	.125		
29	.422	1.	29	.25	30	.25	37	.25	38	.25
30	.422	1.	30	.25	31	.25	38	.25	39	.25
31	.422	1.	31	.25	32	.25	39	.25	40	.25
32	.422	0.	32	.25	33	.25	40	.25	41	.25
33	.422	1.	33	.25	34	.25	41	.25	42	.25
34	.422	1.	34	.25	35	.25	42	.25	43	.25
35	.422	1.	35	.25	36	.25	43	.25	44	.25
36	.422	0.	36	.125	44	.25	45	.125		
37	.422	1.	37	.25	38	.25	46	.25	47	.25
38	.422	1.	38	.25	39	.25	47	.25	48	.25
39	.422	1.	39	.25	40	.25	48	.25	49	.25
40	.422	1.	40	.25	41	.25	49	.25	50	.25
41	.422	1.	41	.25	42	.25	50	.25	51	.25
42	.422	1.	42	.25	43	.25	51	.25	52	.25
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44	.422	1.	44	.25	45	.25	53	.25	54	.25
45	.422	1.	45	.125	54	.25	55	.125		
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47	.422	1.	47	.25	48	.25	57	.25	58	.25
48	.422	0.	48	.25	49	.25	58	.25	59	.25
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62	.422	1.	62	.25	63	.25	73	.25	74	.25
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65	.422	1.	65	.25	66	.25	76	.25	77	.25
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67	.422	1.	67	.25	68	.25	79	.25	80	.25
68	.422	1.	68	.25	69	.25	80	.25	81	.25
69	.422	1.	69	.25	70	.25	81	.25	82	.25
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74	.422	0.	74	.25	75	.25	86	.25	87	.25
75	.422	1.	75	.25	76	.25	87	.25	88	.25
76	.422	1.	76	.25	77	.25	88	.25	89	.25
77	.422	1.	77	.25	78	.25	89	.25	90	.25
78	.422	1.	78	.125	90	.25	91	.125		
79	.422	1.	79	.25	80	.25	92	.25	93	.25
80	.422	1.	80	.25	81	.25	93	.25	94	.25
81	.422	0.	81	.25	82	.25	94	.25	95	.25
82	.422	1.	82	.25	83	.25	95	.25	96	.25
83	.422	1.	83	.25	84	.25	96	.25	97	.25
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85	.422	1.	85	.25	86	.25	98	.25	99	.25
86	.422	1.	86	.25	87	.25	99	.25	100	.25
87	.422	1.	87	.25	88	.25	100	.25	101	.25
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91	.422	0.	91	.125	104	.25	105	.125		
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93	.422	1.	93	.25	94	.25	107	.25	108	.25
94	.422	1.	94	.25	95	.25	108	.25	109	.25
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6	.422	1.	63	.000	143	.000				
7	.422	1.	73	.000	153	.000				
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25	.422	1.	251.500	331.500		
26	.422	1.	261.500	341.500		
27	.422	1.	271.500	351.500		
28	.422	1.	281.500	361.500		
29	.422	1.	291.500	371.500		
30	.422	1.	301.500	381.500		
31	.422	1.	311.500	391.500		
32	.422	1.	321.500	401.500		
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35	.422	1.	351.000	431.000		
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39	.422	1.	391.000	471.000		
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41	.422	1.	410.500	490.500		
42	.422	1.	420.500	500.500		
43	.422	1.	430.500	510.500		
44	.422	1.	440.500	520.500		
45	.422	1.	450.500	530.500		
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49	.422	1.	10.375	80.375	90.125	160.125
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51	.422	1.	20.375	30.375	100.125	110.125
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55	.422	1.	60.375	70.375	140.125	150.125
56	.422	1.	70.250	80.250	150.250	160.250
57	.422	1.	80.375	90.375	160.125	170.125
58	.422	1.	90.250	100.250	170.250	180.250
59	.422	1.	100.375	110.375	180.125	190.125
60	.422	1.	110.250	120.250	190.250	200.250
61	.422	1.	120.375	130.375	200.125	210.125
62	.422	1.	130.250	140.250	210.250	220.250
63	.422	1.	140.375	150.375	220.125	230.125
64	.422	1.	150.250	160.250	230.250	240.250
65	.422	0.	160.375	170.375	240.125	250.125
66	.422	1.	170.250	180.250	250.250	260.250
67	.422	0.	180.375	190.375	260.125	270.125
68	.422	1.	190.250	200.250	270.250	280.250
69	.422	0.	200.375	210.375	280.125	290.125

70	.422	1.	210.250	220.250	290.250	300.250
71	.422	0.	220.375	230.375	300.125	310.125
72	.422	1.	230.250	240.250	310.250	320.250
73	.422	1.	240.375	250.375	320.125	330.125
74	.422	0.	250.250	260.250	330.250	340.250
75	.422	1.	260.375	270.375	340.125	350.125
76	.422	0.	270.250	280.250	350.250	360.250
77	.422	1.	280.375	290.375	360.125	370.125
78	.422	0.	290.250	300.250	370.250	380.250
79	.422	1.	300.375	310.375	380.125	390.125
80	.422	0.	310.250	320.250	390.250	400.250
81	.422	0.	320.375	330.375	400.125	410.125
82	.422	1.	330.250	340.250	410.250	420.250
83	.422	0.	340.375	350.375	420.125	430.125
84	.422	1.	350.250	360.250	430.250	440.250
85	.422	0.	360.375	370.375	440.125	450.125
86	.422	1.	370.250	380.250	450.250	460.250
87	.422	0.	380.375	390.375	460.125	470.125
88	.422	1.	390.250	400.250	470.250	480.250
89	.422	1.	400.375	410.375	480.125	490.125
90	.422	1.	410.250	420.250	490.250	500.250
91	.422	1.	420.375	430.375	500.125	510.125
92	.422	1.	430.250	440.250	510.250	520.250
93	.422	1.	440.375	450.375	520.125	530.125
94	.422	1.	450.250	460.250	530.250	540.250
95	.422	1.	460.375	470.375	540.125	550.125
96	.422	1.	470.250	480.250	550.250	560.250
97	.422	1.	480.375	490.375	560.125	570.125
98	.422	1.	490.250	500.250	570.500	
99	.422	1.	500.375	510.375	570.250	
100	.422	1.	510.250	520.250	570.500	
101	.422	1.	520.375	530.375	570.250	
102	.422	1.	530.250	540.250	570.500	
103	.422	1.	540.375	550.375	570.250	
104	.422	1.	550.250	560.250	570.500	
105	.422	0.	571.000			
3	1	120				
4	2	105				
5	0	0				
6	0	0				
7	0	0				
3.0	.059	655.	388	10.	0.1	400.02431000. .422
slab	20	18	51			
1				3344.3	0.00	
2				3.4	0.00	
3				185.6	0.00	
4				2954.7	0.00	
5				247.5	29.878	0.5 .007.715
6				202.9	0.00	
7				88.1	0.00	
8				361.8	0.00	
9				68.7	0.00	
10				332.2	0.00	
11				3.60	0.00	
12				161.39	0.00	
13				356.69	0.00	
14				194.48	0.00	
15				353.45		
16				303.43		
17				95.22		

18		713.30			
19		300.90			
20		0217.00			
1	10.858	1	2	18	
2	10.858	1	3	19	
3	10.078	2	4	14	7 19
4	11.715	1	5	13	
5	11.715	1	6	14	
6	10.078	1	12	14	
7	10.858	1	8	18	
8	10.858	1	9	19	
9	10.078	2	10	14	18 19
10	11.715	1	11	13	
11	11.715	1	14	14	
12	11.715	1	13	13	
13	11.715	1	14	14	
14	10.155	2	15	14	24 14
15	11.715	1	16	13	
16	11.715	1	17	14	
17	10.078	1	26	12	
18	10.858	1	19	18	
19	10.858	1	20	19	
20	10.078	2	21	17	22 14
21	10.151	1	28	20	
22	11.715	1	23	16	
23	11.200				
24	11.715	1	25	15	
25	11.004	1	29	20	
26	11.397	2	27	11	31 20
27	11.048				
28	215.64	2	29	10	32 9
29	215.64	2	30	10	33 9
30	215.64	2	31	10	34 9
31	215.64	1	35	9	
32	217.03	2	33	8	36 7
33	217.03	2	34	8	37 7
34	217.03	2	35	8	38 7
35	217.03	1	39	7	
36	230.21	2	37	6	40 5
37	230.21	2	38	6	41 5
38	230.21	2	39	6	42 5
39	230.21	1	43	5	
40	343.41	2	41	4	44 3
41	343.41	2	42	4	45 3
42	343.41	2	43	4	46 3
43	343.41	1	47	3	
44	23.459	2	45	1	48 2
45	23.459	2	46	1	49 2
46	23.459	2	47	1	50 2
47	23.459	1	51	2	
48	2				
49	2				
50	2				
51	2				
1	34.645	5.545			
2	09.290	2.005			
3	85.300	4.009			
4	140.50	1.306			
5	99.610	1.531			
6	2.032	4.295			

