TRUMP-BD: A Computer Code for the Analysis of Nuclear Fuel Assemblies Under Severe Accident Conditions

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ABSTRACT

TRUMP-BD (Boil Down) is an extension of the TRUMP (Edwards 1972) computer program for the analysis of nuclear fuel assemblies under severe accident conditions. This extension allows prediction of the heat transfer rates, metal-water oxidation rates, fission product release rates, steam generation and consumption rates, and temperature distributions for nuclear fuel assemblies under core uncover conditions. The heat transfer processes include conduction in solid structures, convection across fluid-solid boundaries, and radiation between interacting surfaces. Metal-water reaction kinetics are modeled with empirical relationships to predict the oxidation rates of steam-exposed Zircaloy and uranium metal. The metal-water oxidation models are parabolic in form with an Arrhenius temperature dependence. Uranium oxidation begins when fuel cladding failure occurs; Zircaloy oxidation occurs continuously at temperatures above 1300°F when metal and steam are available. From the metal-water reactions, the hydrogen generation rate, total hydrogen release, and temporal and spatial distribution of oxide formations are computed. Consumption of steam from the oxidation reactions and the effect of hydrogen on the coolant properties is modeled for independent coolant flow channels. Fission product release from exposed uranium metal Zircaloy-clad fuel is modeled using empirical time and temperature relationships that consider the release to be subject to oxidation and volatilization/diffusion ("bake-out") release mechanisms. Release of the volatile species of iodine (I), tellurium (Te), cesium (Ce), ruthenium (Ru), strontium (Sr), zirconium (Zr), cerium (Cr), and barium (Ba) from uranium metal fuel may be modeled.

For vertically oriented flow channels undergoing coolant boiloff, the liquid-vapor dryout interface location is modeled based on coolant properties, coolant mass flow rate, channel geometry, and power generation. The primary limitations of the code are that material properties remain unaltered with oxidation, and molten material relocation is not modeled. Multiple phase changes for single materials are explicitly modeled, however.

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NOMENCLATURE

a	Metal-water reaction rate constant
A	Empirical constant for fission product release
A _{ox}	Surface area available for oxidation
A _{xs}	Cross-sectional area of boiloff region
b	Metal-water reaction rate constant
B	Empirical constant for fission product release
C	Empirical constant for fission product release
CBDP	Coolant Boilaway and Damage Progression
C _x	Empirical constant for fission product release
f _A	Fraction of fuel-cladding surface area debonded
f _{ps}	Concentration of fission product in surroundings
f _{pf}	Concentration of fission product in fuel
f _{xh}	Hydrogen blanketing rate-limiting factor
F	Fraction of uranium oxidized
FLHT	Full-length, high-temperature
GSCS	Graphite and shield cooling system
h _{eff}	Effective heat transfer coefficient for an uncovering node
h _{fg}	Heat of vaporization
HLM	Half-length model
h _{sc}	Inlet coolant subcooling
k	Thermal conductivity
K _p	Reaction rate constant
l _c	Length of node covered in boiling region
loca	Loss-of-coolant accident
LWR	Light-water reactor
l _{tr}	Length of node in transition region
l _{uc}	Length of node uncovered in dryout region
M	Molecular weight
m _i	Inlet mass flow rate
m _s	Exiting steam mass flow rate
MWR	Metal-water reaction
NRU	National Research Universal

NOMENCLATURE (contd.)

NSAC	Canadian Nuclear Safety Advisory Committee
Nu	Nusselt number
P	Pressure
P(Z)	Axial power at position Z
Pr	Prandtl number
Re	Reynolds number
R _b	Fission product release fraction due to bake-out
R _o	Fission product release fraction due to oxidation
T	Temperature
t	Time
V	Vapor pressure for a fission product
X _h	Hydrogen/steam mass fraction
Z	Axial position

Greek

δ	Metal or gap thickness
ΔQ	Energy release in a time step
Δt	Time step
ΔZ	Node axial length
α	Uranium oxidation area multiplier
$\Delta \delta$	Amount of metal consumed in a time step
ΔH	Heat of reaction
ΔT	Incremental temperature increase
ρ	density
$\bar{\rho}$	Average liquid density below the dryout front
λ	Position of liquid-vapor interface (dryout front)
μ	Viscosity

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TRUMP-BD: A COMPUTER CODE FOR THE ANALYSIS OF NUCLEAR FUEL
ASSEMBLIES UNDER SEVERE ACCIDENT CONDITIONS

1.0 INTRODUCTION

TRUMP-BD (Boil Down) is an extension of the TRUMP (Edwards 1972) computer program designed to analyze thermal and hydrogen evolution responses during severe temperature transients in a reactor core. The TRUMP-BD program language is FORTRAN V and simulations characteristic of severe transients are typically executed on super-computer mainframe machines. TRUMP-BD has been successfully adapted to execute on the Los Alamos National Laboratory Central Computing Facility's array of CRAY-1STM(a) and CRAY-XMP computers and the Hanford Site CRAY-XMP-14. For limited problem sizes, TRUMP-BD has been executed on an Apple Computer Macintosh IITM(b) at the Pacific Northwest Laboratory (PNL)(c).

TRUMP-BD has retained the majority of the computational capabilities of its predecessor version of TRUMP. However, this base version of TRUMP lacked those subroutines associated with general chemical reactions. Although TRUMP-BD is capable of solving the same general nonlinear parabolic partial differential equations as its predecessor code, the extended modeling capabilities tailored for reactor accident analysis may render the code cumbersome to use for some applications.

The impetus for developing TRUMP-BD originated with two PNL research programs sponsored by the U.S. Nuclear Regulatory Commission and conducted in the National Research Universal (NRU) Reactor(d): the Materials Tests

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- (a) Cray-1S is a registered trademark of Cray Research, Inc. Minneapolis, MN.
 - (b) Apple Computer Macintosh II is a registered trademark of Apple Computer, Inc., Cupertino, CA.
 - (c) Operated for the U.S. Department of Energy (DOE) by Battelle Memorial Institute under Contract DE-AC06-76RLO 1830.
 - (d) Operated by Chalk River Nuclear Laboratories, Chalk River, Ontario, Canada.

Program (MT) and the Coolant Boilaway and Damage Progression (CBDP) Program(a). These research programs are directly concerned with the behavior of light-water reactor (LWR) fuel under loss-of-coolant accident (loca) conditions, and have been active for approximately nine years. The TRUMP-BD computer code has been and is currently used for test guidance and to address safety issues relevant to the conduct of these in-reactor tests, providing predictions of hydrogen production rates and integrated release, heatup rates and temperature distributions, radial heat losses, and liquid level position. Although the data from these tests are proprietary, the TRUMP-BD simulation results have been successfully benchmarked against the experimental data (Section 7.0).

Following the incorporation of LWR severe fuel damage models for the NRU CBDP Program, TRUMP-BD was further modified in support of the N Reactor Safety Enhancement Program. N Reactor, located on the U.S. Department of Energy's Hanford site near Richland, Washington, is a 4000 Mwt light-water reactor with cylindrical uranium metal fuel clad with Zircaloy. Models for fuel failure, uranium oxidation, multiple phase changes, and multiple flow channels were incorporated into the code for the analysis of core heatup and hydrogen production for the Hydrogen Mitigation Design Basis Accident (HMDBA), a hypothetical loss-of-coolant accident for the graphite-moderated reactor (Heard et al. 1987). More recently(b), algorithms for fission product release were incorporated into TRUMP-BD as part of a concentrated effort to provide an independent benchmark of fission product release/retention behavior in support of probabilistic risk assessment studies for N Reactor.

The types of geometries that can be modeled require oxidizing nodes (Zircaloy and/or uranium) to be connected (adjacent) to fluid flow channels.

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- (a) Partners in this program with NRC include nuclear organizations from the following countries: Belgium, Canada, England, Federal Republic of Germany, Italy, Japan, The Netherlands, Republic of China (Taiwan), Republic of Korea, Spain, Switzerland, and Sweden.
 - (b) Marseille, T.J., Z.I. Antoniuk, and A.W. Cronenberg. 1989. Fission Product Release Hydrogen Production and Thermal Response of Peak Power Process Tubes in the N Reactor for the Hydrogen Mitigation Design Basis Accident. ESD-89-106, Pacific Northwest Laboratory, Richland, Washington.

The flow channel and surrounding material geometric configurations may be complex three-dimensional structures. The definition of axial levels along the longitudinal length of the model in the direction of the flow dominates a large portion of the TRUMP-BD logic to determine the location where steam-starved (complete conversion of steam to hydrogen) conditions exist. Metal oxidation is limited to Zircaloy and uranium; however, oxidation of other metals can be added quite readily. The reaction kinetics that ultimately determine hydrogen evolution are modeled with parabolic rate equations; thus, formation of an oxide layer inhibits further oxidation of the surface. For uranium oxidation with steam, the Wilson (1966) correlation is applied, whereas for Zircaloy oxidation, a user-specified correlation is chosen from one of four available correlations: Cathcart et al. (1977), Urbanic and Heidrick (1978), Prater and Cartwright (1986), or Baker and Just (1962). The multiple phase changes characteristic of uranium metal behavior during loss-of-coolant accidents can also be modeled.

Fission product release from exposed fuel is modeled using empirical time and temperature varying relationships, originally derived by Birney et al. (1988), for the volatile species of iodine (I), tellurium (Te), and cesium (Ce), as well as the less volatile species of ruthenium (Ru), strontium (Sr), zirconium (Zr), cerium (Cr), and barium (Ba). Subsequent transport and deposition of released fission products are not part of the model, nor is the eventual depletion of inventories due to ongoing nuclear decay.

The code memory requirements can be varied with FORTRAN PARAMETER statements that control the size of arrays (see Section 8.0). Computation time is dependent upon the computer, its memory size and the specific problem, and can vary between seconds and hours of central processing (CPU) time.

TRUMP-BD input and output files are similar in structure to those of TRUMP. The input data files retain their block structure and differ in those areas related to the extended capabilities of TRUMP-BD. The output file maintains the standard TRUMP capabilities and, in addition, provides summaries of the metal-water reactions, hydrogen generation, and fuel failures.

The primary emphasis of this manual is to describe in detail the theory and application of the extended capabilities of TRUMP-BD. This manual can be used as either an appendix to the TRUMP user's manual for new users, or as a stand-alone document for users experienced with the TRUMP code. With this document, a user will be able to construct an input data file, execute a severe fuel damage simulation, and interpret the output data. To fully appreciate the nonlinear parabolic partial differential equation solution method or the complete capabilities of the code, the TRUMP user's manual should be consulted.

2.0 EXTENDED MODELING CAPABILITIES OF TRUMP-BD

The TRUMP-BD code contains modeling capabilities that extend those of TRUMP for problems concerned with metal-water reactions in flow channels. Because TRUMP-BD was historically developed with the intent of addressing hydrogen evolution in nuclear reactor severe accidents, a number of the extensions were designed for the multiple flow channels and boiloff phenomena of reactor core accidents.

The TRUMP-BD code was created from a standard version of TRUMP code (less the subroutines KITTY, CHEM, PLOT, and PRIME). With the exceptions of general chemical reactants, TRUMP plotting, and a restart option, all of the TRUMP capabilities remain in the TRUMP-BD code.

A considerable portion of TRUMP-BD's extended capabilities are revealed by reviewing modifications in the input and output portions of the code. Because the block structure of the TRUMP input has been maintained in TRUMP-BD, the extended capabilities will be discussed following the block structure of the input. The extended capabilities that impact the output file will be discussed separately. Before reviewing the individual input block modifications, a brief overview of the TRUMP-BD extended capabilities is presented.

As previously stated, the TRUMP-BD code was developed to address nuclear reactor core accidents that are characterized by Zircaloy and uranium oxidation with concurrent hydrogen evolution. The chemical energy release for these exothermic reactions and the hydrogen evolution are computed from the mass of metal consumed. The metal oxidation kinetics follow parabolic rate equations. Fission product release from exposed uranium fuel is computed using empirical relationships that consider release to be simultaneously subject to oxidation and volatilization/diffusion ("bake-out") release mechanisms.

The coolant flow regions that supply steam for oxidation are segmented into axial levels in the direction of the flow. Each flow region may be divided into subchannels. In TRUMP-BD terminology, a flow region may be either a grouping of flow subchannels or a single channel. Flow regions may either be oriented vertically or horizontally. A vertically orientated flow region with upward coolant flow may undergo a coolant boiloff, with the liquid/vapor dryout interface computed internally or specified. Depletion of the coolant

by the metal-water reactions occurring at the channel walls is also modeled, as is the effect of hydrogen gas on the convective heat removal.