7	1.286	3.665											
8	1.3892	4.3585											
9	14.5498	8.4894											
10	18.588	8.583											
11	1.3948	4.2718											
12	1.8348	3.2488											
13	2.181	1.4788											
14	1.3892	4.3258											
15	1.3892	4.3815											
16	1.3892	5.2738											
17	34.845	8.8458											
18	1.3892	4.3913											
1	8	1	1	9	1	2	10	1	4	10	1	7	10
		1	11	10	1	16	10	1	22	10	1	29	10
2	8	1	37	10	1	48	10	1	68	10	1	87	10
		1	79	10	1	92	10	1	106	10	1	121	9
4	9	1	121	9	1	122	10	1	123	10	1	124	10
		1	125	10	1	126	10	1	127	10	1	128	10
		2	1	8									
5	9	1	129	10	1	130	10	1	131	10	1	132	10
		1	133	10	1	134	10	1	135	10	1	136	9
		2	2	8									
7	1	2	8	8									
8	1	2	7	8									
10	2	2	6	8	4	1	8						
11	2	2	5	8	4	2	8						
12	9	2	3	8	3	1	9	3	2	10	3	4	10
		3	7	10	3	11	10	3	16	10	3	22	10
		3	29	10									
13	9	2	4	8	3	29	10	3	48	10	3	56	10
		3	67	10	3	79	10	3	92	10	3	106	10
		3	121	9									
15	9	3	121	9	3	122	10	3	123	10	3	124	10
		3	125	10	3	126	10	3	127	10	3	128	10
		5	1	15									
16	9	3	129	10	3	130	10	3	131	10	3	132	10
		3	133	10	3	134	10	3	135	10	3	136	9
		5	1	8									
18	1	4	8	8									
19	1	4	7	8									
21	1	6	1	13									
22	2	4	6	8	6	1	10						
23	2	4	5	8	6	1	10						
24	2	4	3	8	5	1	8						
25	2	4	4	8	5	1	14						
26	1	5	1	7									
27	1	7	1	8									
28	1	6	1	17									
29	3	4	5	4	5	1	5	6	1	3			
30	1	5	1	1									
31	2	5	1	2	7	1	2						

radg	7	2	3										
1	5												
11.478	.8	1.8191	2.4864	3.8578	4.6478	5.4891							
28.845	.9	1.1134	2.8488	3.8623	4.2482	6.6033							
34.809	.9	1.8211	2.8835	3.8339	4.9158	5.8257							
45.273	.8	1.8133	2.2754	3.8982	4.8151	5.8							
54.391	.8	1.1389	2.8385	3.8235	4.8	5.8891							
2	8												

14.351	.8	1.0000	2.0000	3.0103	4.2583	5.1317	6.2192			
		7.0928	8.2817							
24.325	.8	1.0000	2.0000	3.2070	4.4189	5.0677	6.1126			
		7.1185	8.0825							
31.531	.9	1.0463	2.5870	3.0000	4.0000	5.0000	6.0503			
		7.1892	8.2072							
45.545	.9	1.2028	2.3267	3.0000	4.0000	5.0000	6.0339			
		7.1900	8.2400							
52.806	.9	1.2042	2.1844	3.0000	4.0000	5.0000	6.1895			
		7.3127	8.1892							
63.665	.8	1.2602	2.1329	3.0210	4.0513	5.1450	6.0000			
		7.3051	8.0845							
74.351	.8	1.0928	2.1898	3.0304	4.2422	5.2017	6.2571			
		7.0000	8.0000							
84.382	.8	1.2810	2.0818	3.0727	4.3139	5.1217	6.0710			
		7.0579	8.0000							
3	2									
14.295	.8	1.3139	2.0801							
22.800	.9	1.9843	2.0157							
1	1	4	1	2	4	5				
2	2	8	4	5	12	13	11	10	8	7
3	1	4	12	13	15	18				
4	2	8	10	11	24	25	23	22	19	18
5	-2	8	24	25	29	30	31	28	16	15
6	-1	5	21	28	29	23	22			
7	-3	2	27	31						
heat	1	0	1							
		3.66		3.66						
1.0	1.0	1.0	1.0	1.0						
drag	1	5								
100	-1.0			100	-1.0					
1	10	0								
7	5	120.0300	2.1919	2.3502	2.5204	2.6846	2.8488	2.9657	2.	
		9657								
7	2	2.0300	1.1919	1.3502	1.5204	1.6846	1.8488	1.9657	1.	
		9657	1.							
7	3	4.0300	1.1919	1.3502	1.5204	1.6846	1.8488	1.9657	1.	
		9657	1.							
7	6	7.0300	1.1919	1.3502	1.5204	1.6846	1.8488	1.9657	1.	
		9657	1.							
7	10	11.0300	1.1919	1.3502	1.5204	1.6846	1.8488	1.9657	1.	
		9657	1.							
7	15	16.0300	1.1919	1.3502	1.5204	1.6846	1.8488	1.9657	1.	
		9657	1.							
7	21	22.0300	1.1919	1.3502	1.5204	1.6846	1.8488	1.9657	1.	
		9657	1.							
7	28	29.0300	1.1919	1.3502	1.5204	1.6846	1.8488	1.9657	1.	
		9657	1.							
7	36	37.0300	1.1919	1.3502	1.5204	1.6846	1.8488	1.9657	1.	
		9657	1.							
7	45	46.0300	1.1919	1.3502	1.5204	1.6846	1.8488	1.9657	1.	
		9657	1.							
7	55	56.0300	1.1919	1.3502	1.5204	1.6846	1.8488	1.9657	1.	
		9657	1.							
7	66	67.0300	1.1919	1.3502	1.5204	1.6846	1.8488	1.9657	1.	
		9657	1.							
7	78	79.0300	1.1919	1.3502	1.5204	1.6846	1.8488	1.9657	1.	
		9657	1.							
7	91	92.0300	1.1919	1.3502	1.5204	1.6846	1.8488	1.9657	1.	
		9657	1.							

7	105	106.0388	1.1919	1.3562	1.5204	1.6846	1.8488	1.
		.9657	1.					
7	120	135.0388	1.1919	1.3562	1.5204	1.6846	1.8488	1.
		.9657	1.					
7	1	1.0388	.5.1919	.5.3562	.5.5204	.5.6846	.5.8488	.5
		.9657	.5					
7	130	136.0388	.5.1919	.5.3562	.5.5204	.5.6846	.5.8488	.5
		.9657	.5					
2	2	0						
7	9	57.0388	2.1919	2.3562	2.5204	2.6846	2.8488	2.
		.9657	2.					
7	1	8.0388	1.1919	1.3562	1.5204	1.6846	1.8488	1.
		.9657	1.					
3	1	0						
2	1	10.001	1.5.9999	1.5				
4	1	0						
2	1	10.001	1.5.9999	1.5				
5	1	0						
2	1	10.001	1.5.9999	1.5				
bdry	19	1	4	2				
1		5.24e-8	3.66e+2	0.3333333	.88			
2		4.73e-5						
3		4.60e-5						
4		1.32e-9	7.74e+7	0.3333333	.88			
5		1.09e-6						
6		3.26e-5						
7		1.15e-8	9.85e+4	0.3333333	.88			
8		2.02e-5						
9		9.36e-5						
10		3.94e-6	1.0	.25				
11		2.24e-8						
12		1.09e-7						
13		4.57e-4						
14		5.70e-9	6.02e+5	0.3333333	.88			
15		9.36e-5						
16		6.56e-5						
17		7.05e-5						
18		7.14e-5						
19		1.44e-4						
1	2	0.	65.	1.	65.			
48		18.820	1					
1	1.	1	1.	1				
49		18.820	1					
1	1.	1	1.	1				
50		18.820	1					
1	1.	1	1.	1				
51		18.820	1					
1	1.	1	1.	1				
131.	05322.2	7	4	65.0	65.0			
110.39	8	0						
20.649	15	0						
3	1.0	16	0					
4	2.0	17	0					
5	3.0	18	0					
6	3.75	19	12	20	2	8.02	29	2
				31	2	8.02	32	2
				34	2	8.02	35	2
				37	2	8.02	38	2
						8.02	30	2
						8.02	33	2
						8.02	36	2
						8.02	39	2
712.90	14	0						
1	1.0	8	0					

```

2 1.0 9 27 1 4 1.50 2 4 1.50 3 4 1.50
      4 4 1.50 5 4 1.50 6 4 1.50
      7 4 1.50 8 4 1.50 9 4 1.50
      10 4 1.50 11 4 1.50 12 4 1.50
      13 4 1.50 14 4 1.50 15 4 1.50
      16 4 1.50 17 4 1.50 18 4 1.50
      19 4 1.50 20 4 1.50 21 4 1.50
      22 4 1.50 23 4 1.50 24 4 1.50
      25 4 1.50 26 4 1.50 27 5 1.50

3 1.0 9 0
4 1.0 10 0
212.86322.2 3 3 65.0 65.0
1 1.00 5 0
211.31 6 12 20 2 5.61 29 2 5.61 30 2 5.61
      31 2 5.61 32 2 5.61 33 2 5.61
      34 2 5.61 35 2 5.61 36 2 5.61
      37 2 5.61 38 2 5.61 39 2 5.61

315.50 7 0
1 1.00 2 0
2 1.00 3 0
3 1.00 4 0
calc 1
      30
oper 1 3 1 1
20. 145. 1.e-4.001900250 185. -.000001 0.0
.9185.8535.8690.8535
14
0. 0.0001 0.0002 0.32.0027 0.79.1254 1.04.1801 1.10
.2500 1.10.5843 1.10.8897 1.10.7524 1.05.8150 0.80.9404 0.18
.9405 0.01.0000 0.0
outp 1101 2
endd

```

data from iterative solution using the recirculation module
time = 0.0000 dt = ***** implicit dt = 0.0000 explicit dt = 4.6500 mode = 0

iteration no.	sweep no.	peak clad				total flow (lb/s)	pressure drop(psi)	error			
		temp(f)	fluid	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	217.1	18	36	1	0.004e-11	0.0005410	0.5738	16.6257	0.0186	0.0003
	2	217.5	17	35	1			0.5291	16.6257	0.0447	0.0002
2	1	253.4	15	35	1	0.368e-11	0.0008201	0.4146	2.0054	0.0285	0.0016
	2	283.0	14	35	1			0.4072	2.0054	0.0113	0.0008
3	1	297.9	14	35	1	0.216e-11	0.0008231	0.4091	2.3556	0.0103	0.0003
	2	311.4	13	35	1			0.4048	2.3556	0.0003	0.0003
4	1	320.1	13	35	1	0.128e-11	0.0007704	-0.0304	3.2562	0.0443	0.0031
	2	356.6	12	35	1			-0.0046	3.2562	0.0143	0.0055
5	1	387.3	12	20	1	0.100e-11	0.0007700	0.0155	4.5580	0.0100	0.0004
	2	378.2	12	35	1			0.0226	4.5580	0.0028	0.0003

6	1	384.4	12	35	1	0.597e-12	0.0007672	0.0311	4.0149	0.0042	0.0001
	2	390.5	11	35	1			0.0352	4.0149	0.0026	0.0002
7	1	394.5	11	35	1	0.331e-12	0.0007626	0.0237	4.9098	0.0041	0.0002
	2	398.8	12	35	1			0.0288	4.9098	0.0018	0.0004
8	1	401.8	12	35	1	0.225e-12	0.0007598	0.0330	1.8768	0.0019	0.0001
	2	405.3	12	28	1			0.0369	1.8768	0.0016	0.0001
9	1	407.8	12	28	1	0.111e-12	0.0007573	0.0398	1.6098	0.0015	0.0001
	2	410.6	12	28	1			0.0419	1.6098	0.0014	0.0001
10	1	412.6	12	28	1	0.128e-13	0.0007517	0.0028	4.9612	0.0035	0.0003
	2	417.3	12	28	1			0.0080	4.9612	0.0013	0.0005
11	1	419.2	12	28	1	-0.105e-13	0.0007503	0.0111	1.4475	0.0011	0.0001
	2	421.4	12	28	1			0.0131	1.4475	0.0012	0.0001
12	1	422.8	12	28	1	-0.320e-13	0.0007491	0.0147	0.7751	0.0011	0.0000
	2	424.3	12	28	1			0.0160	0.7751	0.0012	0.0000
13	1	425.4	12	28	1	-0.512e-13	0.0007468	0.0027	1.7608	0.0018	0.0001
	2	427.3	12	28	1			0.0048	1.7608	0.0013	0.0002
14	1	428.2	12	28	1	-0.467e-13	0.0007461	0.0062	0.5892	0.0011	0.0000
	2	429.2	12	28	1			0.0072	0.5892	0.0012	0.0000
15	1	429.9	12	28	1	-0.457e-13	0.0007455	0.0080	0.3478	0.0012	0.0000
	2	430.6	12	28	1			0.0086	0.3478	0.0012	0.0000
16	1	431.1	12	28	1	-0.452e-13	0.0007443	0.0012	0.5548	0.0016	0.0001
	2	432.1	12	28	1			0.0023	0.5548	0.0013	0.0001
17	1	432.6	12	28	1	-0.367e-13	0.0007439	0.0031	0.2352	0.0012	0.0000
	2	433.1	12	28	1			0.0035	0.2352	0.0012	0.0000
18	1	433.4	12	28	1	-0.305e-13	0.0007436	0.0039	0.1667	0.0012	0.0000
	2	433.8	12	28	1			0.0043	0.1667	0.0013	0.0000
19	1	434.0	12	28	1	-0.208e-13	0.0007430	0.0007	0.2269	0.0014	0.0000
	2	434.5	12	28	1			0.0012	0.2269	0.0013	0.0001
20	1	434.7	12	28	1	-0.223e-13	0.0007428	0.0016	0.1117	0.0012	0.0000
	2	435.0	12	28	1			0.0018	0.1117	0.0013	0.0000
21	1	435.1	12	28	1	-0.102e-13	0.0007427	0.0020	0.0010	0.0013	0.0000
	2	435.3	12	28	1			0.0022	0.0010	0.0013	0.0000
22	1	435.4	12	28	1	-0.160e-13	0.0007424	0.0004	0.1039	0.0014	0.0000
	2	435.6	12	28	1			0.0006	0.1039	0.0013	0.0000
23	1	435.8	12	28	1	-0.110e-13	0.0007423	0.0008	0.0540	0.0013	0.0000
	2	435.9	12	28	1			0.0010	0.0540	0.0013	0.0000
24	1	435.9	12	28	1	-0.115e-13	0.0007422	0.0011	0.0401	0.0013	0.0000
	2	436.0	12	28	1			0.0012	0.0401	0.0013	0.0000
25	1	436.1	12	28	1	-0.890e-14	0.0007421	0.0003	0.0514	0.0013	0.0000
	2	436.2	12	28	1			0.0004	0.0514	0.0013	0.0000

26	1	436.3	12	28	1	-0.731e-14	0.0007428	0.0005	0.0266	0.0013	0.0000
	2	436.3	12	28	1			0.0006	0.0266	0.0013	0.0000
27	1	436.3	12	28	1	-0.512e-14	0.0007428	0.0006	0.0191	0.0013	0.0000
	2	436.4	12	28	1			0.0007	0.0191	0.0013	0.0000
28	1	436.4	12	28	1	-0.819e-14	0.0007419	0.0002	0.0266	0.0013	0.0000
	2	436.5	12	28	1			0.0003	0.0266	0.0013	0.0000
29	1	436.5	12	28	1	-0.300e-14	0.0007419	0.0004	0.0137	0.0013	0.0000
	2	436.5	12	28	1			0.0004	0.0137	0.0013	0.0000
30	1	436.5	12	28	1	-0.172e-14	0.0007419	0.0005	0.0099	0.0013	0.0000
	2	436.6	12	28	1			0.0005	0.0099	0.0013	0.0000

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 - 0.9	205.25	210.48	206.72	203.86	200.95	194.92	190.86	202.19	193.60	187.60
0.9 - 17.7	239.23	240.35	241.78	236.66	232.27	224.59	220.26	234.78	226.98	211.30
17.7 - 26.6	269.24	282.21	272.86	265.62	259.64	249.62	244.11	263.56	245.12	232.29
26.6 - 35.4	292.28	308.34	296.78	287.91	280.69	268.82	262.43	285.61	263.67	248.56
35.4 - 44.3	309.00	327.32	314.15	304.11	296.83	282.90	275.93	301.62	277.23	260.56
44.3 - 53.2	320.98	340.92	326.59	315.73	307.63	293.62	286.67	313.15	287.07	269.35
53.2 - 82.0	329.40	350.40	335.33	323.87	314.72	300.09	292.40	321.29	294.00	275.63
82.0 - 70.9	335.03	350.92	341.18	329.29	319.82	304.74	296.94	326.78	298.00	279.87
70.9 - 79.7	338.36	360.83	344.66	332.47	322.75	307.35	299.43	330.07	301.61	282.37
79.7 - 88.6	339.65	362.49	346.03	333.63	323.74	308.11	300.11	331.46	302.67	283.26
88.6 - 97.5	330.09	361.94	345.31	332.80	322.78	307.02	298.99	330.77	301.98	282.53
97.5 -106.3	335.79	358.02	342.18	329.66	319.61	303.82	295.81	327.88	299.31	280.00
106.3 -115.2	329.56	352.24	335.83	323.49	313.54	297.94	290.05	321.97	294.02	275.12
115.2 -124.1	318.72	340.48	324.73	312.90	303.35	288.48	280.85	311.55	284.90	266.90
124.1 -132.9	301.63	321.62	307.22	296.45	287.85	274.33	267.54	294.87	270.54	254.26
132.9 -141.8	280.57	290.14	285.58	276.28	268.97	257.45	251.71	274.24	252.91	238.86
141.8 -150.6	259.59	274.61	264.00	256.23	250.30	240.91	236.27	253.57	235.27	223.46
150.6 -159.5	244.27	257.41	248.26	241.67	236.84	229.10	225.32	238.25	221.98	211.86

side boundary temperature summary time = 0.0000 seconds
boundary slab node no. 48

axial zone (inches)	(1)	(2)
0.0 - 0.9	138.63	65.00
0.9 - 17.7	142.40	65.00
17.7 - 26.6	147.25	65.00
26.6 - 35.4	152.10	65.00
35.4 - 44.3	156.46	65.00

44.3 - 53.2	168.11	65.00
53.2 - 62.0	162.95	65.00
62.0 - 70.9	164.94	65.00
70.9 - 79.7	166.07	65.00
79.7 - 88.6	166.35	65.00
88.6 - 97.5	165.78	65.00
97.5 - 106.3	164.37	65.00
106.3 - 115.2	162.18	65.00
115.2 - 124.1	159.24	65.00
124.1 - 132.9	155.78	65.00
132.9 - 141.8	152.11	65.00
141.8 - 150.6	148.08	65.00
150.6 - 159.5	148.21	65.00

calculated rod temperatures at time = 0.0000 seconds
 rod no. 32
 assembly 1 (fuel type 1 - cylinder)
 Rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.368)