Beyond these major extensions, the TRUMP-BD code includes modifications to track select node quantities such as temperature, nuclear and chemical heat generation, hydrogen evolution, and metal oxidation. A variety of heat transfer correlations and models have also been incorporated. Because of the elevated temperatures characteristic of severe reactor accidents, the capability to model multiple phase changes is also included in TRUMP-BD.

A complete compilation of the extensions and code modifications will be discussed in the following review of the TRUMP-BD input blocks and output file. The modeling restrictions and limitations of the TRUMP-BD extensions are also presented.

2.1 INPUT DATA BLOCKS AND OUTPUT

Described below are the extensions to the standard TRUMP input blocks and output file.

2.1.1 BLOCK 1

TRUMP-BD has extended the standard graphics file of standard TRUMP. Graphics files are used to store various output data sets for subsequent graphic processing. Three graphics post-processing files may be generated: 1) a "system summary" file (TAPE3) that contains data on the overall model results, i.e., total nuclear and metal-water reaction power, hydrogen generation rate, fission product release, etc.; 2) a "special node" temperature output file (TAPE5); and 3) an axial profile file that contains data for each axial level, including total heat generation rate, radial heat loss, leaving hydrogen fraction from coolant flow regions, amount of unoxidized metal remaining and user-specified node temperatures (TAPE11). The time intervals between data transfers to these graphic output files is controlled by parameters in BLOCK 1.

Diagnostic printouts added to the output file summarize heat generation, convection, internode heat transfer, oxidation, and heat losses. TRUMP-BD also includes provisions for writing information about user-specified "special output nodes" at different intervals than the normal output. Special output

nodes permit the user to track the temperatures and information on the current phase change of a few select nodes without having to print the complete normal output block, thus reducing the output file size.

Additionally, TRUMP-BD includes capabilities for suppressing portions of the normal output through input parameters in BLOCK 1. One option is to suppress the output of node material properties, internal connection properties, node heat content, and node temperature changes during a simulation. Other options suppress output data previously printed in TRUMP, such as indication in the output file when a "regular" node is changed to a "special" node in the calculational scheme, and/or indication in the output file when a repeated cycle (time step) has occurred.

2.1.2 BLOCK 2

Parameters necessary for describing materials comprise the BLOCK 2 input. Because TRUMP-BD was designed with the intent to model the oxidation of uranium and Zircaloy metal in the presence of steam, these materials have been restricted to unique material identification numbers: 1 for uranium, 100 for Zircaloy, 10 for steam or water, and 11 for hydrogen. These material numbers trigger the appropriate oxidation algorithms or property mixture models within the code. Oxidation of the metals yields hydrogen gas that subsequently becomes part of the coolant. Through appropriate inputs in BLOCK 2, the effects of combined steam/hydrogen mixtures can be modeled. Binary gas property mixtures affect the coolant's ability to oxidize metal, absorb heat, and convect heat away from the channel surfaces. These phenomena are accounted for by allowing the coolant properties to change along the coolant channel in response to depleting steam and evolving hydrogen quantities.

The capability to model multiple phase changes for materials is also an extended capability defined in BLOCK 2 (the original TRUMP code allowed only a single phase change). Additionally, the effect of temperature on internally calculated convective heat transfer coefficients has been added, requiring specification of coolant density and viscosity. As in the standard TRUMP code, constant density is assumed for convective transport.

2.1.3 BLOCK 3

BLOCK 3 and the associated chemical reaction algorithms (subroutine CHEM) were not included in the version of TRUMP that served as a base for TRUMP-BD.

2.1.4 BLOCK 4

The TRUMP-BD code extensions that pertain to BLOCK 4 include data concerning coolant boiloffs (dryout front position vs. time), the number and length of axial nodes (levels), node fuel "pin" numbers (fuel elements), and node oxidation data (exposed surface area, thickness, and associated flow region). For coolant boiloff problems, the dryout front location may be prescribed as a function of time, with the user having the option of varying the power (BLOCK 9) or coolant mass flow rate (BLOCK 10) to obtain a desired liquid level history.

The concept of axial levels is unique to the TRUMP-BD code and is necessary to calculate the location where fully-consumed conditions exist (complete conversion of steam to hydrogen). Axial levels are defined by structuring the noding scheme into distinct axial segments in the direction of flow along the length of the coolant channels. Up to 99 axial levels may be defined for a given problem. Axial segmenting permits the modeling of dryout fronts, steam depletion, and hydrogen evolution. Axial levels may vary in length from level to level.

Specifications of flow regions and fuel pin numbers are also particular to TRUMP-BD. Flow regions are necessary to associate oxidizing surfaces with a particular steam source. This allows hydrogen evolution and steam depletion to be uniquely calculated for a flow region. A fuel pin is a grouping of fuel nodes that represent a fuel rod or element. Fuel failures are determined for a particular fuel pin and affect all fuel nodes assigned to that fuel pin at a given axial level. Oxidation of uranium nodes can occur only after fuel failure.

For oxidizing nodes, a metal-water reaction material type (1 for uranium, 100 for Zircaloy), a surface oxidation area, and material thickness must be prescribed. Inputs for these nodes are declared in BLOCK 4. Typically, the oxidation area is defined as that area exposed to the coolant.

2.1.5 BLOCK 5

BLOCK 5 contains the parameters that describe the thermal connections between nodes. TRUMP-BD was extended to allow temperature or time-dependent thermal connections. Additionally, heat transfer between connected nodes can be specified from the following correlations or models:

- The Dittus-Boelter correlation is intended for heat transfer between fully-developed turbulent flow and a channel wall(a).
- The Wong-Hochreiter (1981) correlation describes the heat transfer between the fuel cladding and steam for low Reynolds number, forced convection steam cooling under core dryout conditions(a).
- The N Reactor gap conductance model computes a heat transfer coefficient between the Zircaloy-2 cladding and uranium metal for N Reactor fuel under clad debonding conditions. The correlation is based on information contained in N Reactor safety analysis documents(b).
- The thermal bridge model is designed to handle irreversible step changes in a heat transfer coefficient dependent on a node temperature. The bridge model has proved valuable in describing the discontinuities that occur when a fuel element fails. Fuel failures are representative of irreversible processes that impact the heat transfer between connected nodes.
- The variable heat transfer option allows the user to specify a temperature or time-dependent heat transfer between two connected nodes. A typical application for this capability is the contact conductance between two solid materials.

(a) The necessary fluid properties are computed within TRUMP-BD and are dependent on the local velocity, coolant temperature, pressure (assumed constant), and gas composition.

(b) UNC 1978, N Reactor Updated Safety Analysis Report: NUSAR, United Nuclear Industries, UNI-M-90, Richland, Washington.

2.1.6 BLOCK 6

BLOCK 6 contains parameters that describe thermal connections to external nodes. The extended capabilities are limited to heat loss accounting. Heat losses to external heat sinks or sources are accounted for by denoting specific external node numbers. Heat transfer for all connections to external node 1000 are labeled as axial heat losses in the OUTPUT file; similarly all heat transfer through external node 2000 is considered as radial heat losses in the OUTPUT file. Heat transfer to all other external node numbers is labeled as miscellaneous heat losses in the OUTPUT file.

2.1.7 BLOCK 7, BLOCK 8

No extended capabilities are directly associated with BLOCK 7 or BLOCK 8. The input structure for these blocks remain identical to the base TRUMP code.

2.1.8 BLOCK 9

For TRUMP-BD problems, BLOCK 9 is used to specify information about node initial conditions, heat generation, metal-water reactions, fuel failure, and steam depletion. An extensive number of modifications to this input block were made for reactor applications.

Specification of node heat generation has been considerably revamped. Node internal heat generation is now computed by specifying an average fuel rod power, an axial power distribution, a radial power factor^(a), and a time-varying power history. This capability eliminates the need to specify individual power/time histories for each node. The axial power distribution may be user-specified or calculated from a chopped-cosine profile. Time-varying heat generation may be specified either for boiloff or nonboiloff problems.

A significant extension of the BLOCK 9 input involves metal-water reactions. Although the Zircaloy-water reaction is ignored below node temperatures of 1300°F, several oxidation kinetic equations are available to the user. One of four parabolic kinetic equations can be selected: Cathcart et al. (1977), Urbanic and Heidrick (1978), Prater and Courtwright (1968), or Baker and Just (1967).

(a) The radial direction is defined as perpendicular to the axial direction.

Uranium oxidation follows the Wilson (1966) parabolic kinetic equation but is computed only for times following fuel pin failure. All fuel nodes assigned to a fuel pin will undergo oxidation once its associated fuel surpasses the fuel failure temperature. A uranium oxidation area multiplier (modifying the data specified in BLOCK 4) is used to account for local changes due to fuel relocation and/or swelling, and may be declared as a function of the uranium node temperature. Another control option the user has with respect to metal oxidation is the amount of steam available for oxidation. The user may either declare oxidation based on the amount of local steam available or select the unlimited steam model, which assures unlimited steam availability for metal-water oxidation. Oxidation may also be limited by invoking the hydrogen blanketing model. With this model the presence of hydrogen limits the oxidation reaction rate.

TRUMP-BD allows rapid initialization of node temperatures and phase change concentrations. For multiple phase change materials, the active phase change may be initially declared along with the initial phase change fraction. An axial variation in initial temperature may also be described.

Some miscellaneous extensions associated with BLOCK 9 allow the user to differentiate and uniquely specify gamma heating and fission volumetric heat generation rates. An integrated power profile table must also be prescribed in conjunction with the axial power profile for boiloff simulations. Time-dependent power generation and/or time-dependent inlet flow can be selected as a forcing function for coolant boiloff simulations in BLOCKs 9 and 10, respectively.

2.1.9 BLOCK 10

BLOCK 10 contains parameters that describe the flow regions, flow connections, and the necessary variables for a boiloff simulation. Boiloff simulations require a prescription of two out of the following three parameters: 1) energy deposited to the coolant, 2) coolant inlet mass flow rate, and 3) the initial dryout front location. The unspecified parameter is then computed by TRUMP-BD. All three parameters may be declared as a function of simulation time with table inputs: the dryout front position in BLOCK 4, the power generation in BLOCK 9, and the mass flow rate in BLOCK 10.

TRUMP-BD differs from TRUMP with the addition of flow regions and flow subchannels. These concepts have been introduced to facilitate the tracking of steam availability and hydrogen evolved from oxidizing surfaces. Several flow regions may be declared for a single simulation with each flow region composed of multiple flow channels. Only a single flow region undergoes coolant boiloff in a given simulation. The amount of steam available for oxidation and convective heat transfer from solid surfaces is based on the flow for a given flow region. The convective transport is based on subchannel flow, however. Each flow region can have a unique time-dependent mass flow; all subchannel flows within a region are varied similarly.

2.1.10 BLOCK 11

BLOCK 11 in the base version of TRUMP contains output control. Control of output in TRUMP-BD has been transferred to other input blocks previously described, therefore BLOCK 11 is not used in TRUMP-BD and its associated subroutines.

2.1.11 BLOCK 12

BLOCK 12 remains unaltered between TRUMP and TRUMP-BD, therefore retaining the capability for node properties to be dependent on remote temperatures.

2.1.12 BLOCK 13

BLOCK 13 was added to provide user-supplied information about fission products needed to model fission product release during the simulation of a zircaloy-clad uranium fuel nuclear assembly undergoing a severe loss-of-coolant accident.

Among the required input parameters are:

- The number of fission products being modeled
- The whole core initial inventory of each fission product, and the fraction of whole core power generation that occurs in the specific fuel assembly being modeled. (These are used in the computation of initial uranium node fission product inventories during the first time step).
- Four empirical constants for each fission product being modeled. These are used as coefficients in the oxidation and bake-out empirical relationships for fission product release in TRUMP-BD.

Using current inventories, the total fission product release is computed for each failed fuel node at each time step subsequent to failure. Node inventories are then updated before the next time step.

2.1.13 OUTPUT

Output unique to TRUMP-BD is typically controlled through input parameters unique to TRUMP-BD. TRUMP-BD also provides control over the standard TRUMP output through the output suppression parameters. These parameters should be used to prevent unwanted output from enlarging the OUTPUT file. TRUMP-BD's extended output is summarized below; a complete discussion of the output and graphics files is presented in Section 5.0.

Output parameters related to boiloff simulations and the restructuring of the BLOCK 9 (internal heat generation) input of TRUMP-BD include:

- coolant state properties
- integrated axial power at dryout front
- coolant mass flow rate (boiloff region)
- axial location of the dryout front
- rod average power.