* fuel temperatures(f.)						
*						
axial zone	heat flux	type	hsurf	fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2)			
0.0 - 8.9	0.0000	1	10.0	224.3	224.3	
8.9 - 17.7	0.0000	1	10.6	287.2	287.2	
17.7 - 26.6	0.0000	1	11.0	333.9	333.8	
26.6 - 35.4	0.0000	1	11.3	365.7	365.6	
35.4 - 44.3	0.0000	1	11.5	387.3	387.2	
44.3 - 53.2	0.0000	1	11.6	402.6	402.6	
53.2 - 62.0	0.0000	1	11.7	413.5	413.4	
62.0 - 70.9	0.0000	1	11.8	420.9	420.8	
70.9 - 79.7	0.0000	1	11.8	425.6	425.5	
79.7 - 88.6	0.0000	1	11.8	428.0	427.9	
88.6 - 97.5	0.0000	1	11.8	428.1	428.0	
97.5 - 106.3	0.0000	1	11.8	425.7	425.6	
106.3 - 115.2	0.0000	1	11.8	419.8	419.8	
115.2 - 124.1	0.0000	1	11.7	407.6	407.6	
124.1 - 132.9	0.0000	1	11.5	382.3	382.3	
132.9 - 141.8	0.0000	1	11.1	348.5	348.4	
141.8 - 150.6	0.0000	1	10.8	311.8	311.8	
150.6 - 159.5	0.0000	1	10.5	278.0	278.0	

calculated rod temperatures at time = 0.0000 seconds
 rod no. 74
 assembly 2 (fuel type 1 - cylinder)
 Rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.368)

* fuel temperatures(f.)						
*						
axial zone	heat flux	type	hsurf	fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2)			
0.0 - 8.9	0.0000	1	9.4	219.6	219.7	
8.9 - 17.7	0.0000	1	9.9	275.2	275.2	

17.7 - 26.6	0.0000	1	10.3	316.5	316.5
26.6 - 35.4	0.0000	1	10.5	344.9	345.0
35.4 - 44.3	0.0000	1	10.7	364.3	364.4
44.3 - 53.2	0.0000	1	10.8	378.1	378.2
53.2 - 62.0	0.0000	1	10.9	387.8	387.9
62.0 - 70.9	0.0000	1	10.9	394.4	394.5
70.9 - 79.7	0.0000	1	11.0	398.5	398.6
79.7 - 88.6	0.0000	1	11.0	400.5	400.6
88.6 - 97.5	0.0000	1	11.0	400.3	400.4
97.5 - 106.3	0.0000	1	11.0	397.8	397.9
106.3 - 115.2	0.0000	1	10.9	391.9	392.0
115.2 - 124.1	0.0000	1	10.8	380.2	380.3
124.1 - 132.9	0.0000	1	10.6	356.8	356.9
132.9 - 141.8	0.0000	1	10.3	326.1	326.1
141.8 - 150.6	0.0000	1	10.1	293.2	293.3
150.6 - 159.5	0.0000	1	9.8	263.8	263.8

calculated rod temperatures at time = 0.0000 seconds

rod no. 74

assembly 3 (fuel type 1 - cylinder)

rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.366)

* fuel temperatures(f.)						
*						
axial zone	heat flux	type	hsurf	* fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-ft2) *			
0.0 - 8.9	0.0000	1	9.9	214.5	214.5	
8.9 - 17.7	0.0000	1	10.4	260.7	260.6	
17.7 - 26.6	0.0000	1	10.7	303.2	303.1	
26.6 - 35.4	0.0000	1	10.9	326.9	326.8	
35.4 - 44.3	0.0000	1	11.1	342.4	342.4	
44.3 - 53.2	0.0000	1	11.2	353.5	353.4	
53.2 - 62.0	0.0000	1	11.3	361.2	361.2	
62.0 - 70.9	0.0000	1	11.3	366.4	366.4	
70.9 - 79.7	0.0000	1	11.3	369.5	369.5	
79.7 - 88.6	0.0000	1	11.3	370.8	370.7	
88.6 - 97.5	0.0000	1	11.3	370.2	370.2	
97.5 - 106.3	0.0000	1	11.3	367.6	367.6	
106.3 - 115.2	0.0000	1	11.3	362.4	362.3	
115.2 - 124.1	0.0000	1	11.2	352.0	351.9	
124.1 - 132.9	0.0000	1	11.0	330.3	330.3	
132.9 - 141.8	0.0000	1	10.7	302.0	301.9	
141.8 - 150.6	0.0000	1	10.4	271.6	271.6	
150.6 - 159.5	0.0000	1	10.2	243.3	243.3	

calculated rod temperatures at time = 0.0000 seconds

rod no. 78

assembly 4 (fuel type 1 - cylinder)

rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.366)

* fuel temperatures(f.)						
*						
axial zone	heat flux	type	hsurf	* fluid	clad	

(in.)	(mbtu/hr-ft2)		(b/h-ft2) *		
0.0 - 8.9	0.0000	1	9.3	208.0	208.0
8.9 - 17.7	0.0000	1	9.7	251.7	251.7
17.7 - 26.6	0.0000	1	10.0	282.6	282.6
26.6 - 35.4	0.0000	1	10.1	302.6	302.6
35.4 - 44.3	0.0000	1	10.3	315.8	315.8
44.3 - 53.2	0.0000	1	10.3	325.3	325.3
53.2 - 62.0	0.0000	1	10.4	332.0	332.0
62.0 - 70.9	0.0000	1	10.4	336.6	336.6
70.9 - 79.7	0.0000	1	10.5	339.3	339.3
79.7 - 88.6	0.0000	1	10.5	340.4	340.4
88.6 - 97.5	0.0000	1	10.6	339.9	339.9
97.5 - 106.3	0.0000	1	10.4	337.6	337.6
106.3 - 115.2	0.0000	1	10.4	332.8	332.8
115.2 - 124.1	0.0000	1	10.3	323.4	323.4
124.1 - 132.9	0.0000	1	10.2	303.6	303.6
132.9 - 141.8	0.0000	1	9.9	277.9	277.9
141.8 - 150.6	0.0000	1	9.7	250.5	250.5
150.6 - 159.5	0.0000	1	9.5	224.9	224.9

-8888

1 1 bn-24 horizontal helium full-load validation analysis
prop 7 5
1. 0. 100.0 .0760 1.24 83.33 .0410
2. 200. 348.0 .0970 1.24 119.78 .0533
3. 400. 596.0 .1150 1.24 156.25 .0641
5. 600. 844.0 .1290 1.24 192.31 .0727
10. 800. 1092.0 .1360 1.24 229.36 .0823
15. 1000. 1340.0 .1380 1.24 265.25 .0907
20. 1500. 1588.0 .1380 1.24 357.14 .1138
1 alum 58.88
2 steel 24.
3 rescu 10.69
4 radme 4.0000
5 tilt 119.0

chan 22 18
159.5 90.0
1 1 57 0 0
1 1 0 0 1
11.4180.9594.800 2.19844.427 8.19844.427 9.9870 .280
21.4180.9594.800 3.19844.427 10.987 .280
32.1699.1574.800 4.19844.427 11.987 .486
42.1099.1574.800 6.19844.427 12.987 .486
52.9209.3554.800 8.19844.427 13.987 .688
62.9209.3554.800 7.19844.427 14.987 .688
72.1699.1574.800 8.19844.427 15.987 .486
82.1699.1574.800 16.9870 .486
91.1518.6198.619 10.14101.971 16.14101.971 17.8460 .5630
101.1518.6198.619 11.14101.971 18.846 .563
111.1518.6198.619 12.14101.971 19.846 .563
121.1518.6198.619 13.14101.971 20.846 .563
131.1518.6198.619 14.14101.971 21.846 .563
141.1518.6198.619 15.14101.971 22.846 .563
151.1518.6198.619 16.14101.971 23.846 .563
161.1518.6198.619 24.8460 .5630
17.89137.6336.132 18.0793.097 24.1410 .563 25.519 .563
18.89137.6336.132 19.0793.097 26.519 .563
19.89137.6336.132 20.0793.097 27.519 .563
20.89137.6336.132 21.0793.097 28.519 .563
21.89137.6336.132 22.0793.097 29.519 .563
22.89137.6336.132 23.0793.097 30.519 .563
23.89137.6336.132 24.0793.097 31.519 .563
24.89137.6336.132 32.519 .563
25.71438.3074.800 26.0792.534 32.0792.534 33.502 .563
26.71438.3074.800 27.0792.534 34.502 .563
27.71438.3074.800 28.0792.535 35.502 .563
28.71438.3074.800 29.0792.534 36.502 .563
29.71438.3074.800 30.0792.534 37.502 .563
30.71438.3074.800 31.0792.534 38.502 .563
31.71438.3074.800 32.0792.534 39.502 .563
32.71438.3074.800 40.502 .563
33.56004.8843.812 34.0791.971 40.0791.971 41.361 .563
34.56004.8843.812 35.0791.971 42.361 .563
35.56004.8843.812 36.0791.971 43.361 .563
36.56004.8843.812 37.0791.971 44.361 .563
37.56004.8843.812 38.0791.971 45.361 .563
38.56004.8843.812 39.0791.971 46.361 .563
39.56004.8843.812 40.0791.971 47.361 .563
40.56004.8843.812 48.361 .563
41.43083.3643.149 42.0791.408 48.0791.408 49.282 .563

42.43083.3643.149	43.0791.408	50.282.563	
43.43083.3643.149	44.0791.408	51.282.563	
44.43083.3643.149	45.0791.408	52.282.563	
45.43083.3643.149	46.0791.408	53.282.563	
46.43083.3643.149	47.0791.408	54.282.563	
47.43083.3643.149	48.0791.408	55.282.563	
48.43083.3643.149	50.282.563		
49.26551.9891.989	50.141.8445	50.1410.8445	57.1410.503
50.26551.9891.989	51.141.8445	57.141.503	
51.26551.9891.989	52.141.8445	57.141.503	
52.26551.9891.989	53.141.8445	57.141.503	
53.26551.9891.989	54.141.8445	57.141.503	
54.26551.9891.989	56.141.8445	57.141.503	
55.26551.9891.989	56.141.8445	57.141.503	
58.26551.9891.989	57.141.503		
57.81405.6923.977			
2 1 57 0 0 0			
1 1 0 0 1			
3 1 57 0 0 0			
1 1 0 0 1			
4 1 57 0 0 0			
1 1 0 0 1			
5 2 1 0 0 0			
1 1 0 0 1			
158.6932.15			
6 3 1 0 0 0			
1 1 0 0 1			
17.89918.68			
7 4 1 0 0 0			
1 1 0 0 1			
19.22512.51			
8 1 57 0 0 0			
1 1 0 0 1			
9 1 57 0 0 0			
1 1 0 0 1			
10 2 1 0 0 0			
1 1 0 0 1			
11 3 1 0 0 0			
1 1 0 0 1			
12 1 57 0 0 0			
1 1 0 0 1			
13 1 57 0 0 0			
1 1 0 0 1			
14 1 57 0 0 0			
1 1 0 0 1			
15 1 57 0 0 0			
1 1 0 0 1			
16 2 1 0 0 0			
1 1 0 0 1			
17 3 1 0 0 0			
1 1 0 0 1			
18 4 1 0 0 0			
1 1 0 0 1			
19 1 57 0 0 0			
1 1 0 0 0			
20 1 57 0 0 0			
1 1 0 0 1			
21 2 1 0 0 0			
1 1 0 0 1			
22 3 1 0 0 0			

	1	1	0	0	1				
roda	22	1	1	0	0	1			
1	1	105							
1	.422	1.	13.000	93.000					
2	.422	1.	23.000	103.000					
3	.422	1.	33.000	113.000					
4	.422	1.	43.000	123.000					
5	.422	1.	53.000	133.000					
6	.422	1.	63.000	143.000					
7	.422	1.	73.000	153.000					
8	.422	1.	83.000	163.000					
9	.422	1.	92.500	172.500					
10	.422	1.	102.500	182.500					
11	.422	1.	112.500	192.500					
12	.422	1.	122.500	202.500					
13	.422	1.	132.500	212.500					
14	.422	1.	142.500	222.500					
15	.422	1.	152.500	232.500					
16	.422	1.	162.500	242.500					
17	.422	.75	172.000	252.000					
18	.422	.75	182.000	262.000					
19	.422	.75	192.000	272.000					
20	.422	.75	202.000	282.000					
21	.422	.75	212.000	292.000					
22	.422	.75	222.000	302.000					
23	.422	.75	232.000	312.000					
24	.422	.75	242.000	322.000					
25	.422	1.	251.500	331.500					
26	.422	1.	261.500	341.500					
27	.422	1.	271.500	351.500					
28	.422	1.	281.500	361.500					
29	.422	1.	291.500	371.500					
30	.422	1.	301.500	381.500					
31	.422	1.	311.500	391.500					
32	.422	1.	321.500	401.500					
33	.422	1.	331.000	411.000					
34	.422	1.	341.000	421.000					
35	.422	1.	351.000	431.000					
36	.422	1.	361.000	441.000					
37	.422	1.	371.000	451.000					
38	.422	1.	381.000	461.000					
39	.422	1.	391.000	471.000					
40	.422	1.	401.000	481.000					
41	.422	1.	410.500	490.500					
42	.422	1.	420.500	500.500					
43	.422	1.	430.500	510.500					
44	.422	1.	440.500	520.500					
45	.422	1.	450.500	530.500					
46	.422	1.	460.500	540.500					
47	.422	1.	470.500	550.500					
48	.422	1.	480.500	560.500					
49	.422	1.	10.375	80.375	90.125	100.125			
50	.422	1.	10.250	20.250	90.250	100.250			
51	.422	1.	20.375	30.375	100.125	110.125			
52	.422	1.	30.250	40.250	110.250	120.250			
53	.422	1.	40.375	50.375	120.125	130.125			
54	.422	1.	50.250	60.250	130.250	140.250			
55	.422	1.	60.375	70.375	140.125	150.125			
56	.422	1.	70.250	80.250	150.250	160.250			

57	.422	1.	80.375	90.375	160.125	170.125
58	.422	1.	90.250	100.250	170.250	180.250
59	.422	1.	100.375	110.375	180.125	190.125
60	.422	1.	110.250	120.250	190.250	200.250
61	.422	1.	120.375	130.375	200.125	210.125
62	.422	1.	130.250	140.250	210.250	220.250
63	.422	1.	140.375	150.375	220.125	230.125
64	.422	1.	150.250	160.250	230.250	240.250
65	.422	0.	160.375	170.375	240.125	250.125
66	.422	1.	170.250	180.250	250.250	260.250
67	.422	0.	180.375	190.375	260.125	270.125
68	.422	1.	190.250	200.250	270.250	280.250
69	.422	0.	200.375	210.375	280.125	290.125
70	.422	1.	210.250	220.250	290.250	300.250
71	.422	0.	220.375	230.375	300.125	310.125
72	.422	1.	230.250	240.250	310.250	320.250
73	.422	1.	240.375	250.375	320.125	330.125
74	.422	0.	250.250	260.250	330.250	340.250
75	.422	1.	260.375	270.375	340.125	350.125
76	.422	0.	270.250	280.250	350.250	360.250
77	.422	1.	280.375	290.375	360.125	370.125
78	.422	0.	290.250	300.250	370.250	380.250
79	.422	1.	300.375	310.375	380.125	390.125
80	.422	0.	310.250	320.250	390.250	400.250
81	.422	0.	320.375	330.375	400.125	410.125
82	.422	1.	330.250	340.250	410.250	420.250
83	.422	0.	340.375	350.375	420.125	430.125
84	.422	1.	350.250	360.250	430.250	440.250
85	.422	0.	360.375	370.375	440.125	450.125
86	.422	1.	370.250	380.250	450.250	460.250
87	.422	0.	380.375	390.375	460.125	470.125
88	.422	1.	390.250	400.250	470.250	480.250
89	.422	1.	400.375	410.375	480.125	490.125
90	.422	1.	410.250	420.250	490.250	500.250
91	.422	1.	420.375	430.375	500.125	510.125
92	.422	1.	430.250	440.250	510.250	520.250
93	.422	1.	440.375	450.375	520.125	530.125
94	.422	1.	450.250	460.250	530.250	540.250
95	.422	1.	460.375	470.375	540.125	550.125
96	.422	1.	470.250	480.250	550.250	560.250
97	.422	1.	490.375	500.375	570.250	
98	.422	1.	490.250	500.250	570.500	
99	.422	1.	500.375	510.375	570.250	
100	.422	1.	510.250	520.250	570.500	
101	.422	1.	520.375	530.375	570.250	
102	.422	1.	530.250	540.250	570.500	
103	.422	1.	540.375	550.375	570.250	
104	.422	1.	550.250	560.250	570.500	
105	.422	0.	571.000			
2		1	105			
3		1	105			
4		1	105			
5		0	0			
6		0	0			
7		0	0			
8		1	105			
9		1	105			
10		0	0			
11		0	0			
12		1	105			

13 1 105
 14 1 105
 15 1 105
 16 0 0
 17 0 0
 18 0 0
 19 1 105
 20 1 105
 21 0 0
 22 0 0

3.0 .059 055. .366 10. 0.1 409. .02431000. .422

slab 22 18 191

1	3344.3	0.00
2	3.4	0.00
3	105.8	0.00
4	2954.7	0.00
5	247.5	29.078 0.5 .807.715
6	202.9	0.00
7	80.1	0.00
8	301.8	0.00
9	68.7	0.00
10	332.2	0.00
11	3.60	0.00
12	161.39	0.00
13	356.09	0.00
14	194.40	0.00
15	353.45	
16	303.43	
17	95.22	
18	713.38	
19	380.00	
20	6198.00	
21	1270.9	
22	11215.0	

1	10.851	2	2	18	142	19
2	10.858	1	3	19		
3	10.078	2	4	14	7	19
4	11.715	1	5	13		
5	11.715	1	6	14		
6	10.078	3	12	14	58	14 82 14
7	10.858	1	8	18		
8	10.858	1	9	19		
9	10.078	2	10	14	18	19
10	11.715	1	11	13		
11	11.715	1	14	14		
12	11.715	1	13	13		
13	11.715	1	14	14		
14	10.155	2	15	14	24	14
15	11.715	1	18	13		
16	11.715	1	17	14		
17	10.078	3	20	12	86	14 75 12
18	10.858	1	19	18		
19	10.858	1	20	19		
20	10.078	2	21	17	22	14
21	10.151	1	28	22		
22	11.715	1	23	16		
23	11.280					
24	11.715	1	25	15		
25	11.884	1	29	22		
26	11.397	2	27	11	31	22