With respect to metal-water reactions and maximum metal temperatures, TRUMP-BD output includes:

- maximum Zircaloy (material type 100) and uranium (material type 1) temperatures
- node heat generation from oxidation and other sources
- metal thickness remaining
- coolant hydrogen and steam concentrations
- hydrogen production rate and total hydrogen evolution.

The metal-water reaction data is also detailed by axial level. Comprised in these results are:

- oxidation heat generation uniquely from uranium and Zircaloy
- average uranium and Zircaloy thickness remaining
- hydrogen production rate from uranium and Zircaloy.

The following fission product release results are written for each fission product for each failed fuel node, along with the sum total for the entire model:

- integral release due to oxidation and bake-out release mechanisms
- release rate due to oxidation and bake-out release mechanisms.

TRUMP-BD also prints parameters important for output diagnostics. The extended output includes:

- special output node temperatures
- heat generation by fuel pin
- variable heat transfer coefficient summaries
- radial and axial heat loss values
- phase change status
- detailed heat balance information.

The heat balance information contains quantitative results for numerous heat sources, sinks, and transfer pathways. Each simulation is completed with a final system summary, which reports temperatures, oxidation thicknesses, and heat generation rates for all nodes.

In conclusion, TRUMP-BD modeling capabilities extend those of the base TRUMP code in the area of severe reactor accidents. Although a major portion of the extensions have limited application beyond this class of problems, the code has remained general enough to address a variety of problems. With a little insight, a user can take advantage of the code's extended capabilities beyond the scope discussed here. For example, a passive solar phase change problem could be solved with the multiple phase change and variable heat transfer coefficient capabilities of TRUMP-BD. Conduction problems with expanding and contracting material gaps are also within TRUMP-BD's capacity.

2.2 MODELING RESTRICTIONS AND LIMITATIONS

In keeping with the concepts of standard TRUMP, multi-dimensional models with mixed geometry coordinate systems (e.g., Cartesian, polar, and spherical) can be created and the transient and steady-state temperature distributions obtained. The major limitation of standard TRUMP that carries over to TRUMP-BD is that the mass and momentum conservation equations for the fluid are not part of the solution scheme. Without the coupling of these conservation equations to the fluid energy equation, the fluid flow field must be specified *a priori* for a model, requiring the user to provide the proper feedback between the temperature and flow distributions.

Another limitation of both TRUMP and TRUMP-BD is that the model geometry always remains intact; i.e., no material relocation or swelling is accounted for. For horizontally oriented fuel assemblies the effect of this limitation is difficult to accurately assess. However, in vertically oriented fuel assemblies this limitation may actually provide an extra degree of conservatism as fuel will not relocate out of the high temperature regions of the model after mechanical failure or melting temperatures are exceeded.

Inherent with the modeling extensions that are part of TRUMP-BD are several additional modeling restrictions and limitations. These can be categorized into three groups: 1) input, 2) metal-water reaction modeling, and 3) coolant boiloff modeling. The restrictions and limitations of each of these groups are discussed below.

2.2.1 Input Restrictions

The major restriction imposed on the input by TRUMP-BD concerns the structuring of the model into axial levels; the current restrictions are that no more than 99 axial levels are included in the model and that no more than 999 uniquely specified nodes reside in an axial level. Additionally, the model noding scheme must be structured such that the axial level number increases along the direction of flow. This requirement enables the code to calculate the onset of steam depletion for problems with metal-water reactions and the position of the liquid-vapor interface for boiloff simulations.

Axial levels are simply defined as the thousandths place of the node number. For example, node 5001 would reside in the fifth axial level; its "base" node number(a) is 001. The concept of axial levels, although convenient with respect to the code logic structure, also provides the user with an instantaneous picture of the axial position of the node within the model. The axial level designation must be adhered to for metal-water reaction nodes, flow nodes, and boundary heat transfer nodes; other types of nodes and nodes connected to the aforementioned nodes do not necessarily have to follow this naming convention.

-
- (a) Base node numbers can be used to identify different material types or different radial positions in a model. For example, all fuel nodes may be assigned base node numbers of 001-099, cladding nodes 101-199, flow nodes 201-299, etc.

Other restrictions implicit in any computer code are the array sizes; these restrictions can be eliminated by increasing the array size through the FORTRAN PARAMETER statements in the code. Details of code dimensions and means to vary the existing array sizes are presented in Section 8.0.

Other restrictions include:

- Uranium must have a material identification number of 1, Zircaloy 100, and steam and hydrogen 10 and 11, respectively.
- Zero-volume nodes used to specify inlet flow boundary conditions must have an axial level designator of zero; i.e., node 401.
- Temperature units must be entered in degrees Fahrenheit (°F), time in hours (h), mass in pounds-mass (lbm), dimensions in inches (in.), and energy in Btu(a).

2.2.2 Metal-Water Reaction Modeling

The modeling of the metal-water reactions include the following assumptions/limitations:

- The reactions compute the amount of metal consumed and are modeled as parabolic with an Arrhenius-temperature dependence.
- The growth of the oxygen-stabilized alpha-Zircaloy layer is not accounted for.
- In the event of full conversion of available steam at an axial level, the oxidation is reapportioned such that all oxidizing nodes on a level receive some steam. In this scenario, the steam available for oxidation will be based on the node temperature, oxide layer thickness, and surface area; thus, nodes with a greater "appetite" (i.e., higher temperature) for steam will receive more steam than nodes with a less vigorous oxidation rate.
- The oxidation is assumed to take place at isothermal conditions in a time step.

(a) The exception to this is the average rod linear heat generation rate, RODAVE, which must be specified as kW/ft-rod.

- Oxidation of uranium fuel nodes is modeled once a user-prescribed failure temperature has been exceeded by the node. Thereafter, the uranium surface area available for oxidation may be specified as a function of temperature. However, the Zircaloy surface area available for oxidation remains constant at 100% of its intact, exposed surface.

2.2.3 Simulation of Coolant Boiloffs

The coolant boiloff model includes the following assumptions/limitations:

- Only one flow region can undergo a coolant boiloff.
- The coolant temperature below the dryout front remains at the user-specified initial temperature until the coolant node is partially uncovered. The initial coolant node temperatures for boiloff problems should therefore be set to the saturation temperature.
- All energy produced within the boiloff channel below the dryout front goes to vaporizing the coolant.
- The system pressure and inlet coolant properties are assumed to be invariant with time.
- Because the boiloff steaming rates are not assumed to vary significantly with time, the time rate of change of the coolant density is not explicitly accounted for.

2.2.4 Fission Product Release

The fission product release model for zircaloy-clad uranium fuel includes the following assumptions/limitations:

- Fission product release is based on both oxidation and volatilization/diffusion ("bake-out") release mechanisms, and is assumed to operate continuously subsequent to fuel failure, regardless of whether the uranium is in a solid or liquid phase.
- Fission product inventories are apportioned to individual uranium fuel nodes based on the fraction of whole core fission power generation occurring within the node.
- The deposition and transport of fission products subsequent to release from exposed fuel is not tracked.

- No depletion of fission product inventories as a result of nuclear decay is considered.
- The heat generation as a function of time is not affected by the fission products released.

3.0 TRUMP-BD SUBROUTINES

3.1 OVERVIEW

TRUMP-BD consists of a main program (TRUMP) and several required and optional subroutine, divided according to logical function, the sequence of calculations, and the various modes of heat production and transport. The subroutines required for all problems are HEART, THERM, FINK, SPECK, TALLY for the input phase and time step phases of the calculation; SEEK1 and SEEK2 for the input phase only; and REFER for the initialization phase only. The optional subroutines include GEN for problems with internal heat sources, sinks, and/or metal-water reactions, FLOW for problems with convection and/or coolant boiloffs, SURE for problems with boundary conditions, HTRANS for problems which require time or temperature-dependent internal thermal connections, FISPROD for problems in which fission product release from exposed uranium is to be modeled, and TIMER for obtaining the machine time used by each problem. (HTRANS and FISPROD are new subroutines added to TRUMP-BD.) The additional entry points THERM1 and THERM2 in THERM are used for calculation of phase change transitions. The additional entry point TALLY1 in TALLY is for the option of creating a restart file (OUTAPE) containing final values of node temperatures, phase, heat generation, etc. Subroutines CHEM, PLOT, and KITTY, available in the original TRUMP released by Lawrence Livermore National Laboratory, are not included in TRUMP-BD.

Presented below are descriptions of the code's subroutines. Subroutines that were significantly modified from the original TRUMP code are described in greater detail. Definitions for the code variables referenced below are provided in Appendix A.

3.2 PROGRAM TRUMP

The TRUMP program opens all required "units", reads and writes (echoes) the input file's "image" to the beginning of the standard output file, rewinds the input file, and calls HEART, the program driver subroutine.

3.3 SUBROUTINE HEART

Subroutine HEART is the logic control center of TRUMP-BD. The majority of calls to other TRUMP-BD subroutines (except PRIME, SEEK1, SEEK2, REFER, HTRANS and FISPROD during time step calculations) are made from HEART. Before any input data are read, several flags are initially set and the machine clock is monitored. Any TRUMP-BD control cards (e.g., *CHECK, etc.) preceding the "Problem Name Card" are read in, and the appropriate variables are initially set.

The subroutine calls for reading in data from the various input BLOCKs are then made; these calls are presented in Table 3.1.

After the "Data End Card" is read in, the "Problem Name" and integer value on the "Data End Card" are stored in new locations, and subroutines TALLY and SPECK are called to initialize program variables before the first time step (KCYC = 0).

Following the initialization phase, calls are then made to the subroutines required for the time step calculations (KCYC > 0); this sequence of calls is presented in Table 3.2. After each time step is completed, various tests are made to determine whether the problem should be continued, ended, or interrupted. If the problem is ended, the input file is read again. Assuming

TABLE 3.1. Subroutine Calls - Input Phase

<u>DATA BLOCK</u>	<u>SUBROUTINE</u>
1	TALLY
2	THERM
4	THERM
5	FINK
6	SURE
7	SURE
8	GEN
9	TALLY
10	FLOW
12	THERM
13(a)	FISPROD

(a) Optional call by HEART.

an end-of-file condition is found, control is returned to the main program TRUMP. If another problem follows in the input file, execution of this next problem begins.

The machine clock is monitored using subroutine TIMER at the beginning of each problem after all data has been read in, and again when the problem is interrupted or ended.

3.4 SUBROUTINE THERM

Subroutine THERM is entered to read in the data items in data BLOCK 2 (material properties), BLOCK 4 (node descriptions), and BLOCK 12 (nodes with properties dependent on temperatures of other nodes). All input data and immediately derived data, such as table slopes, material energy content, and node classifications and volumes, are written to the OUTPUT file. Variable steam and hydrogen density (VISTAB) and viscosity (RHOTAB) tables may be read from BLOCK 2 for TRUMP-BD problems that model temperature and/or concentration-dependent convection within the fuel bundle coolant flow regions. An array

TABLE 3.2. Order of Subroutine Calls - Time Step Phase

<u>Subroutine</u>	<u>Function</u>
THERM	Update properties.
HTRANS(a)	Update temperature/time dependent internal thermal connections.
GEN	Temperature change from heat generation.
FINK	Temperature change from internal thermal connections.
FLOW	Temperature change from convection; computes liquid level.
SURE	Temperature change from external thermal connections.
THERM1	Latent heat absorbed or released by nodes.
SPECK	Final calculation of heat flow across all connections.
THERM2	Final calculation of latent heat absorbed or released by nodes.
TALLY	Current time step accepted or rejected; subsequent time step size determined; node temperatures updated; criteria for ending problem checked; output data written.
FISPROD(b)	Fission product release from failed uranium fuel nodes.

(a) Optional call by THERM.

(b) Optional call by TALLY.

ZRNOXE is created at the end of the input phase that contains the indices of nodes which can undergo a metal-water reaction (identified in BLOCK 4).

Subroutines PRIME, SEEK1, SEEK2, and REFER are called by THERM during the input phase before returning to HEART.

For the first time step (initialization phase, KCYC = 0), subroutine THERM is entered to initially set cross-reference tables that relate the node list to the material list and relate the remote temperature dependence list to the node list. The node conductivities, masses, densities, heat capacities and heat contents are calculated. The total material volumes, masses, heat capacities, heat contents, and average temperatures are also calculated at this point. Additionally, the phase concentrations in materials with phase transitions involving latent heat are initially set.

For each subsequent time step (KCYC > 0), THERM is entered to recalculate any of the quantities above that are variable. If time or temperature-dependent thermal connections are specified in BLOCK 5 of the input, THERM calls subroutine HTRANS to update the internal thermal connections.