27	11.048								
28	215.64	2	29	10	32	9			
29	215.64	2	30	10	33	9			
30	215.64	2	31	10	34	9			
31	215.64	2	35	9	80	10			
32	217.03	2	33	8	36	7			
33	217.03	2	34	8	37	7			
34	217.03	2	35	8	38	7			
35	217.03	2	39	7	84	8			
36	238.21	2	37	6	40	5			
37	238.21	2	38	6	41	5			
38	238.21	2	39	6	42	5			
39	238.21	2	43	5	88	6			
40	343.41	2	41	4	44	3			
41	343.41	2	42	4	45	3			
42	343.41	2	43	4	46	3			
43	343.41	2	47	3	92	4			
44	23.459	2	45	1	48	2			
45	23.459	2	46	1	49	2			
46	23.459	2	47	1	50	2			
47	23.459	2	51	2	90	1			
48	2								
49	2								
50	2								
51	2								
52	11.715	2	53	13	142	14			
53	11.715	1	54	14					
54	10.155	3	55	14	57	14	101	14	
55	11.715	1	56	13					
56	11.715								
57	11.715	1	58	13					
58	11.715	1	59	14					
59	10.155	3	60	14	67	14	104	14	
60	11.715	1	61	13					
61	11.715	1	64	14					
62	11.715	1	63	13					
63	11.715	1	64	14					
64	10.155	2	65	14	73	14			
65	11.715	1	66	13					
66	11.715								
67	11.715	1	68	13					
68	11.715	1	69	14					
69	10.155	3	70	17	71	14	112	14	
70	10.151	2	77	20	118	20			
71	11.715	1	72	15					
72	11.200								
73	11.715	1	74	15					
74	11.684	1	78	20					
75	11.397	2	76	11	80	20			
76	11.040								
77	215.64	3	78	10	81	9	110	10	
78	215.64	2	79	10	82	9			
79	215.64	2	80	10	83	9			
80	215.64	1	84	9					
81	217.03	3	82	8	85	7	122	8	
82	217.03	2	83	8	86	7			
83	217.03	2	84	8	87	7			
84	217.03	1	88	7					
85	238.21	3	86	6	89	5	126	6	
86	238.21	2	87	6	90	5			

87	238.21	2	88	6	91	5			
88	238.21	1	92	5					
89	343.41	3	98	4	93	3	138	4	
90	343.41	2	91	4	94	3			
91	343.41	2	92	4	95	3			
92	343.41	1	98	3					
93	23.459	3	94	1	97	2	134	1	
94	23.459	2	95	1	98	2			
95	23.459	2	98	1	99	2			
96	23.459	1	100	2					
97	2								
98	2								
99	2								
100	2								
101	11.715	1	102	13					
102	11.715	1	103	14					
103	10.155	3	100	14	153	14	147	14	
104	11.715	1	105	13					
105	11.715	1	108	14					
106	11.715	1	107	13					
107	11.715	1	108	14					
108	10.155	2	109	14	114	14			
109	11.715	1	110	13					
110	11.715	1	111	14					
111	10.155	3	118	12	157	14	166	12	
112	11.715	1	113	16					
113	11.280								
114	11.715	1	115	15					
115	11.884	1	119	20					
116	11.397	2	117	11	121	20			
117	11.848								
118	215.64	2	119	10	122	9			
119	215.84	2	120	10	123	9			
120	215.84	2	121	10	124	9			
121	215.64	2	125	9	171	10			
122	217.03	2	123	8	126	7			
123	217.03	2	124	8	127	7			
124	217.03	2	125	8	128	7			
125	217.03	2	129	7	175	8			
126	238.21	2	127	6	130	5			
127	238.21	2	128	6	131	5			
128	238.21	2	129	6	132	5			
129	238.21	2	133	5	179	6			
130	343.41	2	131	4	134	3			
131	343.41	2	132	4	135	3			
132	343.41	2	133	4	136	3			
133	343.41	2	137	3	183	4			
134	23.459	2	135	1	138	2			
135	23.459	2	136	1	139	2			
136	23.459	2	137	1	140	2			
137	23.459	2	141	2	187	1			
138	2								
139	2								
140	2								
141	2								
142	10.155	1	143	19					
143	10.885	1	144	18					
144	10.885	1	145	19					
145	10.155	2	148	14	148	19			
146	11.715	1	147	13					

147	11.715				
148	10.885	1	149	18	
149	10.885	1	150	19	
150	10.155	2	151	14	150 19
151	11.715	1	152	13	
152	11.715	1	155	14	
153	11.715	1	154	13	
154	11.715	1	155	14	
155	10.155	2	150	14	104 14
156	11.715	1	157	13	
157	11.715				
158	10.885	1	159	18	
159	10.885	1	160	19	
160	10.155	2	161	17	162 14
161	10.151	1	160	21	
162	11.715	1	163	16	
163	11.200				
164	11.715	1	165	15	
165	11.604	1	169	21	
166	11.397	2	167	11	171 21
167	11.046				
168	215.64	2	168	16	172 9
169	215.64	2	170	16	173 9
170	215.64	2	171	16	174 9
171	215.64	1	175	9	
172	217.03	2	173	8	176 7
173	217.03	2	174	8	177 7
174	217.03	2	175	8	178 7
175	217.03	1	179	7	
176	230.21	2	177	6	180 5
177	230.21	2	178	6	181 5
178	230.21	2	179	6	182 5
179	230.21	1	183	5	
180	343.41	2	181	4	184 3
181	343.41	2	182	4	185 3
182	343.41	2	183	4	186 3
183	343.41	1	187	3	
184	23.459	2	185	1	188 2
185	23.459	2	186	1	189 2
186	23.459	2	187	1	190 2
187	23.459	1	191	2	
188	2				
189	2				
190	2				
191	2				
1	34.845	5.545			
2	69.290	2.806			
3	85.380	4.009			
4	140.56	1.380			
5	99.610	1.531			
6	2.032	4.296			
7	1.206	3.605			
8	1.3692	4.3505			
9	14.5490	8.4894			
10	18.500	8.503			
11	1.3940	4.2718			
12	1.8340	3.2480			
13	2.181	1.4700			
14	1.3692	4.3250			
15	1.3692	4.3615			

110	2	14	3	8	16	1	8												
112	2	15	4	8	17	1	16												
113	2	15	3	8	17	1	16												
114	2	15	1	8	16	1	8												
115	2	15	2	8	16	1	14												
116	1	16	1	7															
117	1	18	1	6															
118	1	17	1	17															
119	3	15	3	4	18	1	5	17	1	3									
120	1	18	1	1															
121	2	16	1	2	18	1	2												
143	1	12	7	8															
144	1	12	8	8															
146	2	12	1	8	19	6	8												
147	2	12	2	8	19	5	8												
148	1	19	7	8															
149	1	19	8	8															
151	2	19	1	8	20	6	8												
152	2	19	2	8	20	5	8												
153	2	19	4	8	14	7	8												
154	2	19	3	8	14	8	8												
156	2	14	1	8	21	1	15												
157	2	14	2	8	21	1	8												
158	1	20	7	8															
159	1	20	8	8															
161	1	22	1	13															
162	1	20	1	8	22	1	18												
163	2	20	2	8	22	1	16												
164	2	20	4	8	21	1	8												
165	2	20	3	8	21	1	14												
166	1	21	1	7															
167	1	18	1	6															
168	1	22	1	17															
169	3	20	2	4	21	1	5	22	1	3									
170	1	21	1	1															
171	2	21	1	2	18	1	2												

radg	22	1	3																	
1	5																			
11.470	.8	1.0191	2.4064	3.0578	4.0478	5.4091														
26.045	.9	1.1134	2.0408	3.0023	4.2402	5.0033														
34.009	.9	1.0211	2.0035	3.0339	4.9158	5.0257														
45.273	.8	1.0133	2.2764	3.0062	4.0151	5.0														
54.391	.8	1.1369	2.0305	3.0235	4.0	5.0091														
2	8																			
14.351	.8	1.0000	2.0000	3.0163	4.2583	5.1317	6.2192													
		7.0928	8.2817																	
24.325	.8	1.0000	2.0000	3.2078	4.4189	5.0677	6.1126													
		7.1105	8.0025																	
31.531	.9	1.0463	2.5070	3.0000	4.0000	5.0000	6.0503													
		7.1092	8.2072																	
45.545	.9	1.2026	2.3267	3.0000	4.0000	5.0000	6.0339													
		7.1900	8.2468																	
52.006	.9	1.2042	2.1044	3.0000	4.0000	5.0000	6.1895													
		7.3127	8.1092																	
63.665	.8	1.2002	2.1329	3.0210	4.0513	5.1460	6.0000													
		7.3051	8.0045																	
74.351	.8	1.0920	2.1090	3.0384	4.2422	5.2017	6.2571													
		7.0000	8.0000																	
84.362	.8	1.2810	2.0818	3.0727	4.3139	5.1217	6.0710													

```

          7.0579  8.0000
3      4
14.295  .8  1.3139  2.6861  3.0000  4.0000
22.994  .9  1.9843  2.0157  3.0000  4.0000
32.994  .9  1.0000  2.0000  3.0157  4.9843
44.295  .8  1.0000  2.0000  3.6861  4.3139
1  1  0  52  53  55  56  5  4  2  1
2  1  0  4  5  12  13  11  10  8  7
3  1  0  62  63  65  66  16  15  13  12
4  1  0  10  11  24  25  23  22  19  18
5  -2  8  24  25  29  30  31  26  18  15
6  -1  5  21  28  29  23  22
7  -3  4  27  31  00  76
8  1  0  57  58  60  61  63  62  58  55
9  1  0  67  68  71  72  74  73  61  60
10 -2  8  73  74  78  79  80  75  66  65
11 -1  5  70  77  78  72  71
12  1  0  146  147  102  101  53  52  143  144
13  1  0  106  107  105  104  58  57  101  102
14  1  0  156  157  110  109  107  106  153  154
15  1  0  114  115  113  112  68  67  104  105
16  -2  8  114  115  119  120  121  116  110  109
17  -1  5  70  118  119  113  112
18  -3  4  117  121  171  167
19  1  0  151  152  154  153  147  146  148  149
20  1  0  162  163  165  164  152  151  158  159
21  -2  8  164  165  169  170  171  168  157  156
22  -1  5  161  168  169  183  182
heat  1  0  1
          3.66          3.66
1.0 1.0 1.0 1.0 1.0
drag  1  4
100 -1.0          100 -1.0
1  2  0
7  9  67.0388  2..1919  2..3582  2..5204  2..6846  2..8488  2.
    9657  2.
7  1  8.0388  1..1919  1..3582  1..5204  1..6846  1..8488  1.
    9657  1.
2  1  0
2  1  10.001  1.5.9999  1.5
3  1  0
2  1  10.001  1.5.9999  1.5
4  1  0
2  1  10.001  1.5.9999  1.5
bdry  19  1  18  2
1  5.24e-8  3.66e+2  0.3333333  .88
2  4.73e-5
3  4.60e-5
4  1.32e-9  7.74e+7  0.3333333  .88
5  1.89e-8
6  3.26e-5
7  1.15e-8  9.86e+4  0.3333333  .88
8  2.82e-5
9  9.36e-5
10  3.94e-8  1.0  .25
11  2.24e-8
12  1.89e-7
13  4.57e-4
14  5.70e-9  8.02e+5  0.3333333  .88
15  9.38e-5