At intervals determined by input data, summary data are written out for each material, listing name, number, heat capacity, heat content, average temperature phase, transition temperature(s), and latent heat(s) of transition. When specified by the user, summary data are written out for each node, listing node number, material type, classification, location, volume, mass, heat capacity, conductivity, net conductance, and time constant.

If the problem includes nodes having phase changes, THERM is entered at each time step at entry THERM1 to estimate the amount of latent heat released or absorbed for each node. THERM is also entered at entry THERM2 after temperature changes are calculated in subroutine SPECK for the final calculation of release or absorption of latent heat.

3.5 SUBROUTINE GEN

Subroutine GEN performs three major functions:

- reads and processes input from BLOCK 8 relating to node internal variable heat generation for standard TRUMP problems

- computes the amount of metal (either uranium or zirconium) consumed and the corresponding energy release and hydrogen production during the time step as a result of chemical reactions
- computes the effective temperature rise of each node due to total heat generation.

Details of each of the three functions are described below.

3.5.1 Input BLOCK 8

BLOCK 8 input allows nodes with variable internal heat generation to be specified for standard TRUMP problems. BLOCK 8 input requires that a unique variable heat generation table be entered for each node with varying internal heat generation.

During the input phase, a call to GEN by HEART will occur to read BLOCK 8 variable heat generation data. All nodes with variable heat generation specified are read in. All input and immediately derived data, such as table slopes, are written out.

3.5.2 Metal-Water Reactions

Two metal-water reactions are considered in GEN : 1) zirconium-steam (Zr-H₂O), and uranium-steam (U-H₂O). For each reaction, the amount of metal consumed, energy release, and associated production of hydrogen (and depletion of steam) is computed at each time step. The chemical statements for each of these reactions are:

where K_p is the reaction rate constant, and ΔH is the heat of reaction. Since the alloys Zircaloy-2 and Zircaloy-4 used for fuel rod cladding are composed primarily of zirconium, their reaction rates and heat of reactions are assumed identical to that of zirconium. Thus, Zircaloy and zirconium are assumed identical for modeling purposes.

The axial level concept is critical in the modeling of the metal-water reactions. The node numbering nomenclature must therefore be strictly adhered to so that the location of steam-starved conditions can be determined. An internal pointer array ZRNOXE is constructed in which all oxidizable nodes are arranged by axial level (the order of nodes on a give plane is based on their respective order in the input). Node oxidation is calculated for all metal-water reaction nodes in the order of the ZRNOXE array, computing the oxidation of all nodes in an axial level (planar sweep) before proceeding to the next axial level (axial level sweep); an example of how the metal-water reaction pointer array ZRNOXE is constructed from the BLOCK 4 input is presented in Table 3.3.

For each time step, subroutine GEN scans each flow region and axial level of the model (from $n = 1$ to NLEVELS), and every surface on a level [from $i = 1$ to NSURF(n)], to determine which nodes contain oxidizable material (either uranium or Zircaloy). If a positive uranium or Zircaloy thickness has been specified for a node, the possibility of a metal-water reaction is investigated. The uranium or Zircaloy metal thickness for a node is identified by reference to an entry in vector ZRTHIK(j). Subscript j is set by reference to the entry in vector ZRNOXE(a) [$j = \text{ZRNOXE}(k)$] where subscript k is the metal-water reaction node index, defined as:

$$\begin{array}{ll} k = i & \text{for } n = 1 \text{ (axial level 1)} \\ k = i + \text{MWSURF}(n-1) & \text{for } n \geq 2 \text{ (axial levels 2 and above)} \end{array}$$

where indices i and n correspond to the current surface and axial level, respectively.

During the oxidation planar sweep, a continual check on the amount of steam remaining is made. If more steam is consumed than is available, the oxidation reactions are allowed to continue assuming steam availability, and a steam-depletion flag is set (NZDEP), indicating the affected flow region and axial level. At the completion of the planar sweep calculations, a damping factor, QDAMP, is computed based on the ratio of steam available to the amount

(a) Vector ZRNOXE relates metal-water reaction index to the node number index.

TABLE 3.3. Illustration of Metal-Water Reaction Node Pointer Array

<u>n</u>	<u>BLOCK 4 Input</u>	<u>Pointer Array</u>	
	<u>NODE(n)</u>	<u>ZRNOXE(n)</u>	<u>NODE(ZRNOXE(n))</u>
1	1301	1	1301
2	2301	6	1302
3	3301	11	1501
4	4301	2	2301
5	5301	7	2302
6	1302	12	2501
7	2302	3	3301
8	3302	8	3302
9	4302	13	3501
10	5302	4	4301
11	1501	9	4302
12	2501	14	4501
13	3501	5	5301
14	4501	10	5302
15	5501	15	5501

of steam consumed (assuming availability) for the steam-depleted axial level. The amount of metal consumed is then recomputed, adjusted by the damping factor. From this revised thickness consumed, new values of energy release and hydrogen production are computed. This procedure prevents the first node in a planar sweep from continually consuming the available steam, resulting in a more equal apportionment of steam among the oxidizing nodes.

The reacting node material type is identified by the value of vector NOXMAT(j), where j is as defined above. For material type 100 (NOXMAT(j) = 100), the Zr-H₂O reaction logic will be used. For material type 1 (NOXMAT(j) = 1), the U-H₂O logic will be used. Vectors NSURF, MWRSURF, ZRNOXE, ZRTHIK, and NOXMAT are set via input provided in BLOCK 4.

3.5.2.1 Zircaloy-Water Reaction

The Zr-H₂O reaction can be modeled with any one of four correlations:

- Cathcart et al. (1977). Chosen by setting MWRCOR = 0 (BLOCK 9, Card C)
- Urbanic and Heidrick (1978). Chosen by setting MWRCOR = 1
- Prater and Courtright (1986). Chosen by setting MWRCOR = 2
- Baker and Just (1962). Chosen by setting MWRCOR = 3.

All metal-water reactions can be eliminated by specifying MWRCOR = -1. Each of these correlations model the temperature-dependent consumption of metal using a parabolic, Arrhenius-rate relation of the form(a)

$$\delta = b \sqrt{t} e^{-a/T} \quad (3.1)$$

where: δ = thickness of metal consumed by the reaction, m
 a = Arrhenius-rate reaction coefficient, K
 b = Arrhenius-rate reaction coefficient, m/ $\sqrt{\text{sec}}$
 T = node temperature, K
 t = time (seconds) for which the metal is exposed to steam at temperature, T.

The specific values of the Arrhenius-rate coefficients are determined by the metal-water reaction correlation employed and the temperature of the oxidizing node. Below 1300°F (977 K), the reaction rate is assumed to be negligible and the oxidation logic is skipped; therefore, no metal-water reaction occurs at node temperatures below 1300°F (977 K). At node temperatures above 1300°F, the following coefficients are used:

- Cathcart et al. correlation
 - $a = -20070 \text{ K}$
 - $b = 6.4506(10)^{-6} \text{ m}/\sqrt{\text{sec}}$
- Urbanic & Heidrick correlation
 - for $1300^\circ\text{F} \leq T < 2894^\circ\text{F}$
 - $a = -13553 \text{ K}$
 - $b = 1.169(10)^{-7} \text{ m}/\sqrt{\text{sec}}$
 - for $2894^\circ\text{F} \leq T$
 - $a = -16610 \text{ K}$
 - $b = 2.0868(10)^{-6} \text{ m}/\sqrt{\text{sec}}$

(a) The calculation of metal consumed and energy released is done in units of meters, degrees Kelvin, Joules, and seconds.

- Prater & Courtright correlation

- for $1300^{\circ}\text{F} \leq T < 2750^{\circ}\text{F}$

$$a = -24460 \text{ K}$$

$$b = 4.481(10)^{-5} \text{ m}/\sqrt{\text{sec}}$$

- for $2750^{\circ}\text{F} \leq T$

$$a = -28420 \text{ K}$$

$$b = 1.32496(10)^{-3} \text{ m}/\sqrt{\text{sec}}$$

- Baker & Just correlation

$$a = -22899 \text{ K}$$

$$b = 7.884(10)^{-5} \text{ m}/\sqrt{\text{sec}}.$$

The incremental thickness consumed due to oxidation during the current time step is computed from a modified differential form of the rate equations as:

$$\delta_{t+\Delta t} = \left[\delta_t^2 + f_{xh} b(\Delta t) e^{-a/T} \right]^{\frac{1}{2}} \quad (3.2)$$

where: $\delta_{t+\Delta t}$ = updated metal thickness

δ_t = old-time metal thickness

Δt = time step

f_{xh} = factor to account for hydrogen blanketing of oxidizing node.

The amount of metal consumed is limited to the thickness of the material present in the node and by the availability of steam. The factor f_{xh} is included in Equation (3.2) to account for hydrogen blanketing of the oxidizing node. By specifying HFLAG = 1 (BLOCK 10, Card B), the factor f_{xh} will be updated for each node by the linear relation:

$$f_{xh} = (1.0 - X_h) \quad (3.3)$$

where: X_h = hydrogen fraction in the steam flow region adjacent to the oxidizing node.

When $X_h = 1.0$, all the steam is consumed and all oxidation is stopped.

The rate of energy release, ΔQ , in time step Δt is computed based on the volume of metal consumed and the heat of reaction, as

$$\Delta Q = \rho_{Zr} H_{Zr} \alpha A_{ox} \Delta Z \Delta \delta / \Delta t \quad (3.4)$$

where: ρ_{Zr} = density of zirconium, 6.5×10^6 kg/m³

H_{Zr} = heat of reaction of zirconium, 6.45×10^6 J/kg

α = oxidation area multiplier (for uranium nodes only)

A_{ox} = surface area available for oxidation per unit axial length for the node, m²/m

ΔZ = axial length of node, m

$\Delta \delta$ = amount of material consumed in time step Δt , $\delta_{t+\Delta t} - \delta_t$

Δt = time step, sec.

The user-specified oxidation area for Zircaloy nodes is assumed constant; an oxidation area multiplier of 1.0 is therefore used for the Zr-H₂O reaction.

3.5.2.2 Uranium-Water Reaction

The amount of metal oxidized by the uranium reaction with water is computed in a similar manner with one additional restriction: the associated fuel pin cladding temperature must have exceeded a user-specified "failure temperature" for uranium oxidation to be considered (TFAIL, BLOCK 9, Card C). By restricting the uranium oxidation in this manner, discrete failures of fuel elements (pins) can be modeled. With this feature, uranium oxidation is restricted as long as the accompanying cladding remains intact; upon failure of the cladding, the previously unexposed uranium is assumed to react with the available steam.

The fuel failure model requires that the uranium nodes and Zircaloy nodes that comprise a fuel element be assigned a common pin number (NPN, BLOCK 4, Card D)(a). This convention is illustrated in Figure 3.1, which shows the pin number assignments for a concentric fuel element design. Oxidation of uranium nodes will occur only when the minimum temperature of the cladding nodes (NOXMAT = 100) assigned to that pin exceeds the user-specified failure temperature. Pin numbers need only be assigned to the Zircaloy and uranium nodes of

(a) The value of NPN is loaded into the array PINNO(n) where n is the node index.

a unique fuel element--the fuel element nodes' axial level designation (thousands place of the node number) is used to identify the axial location of a failed fuel element. For a 20 axial level model with the concentric fuel design shown in Figure 3.1, only two unique pin numbers need to be specified.

The amount of uranium metal oxidized in a time step is computed, as before, using the parabolic Arrhenius-rate relation given in Equation (3.1). The coefficients have the same meaning here as in the Zircaloy-water reaction case. Their values are different, however, and are as follows:

- $T < 2192^{\circ}\text{F}$
 $a = 9361 \text{ K}$
 $b = 2.549(10)^{-8} \text{ m}/\sqrt{\text{sec}}$
- $T \geq 2192^{\circ}\text{F}$
 $a = 12582 \text{ K}$
 $b = 2.0784(10)^{-7} \text{ m}/\sqrt{\text{sec}}$

The incremental uranium thickness consumed in time step Δt is limited to the available thickness of the material and the available steam. The energy release rate resulting from this reaction is computed as in Equation (3.3) where the volumetric energy release factor ($\rho_u * \Delta H_u$) for the reaction equals $4.7697(10)^{10} \text{ J/m}^3$. To account for a variable uranium oxidation area, α in Equation (3.3) is adjusted by a user supplied, temperature-dependent multiplier used to account for oxidation area changes due to fuel relocation and/or swelling.

3.5.2.3 Hydrogen Release from Material Reactions

The mass of hydrogen generated from the reaction of Zircaloy or uranium with water during the time step is also computed in subroutine GEN for each node. The mass of metal consumed is first computed; the mass of hydrogen gas produced by the reaction is then calculated from the mole fractions of product and reactant identified in the chemical reactions. The hydrogen generated by each reacting surface on an axial level is computed during each time step and is summarized in the axial level sweep. In accordance with the chemistry, each mole of hydrogen produced in these metal-water reactions requires the consumption of one mole of steam. Therefore, the steam mass flow rate associated with each reacting node is correspondingly depleted. The amount

	<u>MATERIAL</u>	<u>PIN NO.</u>
ZIRCALOY	1
URANIUM	1
ZIRCALOY	2
URANIUM	2

FIGURE 3.1. Illustration of Fuel Pin Assignments for Fuel Failure Modeling

of steam that can be depleted is limited to that available for a flow region at the current axial level. If more steam is required for oxidation than is currently available, the mass of uranium or Zircaloy consumed, the mass of hydrogen produced, and the energy released by the reaction are each reapportioned (reduced) based on the amount of steam available. Because the amount the reaction is reduced is applied uniformly to all oxidizing nodes on a plane (axial level), nodes reacting more vigorously will be allocated more steam than less reacting nodes.

3.5.3 Node Effective Temperature Rise

An estimate of the temperature rise in each node resulting from the node's total heat generation is computed just prior to exiting subroutine GEN. For standard TRUMP problems, this is simply the internal heat generation specified in BLOCK 9 (Card B) and BLOCK 8. For TRUMP-BD, total heat generation is the sum of the heat generation associated with metal-water reactions and the internal heat generation specified in BLOCK 9 (Cards C, D, F-H). The net temperature change from the total heat generation is added to the other temperature changes (i.e., from internal thermal connections, flow, etc.) in subroutine TALLY wherein the nodal temperatures are updated. Thermal capacitances used in the computation of this temperature rise in subroutine GEN are based on estimated node temperatures for the current time step (subroutine THERM). The material properties used to make up this capacitance do not reflect the change in composition of the node resulting from the metal-water reaction, i.e., Zr to ZrO_2 .

3.6 SUBROUTINE FINK

Subroutine FINK is first entered to read in the data items in BLOCK 5, the internal thermal connection list. All input data and immediately derived data, such as connection areas, are written to the OUTPUT file.

If time or temperature-dependent internal thermal connections are specified the thermal connection index and variable heat transfer model type are stored in the variable thermal connection arrays IVARH and IHTCOR for use by subroutine HTRANS.

For the initialization phase ($KCYC = 0$), FINK is entered to initially set the cross-reference table that relates thermal connections to the node list (using REFER), and to set the conductances of each connection.

At each time step, FINK is entered to recalculate the overall conductance of the thermal connections and to calculate the amount of heat flow across each connection and the temperature change of each node due to the internal thermal connections. The conductance is calculated based on the temperature difference at the beginning of the time step.

At intervals determined by the input data, summary data for each thermal connection may be written to the OUTPUT file, including the node numbers, area, interface conductance, radiation exchange factor, overall conductance, cumulative heat flow, and average rate of heat flow across the connection.

3.7 SUBROUTINE FLOW

Subroutine FLOW is used with problems which model 1) convective heat transport, and 2) coolant boiloffs.

Though standard TRUMP mass flow modeling logic can still be utilized, subroutine FLOW has been rewritten to include modeling capabilities needed for reactor applications. Specifically, the user can now model unique mass flow regions, as well as subchannels within a flow region. This modeling difference allows for a simplification of the flow connections from standard TRUMP and also allows for the modeling of coolant boiloffs. A flow region is defined as any flow area enclosed by solid surfaces; a subchannel can be any unique portion of a flow region. A subchannel's mass flow is defined in the input as some fraction of the total mass flow of the flow region. A diagram illustrating the relationship between flow regions and subchannels is presented in Figure 3.2.

The node numbering scheme for flow problems is somewhat restricted in TRUMP-BD. An illustration of the node numbering scheme for a multiple flow region model is presented in Figure 3.3. Note that connected flow channels differ only by the thousandths place of the node number. This allows the subchannel convective heat removal to be properly calculated and printed in the OUTPUT file convection summary. Also, as in standard TRUMP, a zero volume

FIGURE 3.2. Sample Configuration Demonstrating the Relationship between Flow Regions and Flow Subchannels

FIGURE 3.3. Illustration of the Node Numbering Scheme for a Multiple Flow Region Model

node must be specified at the channel inlet; the node number used for this source node and the downstream volume node must differ by 1000. The zero volume source node number must also be less than 1000.

Because of the significant modifications made to this subroutine, the logic during both the input and execution phases of the simulation will be discussed in detail.

3.7.1 Input

Subroutine FLOW is first accessed by HEART during the input phase of TRUMP-BD to read in the data items in BLOCK 10 of the INPUT file. The BLOCK 10 input is used to define flow regions, mass flow connections, and the characteristics of the boiloff.

The first read statement in FLOW is for Card A, "Auto Noding Parameters". This feature has been removed in the coding; therefore, this card should be blank. Card B, the "Flow Description Card", is then read and is used to describe the overall characteristics of the model flow. The variable IMASFG is a flag used to signal whether the TRUMP-BD time-varying mass flow logic is to be used. If IMASFG = 0, standard TRUMP logic is used; IMASFG = -1 flags that no boiloff simulation is to be performed, but TRUMP-BD time-varying flow logic is to be used; IMASFG = +1 indicates that a boiloff of liquid will be simulated and TRUMP-BD time-varying flow logic is to be used. The variable HFLAG is used to flag whether the hydrogen-blanketing model is to be used to limit metal-water reaction rates computed by subroutine GEN. When HFLAG = 0, no hydrogen blanketing is modeled; when HFLAG = 1, hydrogen blanketing is assumed and the reaction rate is limited accordingly (Equation 3.3).

Other variables on Card B pertain only to boiloff simulations, and include the setting of fluid properties (heat of vaporization and inlet coolant subcooling) and the initial liquid-vapor dryout interface position, XINTERI.

For each flow region a series of cards are read by FLOW, starting with Card C, the "Region Delimiter" card. Because the read statement used in FLOW for Card C is also used for Card G (the "Mass Flow Connections" card), FLOW checks after each execution to see which card has been read. If a new flow region is being input, then NREGON, the flow region counter, is incremented and Card D, the "Flow Region Descriptor" card, is now read.

Two control variables are read from Card D. The first, IBOLRGN(NREGION), indicates whether the flow region being input is a boiloff (-1) or non-boiloff (0) region. For boiloff simulations the first flow region input must be the region undergoing the coolant boiloff. The second control variable read from Card D is the mass flow rate computation flag, MASFLG. MASFLG = -1 indicates the flow region's mass flow rate (XMDOX) is user prescribed directly on Card D. MASFLG = 0 indicates the mass flow rate will be specified for individual mass flow connections on Card F rather than by flow region. (The MASFLG = 0 option is used only for standard TRUMP.) MASFLG = 1 indicates the region flow rate will be computed based on the power generation, liquid-vapor interface, and inlet coolant conditions for a boiloff simulation.

After reading Card D, a check is made that HDO, the user-specified length from bulk boiling to dryout conditions, is less than the axial node length (AXDIST(IX), IX = 1,NLEVELS). If HDO exceeds any node length, KWT is set to 5 to indicate an input error has occurred. The variable HDO is used by subroutine HTRANS to determine node convective heat transfer coefficients near the dryout front in boiloff simulations (Section 3.8.8).

The ability to specify time-dependent mass flow rates for all flow connections in a flow region can be accomplished by specifying TRUMP-BD flow logic (MASFLG $\neq$ 0) and by entering a positive value for NTABF (BLOCK 10, Card D), the number of entries in the flow multiplier-time table (Card E). For positive values of NTABF, the flow region mass flow rate multiplier (FMULT) and corresponding time (FTIME) are read in (Card E). To vary the average coolant density (RHOBAR) below the dryout front during a boiloff simulation, table entries relating the average coolant density below the dryout front (RHOCOL) to the exit steam flow rate (XMS) can be specified (Card F). The actual functional relationship between density and mass flow rate must be determined by the user.

At this point the mass flow connections for the current flow region are read (Card G). The input specified in Card G is used to set up the arrays and other variables detailing the relationship between nodes and flow paths. Subroutine FLOW will continue looping through this section until either: 1) a blank card is read, which tells FLOW all input has been supplied for BLOCK

10 and to return control to HEART, or 2) a "Region Delimiter" card (Card C) is encountered, which tells FLOW input cards for another flow region follows.

For TRUMP-BD problems (i.e., MASFLG = 1 or -1), input variable FX (Card G) specifies the fraction of the total flow region flow rate (XMDOX) that applies to the specified connection. When FX is 1.0, the entire flow region mass flow passes through this convection path; when FX is less than 1.0 it indicates the region mass flow is defined by multiple subchannels. The mass flow rate for each flow connection (FLOWN) is then calculated by $FLOWN = FX * XMDOX$.

For standard TRUMP flow problems (MASFLG = 0), FX specifies the actual connection mass flow rate, i.e., $FLOWN = FX$. If in addition $|LTABFL| \geq 2$ is specified on Card G, FLOW will read Card H, the "Region Subchannel Mass Flow Rate Table". This table provides values of mass flow rate vs. time which are used to update each flow connection at each time step of the problem.

3.7.2 Cycling

On the first post-input phase pass (KCYC = 0), subroutine FLOW is entered to cross-reference the flow connection arrays NODF1 and NODF2 with the node array list NODE. FLOW then checks each flow connection to ensure that both nodes are composed of the same materials and that flow paths connected to zero-volume nodes have the appropriate relative flow path lengths. The index pairs representing each flow path are then reordered (if necessary) to produce a positive mass flow between each.

For all subsequent time steps (KCYC > 1) mass flow rates are updated, the temperature changes resulting from mass flow are computed, and any consequent changes in the location of the dryout front (when applicable) are computed.

If IMASFG = 0 (standard TRUMP), the mass flow rate FLOWN is reset by interpolation using values from the mass flow (FLOWT) vs. time or temperature (TVARFL) table (BLOCK 10, Card H) for each connection, and the mass connections are again reordered in the direction of positive mass flow. For IMASFG = 1 or -1, i.e., TRUMP-BD logic, a flow region multiplier FXY(NREGION) is interpolated using values from the mass flow table (BLOCK 10, Card E). All flow connections that make up a given flow region are adjusted by the flow multiplier for that region, FXY(NREGION).

The final computation performed in subroutine FLOW is the temperature-rise associated with convection. The temperature rise is computed based upon the energy loss in the node due to enthalpy transport and the thermal capacitance of the fluid in the node. The resultant ΔT is added in an accumulator array DT for later use in subroutine TALLY. Program flow is then returned to the calling routine.

3.7.3 Coolant Boiloff Modeling

The key concepts and parameters behind the modeling of coolant boiloffs is illustrated in Figure 3.4. As shown, the model can be separated into three distinct regions:

1. the subcooled region where the incoming liquid is brought to saturation conditions,
2. the boiling region, where vapor is generated resulting in a void fraction distribution, and
3. the dryout region, where single-phase vapor is superheated.

Because the dryout region is of primary concern in severe accident modeling, only the heatup of the dryout region is accounted for in TRUMP-BD. Coolant nodes that reside in the subcooled or boiling region remain at their initial temperature until the node becomes partially uncovered. Thus, coolant nodes below the initial dryout front location should be initialized to the coolant saturation temperature. In this manner, boiling in the coolant channel is simulated with the single-phase TRUMP code. The coolant node temperature remains at its initial value by subtracting the temperature rise from heat input from the overall temperature change for the node.

The position of the dryout front (WLEVEL) is calculated from a combination of the mass and energy conservation equations. All energy input to the flow channel is assumed to raise the incoming liquid to saturation conditions and generate steam (Figure 3.4):

$$\int_0^{\lambda} P(Z) dZ = m_i h_{sc} + m_s h_{fg}$$

FIGURE 3.4. Key Concepts and Parameters for Modeling a Coolant Boiloff

where:

- $P(Z)$ = the axial power at position Z
- m_s = the exit steam flow rate
- m_i = the inlet coolant flow rate
- h_{sc} = the inlet coolant subcooling
- h_{fg} = the heat of vaporization
- λ = the position of the dryout front.