```



```

58 4 1.50 59 4 1.50 60 4 1.50
61 4 1.50 62 4 1.50 63 4 1.50
64 4 1.50 65 4 1.50 66 4 1.50
67 4 1.50 68 4 1.50 69 4 1.50
70 4 1.50 71 4 1.50 72 4 1.50
73 4 1.50 74 4 1.50 75 4 1.50
76 5 1.50 101 4 1.50 102 4 1.50
103 4 1.50 104 4 1.50 105 4 1.50
106 4 1.50 107 4 1.50 108 4 1.50
109 4 1.50 110 4 1.50 111 4 1.50
112 4 1.50 113 4 1.50 114 4 1.50
115 4 1.50 116 5 1.50 117 4 1.50
142 4 1.50 143 4 1.50 144 4 1.50
145 4 1.50 146 4 1.50 147 4 1.50
148 4 1.50 149 4 1.50 150 4 1.50
151 4 1.50 152 4 1.50 153 4 1.50
154 4 1.50 155 4 1.50 156 4 1.50
157 4 1.50 158 4 1.50 159 4 1.50
160 4 1.50 161 4 1.50 162 4 1.50
163 4 1.50 164 4 1.50 165 4 1.50
166 4 1.50 167 5 1.50

```

```
3 1.0 9 0
```

```
4 1.0 4 0
```

```
251.401289. 3 3 65.0 65.0
```

```
1 1.00 5 0
```

```
211.31 6 12 28 2 5.61 29 2 5.61 30 2 5.61
```

```
31 2 5.61 32 2 5.61 33 2 5.61
```

```
34 2 5.61 35 2 5.61 36 2 5.61
```

```
37 2 5.61 38 2 5.61 39 2 5.61
```

```
315.50 7 0
```

```
1 1.00 2 0
```

```
2 1.00 3 0
```

```
3 1.00 4 0
```

```
calc 1
```

```
25
```

```
oper 1 3 1 1
```

```
20. 145. 1.e-4.001908250 185. .000000 0.0
```

```
.9185.8025.8025.8449.0000.0000.0000.8449.8449.0000.0000.8025
```

```
.8449.8449.8449.0000.0000.0000.8025.8449.0000.0000
```

```
14
```

```
0. 0.0.0001 0.0.0002 0.32.0627 0.79.1254 1.04.1801 1.10
```

```
.2500 1.10.5643 1.10.6897 1.10.7524 1.05.8150 0.00.9404 0.10
```

```
.9405 0.01.000 0.0
```

```
outp 1101
```

```
endd
```

```
data from iterative solution using the recirculation module
```

```
time = 0.0000 dt = ***** implicit dt = 0.0000 explicit dt = ***** mode = 0
```

iteration no.	sweep no.	peak clad				total flow (lbm/s)	pressure drop(psi)	error			
		temp(f)	fluid	rod	ass.			total energy	flow	fluid energy	rod energy
1	1	214.3	18	104	1	0.356e-10	-0.0003075	0.5590	16.3208	0.0149	0.0004
	2	214.7	17	104	1			0.5347	16.3208	0.0328	0.0006

2	1	254.6	15	104	1	0.146e-10	0.0000000	0.4204	1.0631	0.0291	0.0020
	2	261.5	14	104	1			0.4139	1.0631	0.0142	0.0007
3	1	298.1	13	104	1	0.524e-11	0.0000000	0.4238	0.2048	0.0110	0.0003
	2	307.6	13	104	1			0.4216	0.2048	0.0088	0.0003
4	1	316.6	13	104	1	-0.107e-11	0.0000000	-0.0784	0.1035	0.0391	0.0040
	2	354.0	11	104	1			-0.0355	0.1035	0.0112	0.0006
5	1	365.8	11	104	1	-0.302e-11	0.0000000	-0.0090	0.0375	0.0046	0.0006
	2	376.6	10	104	1			0.0020	0.0375	0.0025	0.0003
6	1	382.3	10	104	1	-0.123e-10	0.0000000	0.0132	0.0245	0.0025	0.0002
	2	387.5	10	104	1			0.0200	0.0245	0.0023	0.0002
7	1	391.9	10	104	1	-0.244e-10	0.0000000	0.0157	0.0160	0.0039	0.0002
	2	395.8	10	104	1			0.0225	0.0160	0.0026	0.0004
8	1	399.2	10	104	1	-0.321e-10	0.0000000	0.0206	0.0105	0.0016	0.0001
	2	402.3	10	104	1			0.0323	0.0105	0.0023	0.0001
9	1	405.1	10	104	1	-0.241e-10	0.0000000	0.0360	0.0068	0.0018	0.0001
	2	407.5	10	104	1			0.0303	0.0068	0.0023	0.0001
10	1	409.8	10	104	1	-0.135e-10	0.0000000	-0.0006	0.0044	0.0038	0.0003
	2	414.2	10	104	1			0.0050	0.0044	0.0025	0.0000
11	1	416.3	10	104	1	-0.506e-11	0.0000000	0.0005	0.0029	0.0020	0.0001
	2	418.2	10	104	1			0.0105	0.0029	0.0023	0.0001
12	1	419.8	10	104	1	-0.136e-11	0.0000000	0.0124	0.0019	0.0021	0.0001
	2	420.9	10	104	1			0.0137	0.0019	0.0023	0.0001
13	1	421.9	10	104	1	0.337e-12	0.0000000	0.0009	0.0012	0.0029	0.0001
	2	423.8	10	104	1			0.0031	0.0012	0.0024	0.0002
14	1	424.5	10	104	1	0.720e-12	0.0000000	0.0046	0.0008	0.0022	0.0001
	2	425.4	10	104	1			0.0055	0.0008	0.0023	0.0001
15	1	426.0	10	104	1	0.506e-12	0.0000000	0.0063	0.0005	0.0022	0.0001
	2	426.8	10	104	1			0.0060	0.0005	0.0023	0.0001
16	1	427.1	10	104	1	0.200e-12	0.0000000	0.0002	0.0003	0.0026	0.0001
	2	427.9	10	104	1			0.0013	0.0003	0.0023	0.0001
17	1	428.3	10	104	1	0.102e-12	0.0000000	0.0019	0.0002	0.0022	0.0001
	2	428.7	10	104	1			0.0024	0.0002	0.0023	0.0001
18	1	429.0	10	104	1	0.350e-14	0.0000000	0.0027	0.0001	0.0023	0.0001
	2	429.3	10	104	1			0.0030	0.0001	0.0023	0.0001
19	1	429.5	10	104	1	-0.413e-13	0.0000000	0.0001	0.0001	0.0024	0.0001
	2	429.8	10	104	1			0.0006	0.0001	0.0023	0.0001
20	1	430.0	10	104	1	-0.414e-13	0.0000000	0.0009	0.0001	0.0023	0.0001
	2	430.2	10	104	1			0.0011	0.0001	0.0023	0.0001
21	1	430.3	10	104	1	-0.300e-13	0.0000000	0.0013	0.0000	0.0023	0.0001
	2	430.4	10	104	1			0.0014	0.0000	0.0023	0.0001

22	1	430.8	10	104	1	-0.224e-13	0.0000000	0.0001	0.0000	0.0024	0.0001
	2	430.7	10	104	1			0.0003	0.0000	0.0023	0.0001
23	1	430.8	10	104	1	-0.127e-13	0.0000000	0.0004	0.0000	0.0023	0.0001
	2	430.9	10	104	1			0.0005	0.0000	0.0023	0.0001
24	1	430.9	10	104	1	-0.673e-14	0.0000000	0.0006	0.0000	0.0023	0.0001
	2	431.0	10	104	1			0.0007	0.0000	0.0023	0.0001