The integrated power to the position of the dryout front is calculated either from the chopped-cosine input data or the user-specified integrated axial power profile. The sum of the inlet subcooling and heat of vaporization, the total energy required to vaporize the inlet coolant, is specified by QBOIL (BLOCK 10, Card B). Note that the exiting steam flow rate, m_s , can differ from the inlet flow, i.e., non-steady state conditions.

The net change in the liquid level is obtained from the conservation of mass,

$$\frac{\partial}{\partial t} [\bar{\rho} A_{xs} \lambda] = m_i - m_s$$

where $\bar{\rho}$ (RHOBAR) is the average density of the liquid pool, and A_{xs} , the cross-sectional area of the boiloff region (FLOWY, BLOCK 10, Card C). Assuming invariant density with time and differentiating gives:

$$\bar{\rho} A_{xs} \frac{\partial \lambda}{\partial t} = m_i - m_s$$

Solving the energy equation for m_s , substituting in the mass balance equation and rearranging gives:

$$\lambda = \lambda_0 + \Delta t \left[m_i (h_{fg} + h_{sc}) - \int_0^\lambda P(Z) dZ \right] / \bar{\rho} A_{xs} h_{fg}$$

where λ_0 is the old-time position of the dryout front. Thus, the position of the dryout front is a function of coolant properties, the integrated power profile, the channel area, and the coolant density. Variations in the power

generation rate and/or inlet coolant flow rate can be used to drive the coolant boil-off. If a prescribed liquid level history is specified (BLOCK 4, Card C), either the coolant inlet flow rate or the power generation is adjusted to give the desired dryout front position.

Until steady-state conditions are reached, more coolant is boiled away than is being replenished by the inlet coolant flow. This phenomena is accounted for in the code as the boiloff region flow rate is increased by the internally-computed ratio of exit to inlet mass flow rate, STRATIO.

An important parameter in the boiloff calculations that must be specified by the user is RHOBAR, the average density of the liquid pool below the dryout front (Figure 3.4). Because this parameter can vary considerably over a range of steaming rates, it is possible to enter a flow rate-dependent density (BLOCK 10, Card F). To obtain the relationship between density and flow rate, the void fraction profile must first be computed; several models and constitutive relationships are available to obtain this information (Zuber and Findlay 1965; Wilson et al. 1962; Cunningham and Yeh 1973).

3.8 SUBROUTINE HTRANS

Subroutine HTRANS computes the time or temperature-dependent internal thermal connections. The user may choose from among a series of heat transfer models or directly input a user-specified table for each variable thermal connection. The choice is made by specifying unique values of IHEAT for each pair of participating nodes in BLOCK 5 (Card B); the values of IHEAT and the corresponding heat transfer models are presented in Table 3.4.

TABLE 3.4. Heat Transfer Models and Correlations - Subroutine HTRANS

<u>IHEAT</u>	<u>Heat Transfer Model or Correlation</u>
1	Wong-Hochreiter correlation
2	Dittus-Boelter correlation
3	N Reactor gap conductance model
4	Thermal bridging model
5	User-specified internal thermal connection

HTRANS also contains two important models for severe accident simulations: 1) a node uncover model that determines the convective heat transfer coefficient for solid surfaces in a partially uncovered node, and 2) a binary mixture property model to account for the effect of hydrogen on the convection heat transfer. Each of the different models accessible in HTRANS is described below.

HTRANS is called by subroutine THERM at the beginning of each time step ($KCYC > 0$) where the heat transfer coefficients of the variable internal thermal connections are updated. The index IVARH is used to identify the current connection index for each pass through HTRANS. A check is made on the value of IHTCOR for each variable internal connection to determine which model to use. Flags are also used to determine whether the node uncover model and/or the binary mixture property are used. Subroutine HTRANS returns to subroutine THERM.

3.8.1 Heat Transfer Correlations and Models

Described below are the two convective heat transfer correlations and the three heat transfer models of TRUMP-BD.

3.8.1.1 Dittus-Boelter Single-Phase Convection Heat Transfer (IHEAT = 1)

A local heat transfer coefficient based on the Dittus-Boelter single-phase heat transfer correlation is computed for an internal thermal connection by specifying IHEAT = 1 (BLOCK 5, Card B)(a). To use this modeling option, the coolant density and viscosity must be specified (BLOCK 2, Cards C and D). By specifying the coolant properties as a function of temperature, the heat transfer coefficient will be updated as a function of the film temperature, i.e., the average of the wall and coolant temperatures. The effect of two different constituents (i.e., steam and hydrogen) on the overall heat transfer can also be accounted for.

Reynolds (Re) and Prandtl (Pr) numbers are computed for the fluid node using the single or binary mixture properties, the hydraulic diameter, D, associated with the fluid node (HIDM, BLOCK 10, Card D), and the characteristic

(a) The value of IHEAT is loaded and used in the array IHTCOR(N) where N is the variable internal thermal connection number ($0 \leq N \leq IJ$), and IJ the total number of variable thermal connections.

flow velocity of the fluid node. Using these parameters, a convection heat transfer coefficient, h , is computed from:

$$Nu = \frac{hD}{k} = 0.023 Re^{0.8} Pr^{0.4}$$

where Nu is the Nusselt number, and k is the gas thermal conductivity, evaluated at the film temperature.

3.8.1.2 Wong-Hochreiter Correlation (IHEAT = 2)

A local heat transfer coefficient based on the Wong-Hochreiter correlation for low Reynolds number forced convection steam cooling under core-uncovery conditions is computed for an internal thermal connection by specifying IHEAT = 2. As with the Dittus-Boelter heat transfer option, the coolant density and viscosity must be specified; the option to evaluate the local heat transfer based on properties of a binary mixture is also available. Again, the properties are evaluated at the film temperature.

The overall heat transfer coefficient is computed as:

$$Nu = hD/k = \begin{array}{ll} 7.86 Pr^{1/3} & \text{for } Re \leq 2000 \\ (-24.55 + 0.0162 Re) Pr^{1/3} & \text{for } 2000 < Re \leq 2500 \\ 0.0797 Re^{0.6774} Pr^{1/3} & \text{for } 2500 < Re \end{array}$$

3.8.1.3 N Reactor Gap Conductance Model (IHEAT = 3)

The temperature-dependent gap conductance model used for modeling the uranium fuel-to-cladding interface resistance is invoked by setting IHEAT = 3. The model accounts for the postulated separation of the fuel/cladding surfaces of the extruded fuel element as temperatures increase above 1490°F and a subsequent decrease in the separation distance as the uranium melt temperature is reached. The overall conductance between the fuel and cladding is evaluated based on the estimated debonded surface area, fuel-to-cladding gap width, and fill-gas (assumed to be xenon). The interface heat transfer coefficient, h (Btu/h-in.²-°F), is computed as follows:

$$h = \begin{cases} 694 & \text{for } T < 1490^{\circ}\text{F} \\ f_A k_{\text{xe}}/\delta + 694(1 - f_A) & \text{for } 1490^{\circ}\text{F} \leq T \leq 2020^{\circ}\text{F} \\ 694 & \text{for } T > 2020^{\circ}\text{F} \end{cases}$$

where: f_A = the fraction of surface area debonded

k_{xe} = xenon gas conductivity, Btu/h-in.- $^{\circ}\text{F}$

δ = fuel-cladding gap thickness, in.

694 = nominal gap conductance, Btu/h-in. 2 - $^{\circ}\text{F}$.

The fractional debonded surface area, xenon gas conductivity, and fuel-clad gap thickness are temperature-dependent quantities. The fractional debonded surface area is computed as:

$$f_A = \begin{cases} 0.0 & \text{for } T < 1490^{\circ}\text{F} \\ \cos[(\pi/2)(T - 1890)/400] & \text{for } 1490^{\circ}\text{F} \leq T \leq 1890^{\circ}\text{F} \\ 1.0 & \text{for } 1890^{\circ}\text{F} < T \leq 1994^{\circ}\text{F} \\ (2020 - T)/26 & \text{for } 1994^{\circ}\text{F} < T \leq 2020^{\circ}\text{F} \\ 0.0 & \text{for } 2020^{\circ}\text{F} < T \end{cases}$$

The temperature used in this computation corresponds to the node representing the uranium material.

The temperature-dependent gap, δ , is computed using the following relationship:

$$\delta = \begin{cases} 0.0 & \text{for } T < 1490^{\circ}\text{F} \\ 0.1(T - 1490)/400 & \text{for } 1490^{\circ}\text{F} \leq T \leq 1890^{\circ}\text{F} \\ 0.1 & \text{for } 1890^{\circ}\text{F} < T \leq 1994^{\circ}\text{F} \\ 0.1(T - 1994)/26 & \text{for } 1994^{\circ}\text{F} < T \leq 2020^{\circ}\text{F} \\ 0.0 & \text{for } 2020^{\circ}\text{F} < T \end{cases}$$

Thus, the gap has a maximum width of 0.1 in.

The temperature-dependent thermal conductivity (Btu/h-in.-°F) of the xenon gas filling the gap is computed as:

$$k_{xe} = \begin{cases} 0.0 & \text{for } T < 1490^{\circ}\text{F} \\ [1.2633 (10)^{-6}](T + 460)^{0.8616} & \text{for } 1490^{\circ}\text{F} \leq T \leq 2020^{\circ}\text{F} \\ 0.0 & \text{for } 2020^{\circ}\text{F} < T \end{cases}$$

3.8.1.4 Thermal Bridging Model (IHEAT = 4)

The thermal-bridging model was implemented to account for a step change in overall heat transfer that may occur due to slumping of components, or step changes in gap sizes. The original user-specified value of heat transfer coefficient (HINT) and area (DLONG*DWIDE) input in BLOCK 5 are replaced by the thermal bridging model variables of HINTV and AREAV once the thermal bridging temperature (TEMPFV) is exceeded. The temperature at which the bridging will occur can be made a function of the uranium node temperature (TEMPFV < 0) or the cladding node temperature (TEMPFV > 0).

This model can also be used to invoke one-time step changes in the internal thermal connection for connected components with materials other than uranium or Zircaloy. In this case, the node temperature, which is compared with TEMPFV, is selected from one of the two nodes connected, N1 or N2 (source and sink nodes). If TFAILV is set to a value greater than zero and the material associated with N1 does not represent Zircaloy (i.e., NOXMAT(N1) ≠ 100), the temperature of node N2 will be used in the conditional check against TEMPFV. Conversely, if TFAILV is less than zero for this connection and the material of node N1 is not uranium (i.e., NOXMAT(N1) ≠ 1), the temperature of node N2 will be used in the conditional check against TEMPFV.

The bridging model may be invoked only once for an internal thermal connection during the execution. The routine sets a flag to prevent resetting the bridging values of HINTV and AREAV any time after this switch is set. The model requires IHEAT = 4 and non-zero entries of HINTV, AREAV, and TEMPFV (BLOCK 5, Card B).

3.8.1.5 User-Specified Variable Internal Thermal Connections (IHEAT = 5)

This heat transfer option directs subroutine HTRANS to interpolate from tabular values the heat transfer coefficient for the internal thermal connection. Subroutine HTRANS performs a linear interpolation between values in the USERH vs. USERT table using the average film temperature for temperature-dependent specified heat transfer coefficients, or SUMTIM for time-dependent cases. The user-specified variable internal thermal connection is created by specifying IHEAT = 5 and a non-zero value of NUSERT (BLOCK 5, Card B) and the appropriate number of entries in the variable heat transfer coefficient table (BLOCK 5, Card C).

3.8.2 Severe Accident Heat Transfer Models

Described below are two heat transfer models used in modeling severe reactor accidents: 1) the node uncover model for boiloff simulations, and 2) a binary gas mixture property model for determining the effect of hydrogen on convective heat transfer.

3.8.2.1 Node Uncovery Model

The node uncover model allows for a smooth transition from two-phase bulk boiling conditions (node covered) to single-phase vapor/dryout conditions (node uncovered) during a boiloff simulation. This model becomes important in determining the heatup for a node that is being uncovered. The model computes an "average" heat transfer coefficient based on the amount of node covered and the magnitude and profile of the local heat transfer coefficients. This average node heat transfer is updated each time step.

In the vicinity of a dryout front, the heat transfer coefficient used for the affected nodes is a combination of the bulk-boiling heat transfer coefficient for the covered region, HBULK (BLOCK 10, Card B), the single-phase vapor convective heat transfer coefficient computed from one of the above correlations (HSTEAM), and a transition region heat transfer coefficient. This "blend region" heat transfer coefficient is used to make the transition from HBULK (representing that portion of the node still immersed in fluid) to the single-phase vapor heat transfer coefficient (representing that portion of the node above the dryout front). The transition region occurs over a user-specified length HDO (BLOCK 10, Card B). In this region, the heat

transfer coefficient is assumed to vary from HBULK to the correlation value, HSTEAM, in exponential fashion:

$$h_{tr} = HBULK \cdot \exp^{X/HDO \cdot \ln(HSTEAM/HBULK)}$$

where: X is the position in the transition zone, i.e., $\leq HDO$

h_{tr} is the local transition zone heat transfer coefficient.