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 - 0.9	244.45	250.07	247.77	241.30	235.49	225.59	219.07	239.49	223.00	212.93
0.9 - 17.7	277.21	291.00	281.42	273.24	260.22	255.31	249.71	270.07	250.67	236.07
17.7 - 26.6	303.44	320.30	300.26	290.09	290.52	277.94	271.44	296.23	272.74	256.65
26.6 - 35.4	321.30	339.72	326.50	310.16	307.23	293.53	280.43	313.62	280.07	270.57
35.4 - 44.3	332.07	351.99	330.26	327.30	310.00	303.74	290.32	324.78	290.00	279.70
44.3 - 53.2	340.15	359.00	346.64	334.50	324.95	310.29	302.00	331.00	304.50	285.79
53.2 - 62.0	344.50	304.24	350.04	330.70	320.00	314.24	300.54	336.14	300.43	289.40
62.0 - 70.9	340.07	300.49	352.23	340.00	331.10	310.23	300.40	330.29	310.43	291.39
70.9 - 79.7	347.01	300.02	352.50	341.23	331.49	310.54	300.79	330.05	310.00	291.70
79.7 - 80.0	345.00	305.29	351.11	339.04	330.13	315.24	307.51	337.29	309.50	290.64
80.0 - 97.5	342.10	301.03	347.03	330.49	320.00	312.14	304.40	333.99	300.02	297.09
97.5 - 100.3	330.22	355.22	341.54	330.00	321.25	300.77	299.25	320.23	301.40	283.10
100.3 - 115.2	320.00	344.07	331.70	321.30	312.20	290.34	291.00	310.99	293.30	275.70
115.2 - 124.1	311.00	320.00	310.00	300.00	290.00	280.00	270.00	300.00	280.00	260.00
124.1 - 132.9	290.27	304.92	294.49	280.23	279.10	260.19	202.45	283.45	202.45	240.22
132.9 - 141.0	205.50	277.00	209.14	202.40	250.90	240.30	243.70	259.00	241.30	229.40
141.0 - 150.0	242.33	252.14	245.45	240.29	230.30	229.91	220.50	230.07	221.22	211.54
150.0 - 159.5	220.43	234.72	229.25	225.14	222.27	217.59	215.15	220.00	200.00	190.00

side boundary temperature summary time = 0.0000 seconds
boundary slab node no. 48

axial zone (inches)	(1)	(2)
0.0 - 0.9	137.54	05.00
0.9 - 17.7	143.44	05.00
17.7 - 26.6	149.94	05.00
26.6 - 35.4	155.50	05.00
35.4 - 44.3	100.00	05.00
44.3 - 53.2	103.37	05.00
53.2 - 62.0	105.01	05.00
62.0 - 70.9	100.00	05.00

78.9 - 79.7	187.18	85.88
79.7 - 88.6	186.61	85.88
88.6 - 97.5	185.14	85.88
97.5 - 106.3	182.79	85.88
106.3 - 115.2	159.55	85.88
115.2 - 124.1	155.46	85.88
124.1 - 132.9	158.86	85.88
132.9 - 141.8	145.36	85.88
141.8 - 150.6	139.97	85.88
150.6 - 159.5	135.55	85.88

calculated rod temperatures at time = 0.0000 seconds

rod no. 74

assembly 1 (fuel type 1 - cylinder)

rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.368)

```

* fuel temperatures(f.)
*
axial zone heat flux type hsurf * fluid clad
(in.) (mbtu/hr-ft2) (b/h-f-ft2) *
0.0 - 8.9 0.0000 1 10.0 287.7 287.6
8.9 - 17.7 0.0000 1 10.4 337.0 337.0
17.7 - 26.6 0.0000 1 10.7 371.9 372.0
26.6 - 35.4 0.0000 1 10.9 392.8 392.9
35.4 - 44.3 0.0000 1 11.0 405.0 405.1
44.3 - 53.2 0.0000 1 11.1 412.6 412.7
53.2 - 62.0 0.0000 1 11.1 417.1 417.2
62.0 - 70.9 0.0000 1 11.1 419.3 419.4
70.9 - 79.7 0.0000 1 11.1 419.6 419.7
79.7 - 88.6 0.0000 1 11.1 418.0 418.1
88.6 - 97.5 0.0000 1 11.1 414.4 414.5
97.5 - 106.3 0.0000 1 11.1 407.9 408.0
106.3 - 115.2 0.0000 1 11.0 397.4 397.5
115.2 - 124.1 0.0000 1 10.8 379.5 379.6
124.1 - 132.9 0.0000 1 10.5 348.1 348.2
132.9 - 141.8 0.0000 1 10.2 316.3 316.3
141.8 - 150.6 0.0000 1 9.9 272.9 272.9
150.6 - 159.5 0.0000 1 9.6 242.2 242.2

```

calculated rod temperatures at time = 0.0000 seconds

rod no. 74

assembly 2 (fuel type 1 - cylinder)

rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.368)

```

* fuel temperatures(f.)
*
axial zone heat flux type hsurf * fluid clad
(in.) (mbtu/hr-ft2) (b/h-f-ft2) *
0.0 - 8.9 0.0000 1 9.9 277.7 277.7
8.9 - 17.7 0.0000 1 10.3 324.6 324.6
17.7 - 26.6 0.0000 1 10.6 357.9 357.9
26.6 - 35.4 0.0000 1 10.8 377.9 378.0
35.4 - 44.3 0.0000 1 10.9 389.7 389.7

```

44.3 - 53.2	0.0000	1	11.0	397.0	397.1
53.2 - 62.0	0.0000	1	11.0	401.4	401.5
62.0 - 70.9	0.0000	1	11.0	403.8	403.7
70.9 - 79.7	0.0000	1	11.0	403.9	404.0
79.7 - 88.6	0.0000	1	11.0	402.4	402.5
88.6 - 97.5	0.0000	1	11.0	398.9	399.1
97.5 - 106.3	0.0000	1	10.9	392.8	392.9
106.3 - 115.2	0.0000	1	10.8	382.8	382.9
115.2 - 124.1	0.0000	1	10.7	365.9	366.1
124.1 - 132.9	0.0000	1	10.4	336.1	336.2
132.9 - 141.8	0.0000	1	10.1	300.3	300.4
141.8 - 150.6	0.0000	1	9.8	264.9	265.0
150.6 - 159.5	0.0000	1	9.6	235.7	235.7

calculated rod temperatures at time = 0.0000 seconds

rod no. 78

assembly 3 (fuel type 1 - cylinder)

rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.368)

* fuel temperatures(f.)						
*						
axial zone	heat flux	type	hsurf	fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2)			*
0.0 - 8.9	0.0000	1	9.8	259.8	259.7	
8.9 - 17.7	0.0000	1	10.1	302.8	302.8	
17.7 - 26.6	0.0000	1	10.4	332.2	332.2	
26.6 - 35.4	0.0000	1	10.5	349.5	349.5	
35.4 - 44.3	0.0000	1	10.6	359.8	359.8	
44.3 - 53.2	0.0000	1	10.7	366.0	366.1	
53.2 - 62.0	0.0000	1	10.7	369.9	369.9	
62.0 - 70.9	0.0000	1	10.7	371.0	371.9	
70.9 - 79.7	0.0000	1	10.7	372.1	372.1	
79.7 - 88.6	0.0000	1	10.7	370.8	370.9	
88.6 - 97.5	0.0000	1	10.7	367.8	367.8	
97.5 - 106.3	0.0000	1	10.7	362.4	362.5	
106.3 - 115.2	0.0000	1	10.6	353.9	353.9	
115.2 - 124.1	0.0000	1	10.6	339.5	339.5	
124.1 - 132.9	0.0000	1	10.2	313.4	313.4	
132.9 - 141.8	0.0000	1	10.0	281.9	282.0	
141.8 - 150.6	0.0000	1	9.7	250.7	250.7	
150.6 - 159.5	0.0000	1	9.5	224.2	224.2	

calculated rod temperatures at time = 0.0000 seconds

rod no. 78

assembly 4 (fuel type 1 - cylinder)

rod o.d. - 0.422 (in.) zone-(fuel dia.(in.)) - 1-(0.368)

* fuel temperatures(f.)						
*						
axial zone	heat flux	type	hsurf	fluid	clad	
(in.)	(mbtu/hr-ft2)		(b/h-f-ft2)			*
0.0 - 8.9	0.0000	1	9.6	244.9	244.9	
8.9 - 17.7	0.0000	1	10.0	283.9	283.8	
17.7 - 26.6	0.0000	1	10.2	310.9	310.9	

25.6 - 35.4	0.0000	1	10.4	326.7	326.7
35.4 - 44.3	0.0000	1	10.4	335.9	335.9
44.3 - 53.2	0.0000	1	10.5	341.9	341.8
53.2 - 62.0	0.0000	1	10.5	346.5	346.6
62.0 - 70.9	0.0000	1	10.5	347.3	347.3
70.9 - 79.7	0.0000	1	10.5	347.7	347.7
79.7 - 88.6	0.0000	1	10.5	346.5	346.6
88.6 - 97.5	0.0000	1	10.5	343.8	343.8
97.5 - 106.3	0.0000	1	10.5	339.1	339.1
106.3 - 115.2	0.0000	1	10.4	331.4	331.5
115.2 - 124.1	0.0000	1	10.3	318.4	318.4
124.1 - 132.9	0.0000	1	10.1	293.9	294.0
132.9 - 141.8	0.0000	1	9.8	264.2	264.2
141.8 - 150.6	0.0000	1	9.6	234.1	234.1
150.6 - 159.5	0.0000	1	9.3	207.6	207.6

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