A schematic illustration of the heat transfer regions and the assumed behavior of the heat transfer coefficient for a node being uncovered is presented in Figure 3.5.

The node uncover model considers two cases: 1) when the extent of the dryout region occurs entirely within one node, and 2) when the extent of this region overlaps two (or more) adjoining nodes. When the dryout region occurs entirely within one node, the following relation is used to compute the overall heat transfer coefficient:

$$h_{eff} = \frac{1}{\Delta Z} \left\{ l_c \cdot HBULK + (l_{hc} - HDO) \cdot HSTEAM + \frac{HDO \cdot (HSTEAM - HBULK)}{\ln(HSTEAM/HBULK)} \right\}$$

where: ΔZ = node axial length

l_c = length of node below dryout front in bulk-boiling region

l_{uc} = length of node above dryout front in dryout region,

$$l_{uc} = \Delta Z - l_c.$$

A similar expression is used for the case in which the dryout region extends into an adjoining downstream node. The convective heat transfer coefficient used for the node containing the dryout front is computed as:

$$h_{eff} = \frac{1}{\Delta Z} \left\{ l_c \cdot HBULK + \left[\frac{HBULK \cdot HDO}{\ln(HSTEAM/HBULK)} \exp^{l_{tr}/HDO \cdot \ln(HSTEAM/HBULK)} - 1 \right] \right\}$$

FIGURE 3.5. Heat Transfer Regimes and Modeling for a Node Being Uncovered

where: l_{tr} = length of transition zone in node, $l_{tr} = \Delta Z - l_c$.

In the adjoining node, the convective heat transfer coefficient is computed as:

$$h_{eff} = \frac{1}{\Delta Z} \left\{ \frac{HBULK \cdot HDO}{2n(HSTEAM/HBULK)} \left[\frac{HSTEAM}{HBULK} - \exp^{l'_{tr}/HDO \cdot 2n(HSTEAM/HBULK)} \right] + l_{uc} \cdot HSTEAM \right\}$$

where: l'_{tr} = length of transition zone in downstream node, $l'_c + HDO - \Delta Z$
 l_{uc} = length of node uncovered in downstream node, $l_{uc} = \Delta Z - l'_{tr}$.

For nodes completely uncovered, the heat transfer coefficient is computed from either the Dittus-Boelter or Wong-Hochreiter correlations.

3.8.2.2 Binary Mixture Property Model

The optional binary property mixture model can be used to assess the effect of two different gaseous components (normally steam and hydrogen from metal-water reactions) on the convection heat transfer coefficient. In this model, the average density, viscosity, thermal conductivity, and heat capacity of a fluid node are evaluated from the thermophysical properties of the gases according to various mixture laws. The density of each constituent of the fluid mixture is assumed to be a function of temperature only. This temperature dependence is provided in the density-versus-temperature arrays RHOTAB and TRHO (BLOCK 2, Card D). Subroutine HTRANS uses the computed fluid temperature and scans array RHOTAB for the density corresponding to that temperature. Linear interpolation is used between points in the array. If the fluid in the node is a binary mixture (usually composed of steam and hydrogen from the metal-water reactions), the mixture density is computed as a mass-weighted average of the constituents.

The mixture viscosity for the node is computed in a manner similar to the density. Table look-ups for the viscosity of each constituent fluid are performed using the viscosity vs. temperature data provided in arrays VISTAB

and TVIS (BLOCK 2, Card C). The viscosity for a binary mixture is computed using Wilke's (1950) semiempirical formula:

$$\mu = \frac{\sum_{i=1}^2 x_i \mu_i}{\sum_{j=1}^2 x_j \phi_{ij}}$$

$$\phi_{ij} = \frac{1}{\sqrt{8}} \left(1 + \frac{M_i}{M_j} \right)^{-\frac{1}{2}} \left[1 + \left(\frac{\mu_i}{\mu_j} \right)^{\frac{1}{2}} \left(\frac{M_j}{M_i} \right)^{\frac{1}{2}} \right]^2$$

where: x_i = mass fraction for constituent i
 M_i = molecular weight of constituent i
 μ_i = viscosity of constituent i

Constituent and mixture heat capacities are computed in a manner analogous to that done for the density. The heat capacitance of each constituent in the mixture is computed using table look-ups with arrays CAPT and TVARC (BLOCK 2, Card E). As before, the fluid temperature assigned to the node is used for the interpolation process. In the event of the fluid in a node representing a binary mixture, the mass-weighted average of the constituent heat capacitances is used to represent the mixture.

Finally, the constituent and mixture fluid thermal conductivities are computed as was done for the viscosities. The thermal conductivity of each constituent is loaded into arrays CONT and TVARK (BLOCK 2, Card F). The node fluid temperature is used to interpolate in these tables and identify the thermal conductivity of each constituent. A mixture thermal conductivity is computed using Wilke's semiempirical formula presented above in the discussion of mixture viscosities (with the constituent viscosities replaced by constituent thermal conductivities).

3.9 SUBROUTINE SURE

Subroutine SURE is entered to read in the data items in data BLOCK 6, the surface-connection list, and in data BLOCK 7, the external temperature (boundary node) list. All input data and immediately derived data, such as connection areas and table slopes, are written out.

For the first time step, SURE is entered to initially set the cross-reference tables that relate the surface-connection list to the node list and boundary node list. The initial values of several quantities are calculated, including the conductance of the surface connections.

At each time step, SURE is entered to calculate the cumulative heat flow across each surface connection, the new boundary node temperatures, the new surface-connection conductances, and the amounts of heat flow across each surface connection. These calculations are based on estimated average conductances during the time step, surface node temperatures at the beginning of the time step, and boundary node temperatures at the end of the time step.

At intervals determined by input data, summary data are written out for each surface connection, including the surface and boundary node numbers, the connection area, the surface conductance, the free-convection exponent, the radiative transfer form factor, the overall conductance, and the net heat flow and average heat flow rate into the surface node from the boundary node. Summary data are written out for each boundary node, including the boundary node number, the external temperature, and the net heat flow and average heat-flow rate into the system from the boundary node. The total heat flow and average flow rate into the system for all boundary nodes are also written out.

SURE calls TRUMP subroutines SEEK2 and REFER, and returns to HEART.

3.10 SUBROUTINE SPECK

Subroutine SPECK is entered after all input data have been read in, and, for the first time step, to initially set various quantities.

At each time step, SPECK is entered to make the final calculation of heat flow across surface connections and internal thermal and mass flow connections, including nodes classified as special nodes. This calculation is based on interpolated values of special node temperatures during the time step, weighted from 0.57 to 1.00 toward the temperatures at the end of the time step.

When special nodes are connected to each other, an iterative calculation is required, which is done by an accelerated method and imposes strict convergence criteria on average and individual temperature changes. Diagnostic

statements are written out if a specified maximum number of iterations are required, and if the problem must be ended because of convergence failure when the smallest time step is being used.

Heat flow into regular nodes connected to special nodes is corrected to maintain an exact heat balance for each connection.

At intervals determined by input data, summary data are written out, including the number of time steps completed; the total, average, and maximum number of iterations used; and the temperature interpolation factor.

SPECK returns to HEART.

3.11 SUBROUTINE TALLY

The input and cycling portions of subroutine TALLY are discussed below.

3.11.1 Input

Because subroutine TALLY reads in two different input blocks, i.e., BLOCK 1 and BLOCK 9, and changes have been made to both, each of the input blocks are discussed below.

3.11.1.1 BLOCK 1

Within BLOCK 1, several additions and/or modifications have been made from the original TRUMP.

Input variable OUTDISC has been added and is read from Card A. OUTDISC acts as a post-processing dump flag. When OUTDISC = 2, graphics dump files TAPE3 and TAPE5 (see Section 5.0) will be created; when OUTDISC = 0, these post-processing files are not created.

Card D, the "Bundle Characterization and Special Output Card", has been added. Diagnostic printout flag, IDIAG, controls what TRUMP-BD output summaries will be created and written to the OUTPUT file (Section 5.0). Variable NSPOUT identifies the number of special output nodes listed on Card E that are read into array NODOUT; node temperatures of the special output nodes at intervals specified by XSPRNT are written to the post-processing output file, TAPE 5. Variable NAXPO identifies the number of special axial output nodes to be entered on Card F and read into array NODEAX. NAXTIM identifies the number of times listed on Card G to be read into array AXTIM;

the axial temperature profiles at times defined by AXTIM for nodes specified by NODEAX are written to post-processing output file, TAPE 11. The last new BLOCK card read by TALLY is Card H, the "Output Suppression Card"; this card limits the amount of extraneous standard TRUMP output written in during a simulation.

3.11.1.2 BLOCK 9

Subroutine TALLY is also entered to read in the input items in BLOCK 9, which include heat generation information and the setting initial conditions.

In BLOCK 9 Card A, the "TRUMP-BD Logic Card", is read first. When LEVFLG = 0, standard TRUMP logic is used and TALLY will try to read Card B, the "Initial Conditions Card"; Cards C through I should be omitted in this case. When LEVFLG = 1, TALLY will route to TRUMP-BD logic and will read Card C through Card I; Card B should be omitted in this case.

Card C is the "Power Generation and Oxidation Description Card". Variable TFAIL, the uranium fuel failure temperature, defaults to 1994°F unless specified by the user (Card C). The metal-water correlation flag, MWRCOR, is then checked by TALLY. If no oxidation is specified (MWRCOR = 0), the variable MWR (whose value is the number of metal-water reaction nodes input in BLOCK 4) is reset to zero. MWR is used within TRUMP-BD as a DO-LOOP index limiter; thus, resetting this variable to zero causes TRUMP-BD to bypass oxidation logic. Also read from Card C is the variable power generation flag, IGENFG. When IGENFG is 1 or -1, indicating time varying heat generation during boiloff (1) and nonboiloff (-1) simulations, Card D, the "Power Generation-Time Table" is read next by TALLY. Following this, a check is made on NOXVAR, the uranium oxidation area variation flag. If NOXVAR is > 0, NOXVAR pairs of OXMULT vs. OXTEMP will be read from Card E, the "Oxidation Area Variation Table". This feature was added to provide a means of varying the available uranium oxidation area with temperature to account for changes due to fuel swelling and/or relocation. For problems in which temperature TFAIL is or has been exceeded for a given fuel pin at a discrete axial level, values of OXMULT are linearly interpolated in TALLY from this table at each time step using TPINMAX. For boiloff simulations, AXMG is used to modify the local heat generation rate for nodes above the dryout front, thus accounting for any power change caused due to voiding of the coolant in the flow region.

The "Axial Power Profile Descriptor Card", Card F, is read next by TALLY. If ICOS, the axial power profile identifier, is found to be 0, a chopped-cosine axial power profile is used. When ICOS = 1, Card G, the "Axial Power Profile and Integral Table" is read. This card requires that the local peaking factor (PMULT) and integrated power (PINT) be specified at user-specified axial positions (PHIGHT) in the table. Note that the integrated power values (PINT) need only to be input for boiloff simulations.

TALLY next reads Card H, the "Node Heat Generation and Temperature Initialization Card". This card is used to specify node axial and radial power factors used by TALLY to derive node heat generation rates, the current phase change mass fractions, and node temperatures to values other than the problem default values read by TALLY in BLOCK 1, Card C.

For each Card H read, TALLY first checks ITXY, the initial temperature axial variation flag. When ITXY > 0, TALLY will read Card I, the "Initial Temperature Axial Variation Card", for ITXY pairs of node temperatures (TOUM) vs. axial position (ZDUM). The initial temperature, TT, of a node is then determined by linear interpolation using the axial position at which the node is located, HEIGHT. When ITXY is zero, TT is set to the value of TXY on Card H; if TXY is not specified, the node temperature is defaulted to the value specified by TONE (BLOCK 1, Card C).

For severe accident problems, the model heat generation is normally a combination of fission and/or gamma heating, along with energy release due to metal-water reactions. TRUMP-BD will compute the time-dependent metal-water reaction heat generation component for Zircaloy/uranium nodes in GEN provided: 1) MWRCOR is ≥ 0 , 2) finite values of node thickness (ZRTHIK) and oxidation area (OXAREA) are specified, and 3) node temperatures are high enough (i.e., $T > 1300^{\circ}\text{F}$ for zirconium, $T > T_{\text{FAIL}}$ for uranium).

To simulate fission and/or gamma heat generation, an average linear heat generation rate for the entire fuel bundle must be specified. This term, RODAVE, is computed by dividing the total fuel bundle heat generation rate (kW) by the total fuel bundle heated length (ft) and the total number of discrete fuel rods or elements; the units of RODAVE are therefore kW/ft-rod.

The average volumetric fission heat generation rate, PAVE, is then calculated by

$$\text{PAVE} = 3412. * (\text{FISAVE}/12.) / (\text{PI} * \text{FUELR} ** 2) \quad (\text{Btu/h-in.}^3)$$

where: FISAVE = the fraction of heat generation by fission, i.e.,
 $\text{RODAVE} * (1 - \text{PGAMMA})$

FUELR = effective radius of fuel rod(s) (BLOCK 1, Card D)

RODAVE = fuel rod average power (kW/ft-rod) (BLOCK 9, Card C)

PGAMMA = fraction of heat generation from gamma heating
(BLOCK 9, Card C)

3412 = conversion from kW to Btu/h

12 = conversion from ft to in.

Note that the total bundle nuclear heat generation rate is composed of a fission and gamma heating contribution; when computing the average volumetric heat generation rate in the fuel (FISAVE), the gamma heat contribution is not included.

The gamma heating volumetric heat generation rate, PGAMMA, is computed from the gamma heating linear heat generation rate (RODAVE*PGAMMA) and an effective component cross-sectional area (i.e., cladding) using

$$\text{PGAMMA} = 3412. * (\text{GAMAVE}/12.) / \text{CLADXC} \quad (\text{Btu/h-in.}^3)$$

where: GAMAVE = PGAMMA*RODAVE, the average linear heat generation rate due to gamma heating (kW/ft-rod)

CLADXC = cross-sectional area of fuel cladding (in.²)

For each node specified on Card H, the "Node Heat Generation and Temperature Initialization Card," the volumetric heat generation rate defined by either PAVE or PGAMMA is used in conjunction with axial and radial power factors and the node volume to determine the node's initial heat generation rate. If the node is a fuel node, the volumetric heat generation rate is computed based on PAVE, specified by setting NGAM = 0 (Card H); for a nonfuel component with

gamma heating, the volumetric heat generation rate is computed from PGAMMA, specified by setting NGAM = 1. The axial power factor, PAXIAL, is either computed from the PMULT vs. PHIGHT table (Card G), if ICOS < 1, or from the chopped-cosine axial profile specified on Card F.

The chopped-cosine axial profile is defined by variables PRATIO and EZERO on Card F. PRATIO is the ratio of peak-to-average (RODAVE) power, assumed to occur at the axial midpoint of the bundle length. EZERO is an extrapolated length at which PAXIAL = 0.0, the imaginary intersection points of the cosine curve at zero (Figure 3.6). An expression for the cosine function defined by extrapolated length and the peak-to-average power ratio is then used by TALLY to calculate a local PAXIAL for each node along the bundle length.

The node radial power factor PRADIL is also input on Card H. This factor accounts for the local variation in heat generation due to the radial and/or circumferential position of the node(a). The initial volumetric node heat generation rate is then PAVE*PAXIAL*PRADIL when NGAM = 0, or PGAMMA*PAXIAL*PRADIL when NGAM = 1.

When NSEQ > 0 on Card H, an additional NSEQ nodes (where N1 is incremented by NADD each time through the loop) are initialized for this Card. When NSEQ + 1 nodes have been initialized, TALLY loops back to read another Card H, continuing until all node initial values have been set, at which point TALLY returns control to HEART.

3.11.2 Cycling

After all input data for a problem has been read in, TALLY is entered to write out a summary of the number and sizes of input data blocks, data carried over from preceding problems, the number of tables of various types, and the numbers of certain types of input items. Next, the initial conditions from BLOCK 9 are used to set the "current" heat generation rate (G), Temperature (T), and phase mass fraction (A) for each node. The problem time, the size of the first time step and interpolation factor, and other variables are initially set.

(a) PRADIL can also be used to model local variations in the axial power profile.

FIGURE 3.6. Characteristics and Variable Definitions for a Chopped-Cosine Axial Power Distribution

Subroutine TALLY is the time step control center of the program. At the end of every time step the original TRUMP numerics in TALLY are used to determine the maximum stable time step for regular nodes. Nodes may be reclassified as "special" nodes to keep the size of the time step from being limited. The largest temperature change for the time step is found. The results of the time step are accepted or rejected based on input data, the largest temperature change, and changes in tabulated quantities during the time step. The size of the next time step is then determined. The new values of node temperatures, heat contents, fluxes, and maximum and minimum temperatures in the system are computed.

When uranium fuel nodes are designated as belonging to a unique fuel "pin" using NPN (BLOCK 4, Card D), the minimum temperature (TPIN) of each pin for each axial level is computed. A check is made on TPIN to see if it exceeds TFAIL, the fuel failure temperature, and also to see if TPIN exceeds TPINMAX, the maximum temperature for the pin thus far in the transient. When a uranium pin is found to have failed, a uranium oxidation area multiplier (OXAREAM) is computed using linear interpolation of TPINMAX in the OXMULT vs. OXTEMP table. If fission products release is being modeled, subroutine FISPROD is called if any fuel has failed.

The total hydrogen production during the current time step is a result of oxidation of uranium (HFROMU) and Zircaloy (HFROMZ), and is computed based on the conversion of chemical reaction heat generation terms (QZRH2O). Additional hydrogen and steam summary information for the model is then also computed, along with FUELMX and CLADMX, the maximum uranium and Zircaloy cladding temperatures in the model, respectively. Special output node temperatures and system summary information is written to TAPE5 and TAPE3 if XSPRNT time has elapsed since they were last written. Special output node temperatures and phase information is also written to OUTPUT, the main output file, after phase concentrations have been updated.

As in the original TRUMP, various criteria for ending the problem are tested. Various criteria for producing output data for the time step are also tested. When required, data for the time step are written to the OUTPUT file. The type and extent of both standard TRUMP and TRUMP-BD output written at this time is discussed in detail in Section 5.0.

TALLY is entered at entry point TALLY1 when a problem is ended in order to write, if required by the input data, the final conditions of the problem to OUTAPE, which can be used to restart the problem (Section 4.0).

TALLY calls TRUMP-BD subroutines FISPROD, SEEK1, REFER and TIMER. TALLY returns to HEART during normal time step cycling.

3.12 SUBROUTINE REFER

Subroutine REFER is entered only during the first time step to produce cross-reference tables relating various input-data item lists. The sequence number in the node list (BLOCK 4) must be found for all nodes listed in data BLOCKs 1, 5, 6, 8, 9, 10, 11, and 12. The sequence number in the material list (BLOCK 2) must be found for each material listed in BLOCK 4. The sequence number in the boundary-node list (BLOCK 7) must be found for each boundary node listed in BLOCK 6. This procedure makes possible the use of arbitrarily chosen identification numbers for each of the four types of items referenced by other data blocks, allowing flexibility in arranging and modifying data decks. Also, the identification numbers may be chosen to convey additional information to the user, such as composition, spatial location, and function in the problem.

The search for each item referenced is made in reverse sequence, so that the latest item in the list is used. If a referenced identification number is not in the list being searched, a diagnostic statement is immediately written out, an error indicator is set, and the problem is terminated.

REFER returns to the calling routine, which may be THERM, GEN, FINK, FLOW, SURE, or TALLY.

3.13 SUBROUTINE SEEK1

Subroutine SEEK1 is entered only during the data-input phase of the problem, when a data BLOCK 2, 4, 7, 8, or 9 of type B is being read in. Since the data carryover feature of the code has been deleted, i.e., type B-input, subroutine SEEK1 is not used.

3.14 SUBROUTINE TIMER

Subroutine TIMER finds the machine time, in seconds, charged to the program since the last call of TIMER, by means of the system subroutine SECOND.

TIMER returns to the calling routine, which may be HEART or TALLY.

3.15 SUBROUTINE FISPROD

Subroutine FISPROD performs three major functions:

- reads and processes input from BLOCK 13 relating to initial fission product inventories and release characteristics
- computes fission product release from failed uranium metal zircaloy-clad fuel nodes subsequent to fuel failure after each time step
- writes fission product special output data to TAPE12.

Details of the first two of these three functions are described below; fission product output data written to TAPE12 is described in Section 5.0

3.15.1 Input BLOCK 13

By specifying an input BLOCK 13, subroutine FISPROD is called by HEART during the input phase to read data on those fission products whose release is being modeled. BLOCK 13 input includes:

- the number of different fission products modeled
- a reference vapor temperature needed for the bake-out term of the fission product release empirical relationship (see Section 3.16.2)
- the fraction of whole-core power generation occurring in the fuel assembly being modeled (variable FPFRAC)
- initial whole-core inventories of each fission product being modeled (vector FPIT)
- four empirical constants for each fission product which are used in the empirical relationships for fission product release
- variables that control the times at which fission product release summaries will be written to TAPE 12 (see Section 3.16.3).

Heat generation rates and volumes for all uranium fuel nodes (computed in TALLY and THERM, respectively) are used by FISPROD during problem initialization (i.e., KCYC = 0), along with BLOCK 13 input FPFRAC and FPIT, to estimate initial node inventories for each fission product by assuming that

each fuel node's fission product inventory is linearly proportional to the percentage of whole-core decay heat generation occurring in that node.

3.15.2 Fission Product Release from Nuclear Fuel

Within FISPROD, the fission product release rate at a given time step from an exposed uranium fuel node is assumed to be the sum total of releases caused by simultaneous mechanisms that account for fuel oxidation and volatilization/diffusion, respectively. The overall mass balance equation used by FISPROD for each species can be written as:

$$(dfp/dt)_i = R_{0i}(f_{ps_i} - f_{pf_i}) + R_{bi}(f_{ps_i} - f_{pf_i}) \quad (3.3)$$

where $(dfp/dt)_i$ = rate of release of fission product i ;

f_{ps_i} = concentration of fission product i in surroundings;

f_{pf_i} = concentration of fission product i in fuel;

and R_{0i} is a conductance defined as the release fraction due to oxidation and R_{bi} is a conductance defined as the release fraction due to volatilization/diffusion. Because accurate determination of surrounding concentrations is not computed by TRUMP-BD, f_{ps} is assumed = 0.0 as a conservatism. After the rate of release dfp/dt from each fuel node is computed, integral releases are updated by multiplying the node's release rate by the time step, and summing this release with the integral total release for the node accumulated from earlier time steps.

Calculation of the conductances R_{0i} and R_{bi} is accomplished with relations derived by Birney et al. (1988), based on available data for zircaloy-clad uranium fuel.

Data for fission product release as a result of uranium oxidation in air are shown in Figures 3.7 through 3.10, while that for oxidation in other environments is shown in Table 3.5. The data in the figures indicate that complete fuel oxidation would release about 100 percent of the iodine, tellurium, and about 30 percent of the cesium. Table 3.5 indicates significantly less release for low volatility species. Using these data, Birney et al. formulated the following empirical correlation, where the release

TABLE 3.5. Fission-Product Release from Uranium Fuel Irradiated to 1.0-atom Percent and Oxidized (Birney, et al. 1988)

Oxidizing Atmosphere	Time Heated (min)	Percent Of U Oxidized	Percent of Total Activity Released					
			I	Te	Cs	Ru	Sr	Zr
Air	20	65	57	71	13	1.8	0.09	0.05
Air	250	100	90	96	24	65	--	0.01
CO ₂	630	100	53	69	1.7(a)	1.0	0.01 ^(a)	0.1
CO ₂ -helium	410	90	68	55	0.9 ^(a)	--	0.01 ^(a)	0.0
Steam-helium	123	65	15	79	0.2 ^(a)	0.01	0.02 ^(a)	0.2
Helium	148	4	47	0.6	2.0		0.9	-

fraction (R_0) of a particular species is related to the extent of Uranium oxidation as follows:

$$R_0 = C_X F \quad (3.4)$$

where F is the fraction of uranium oxidized. The release constant (C_X) for each fission product species is given in Table 3.6.

The predicted fraction of uranium oxidized (F) is directly computed by FISPROD; thus, the release fraction (R_0) for each fission product can be calculated at each time step.

TABLE 3.6. Oxidation-Induced Fission Product Release Constants

Iodine	$C_X = 1$
Tellurium	$C_X = 1$
Cesium	$C_X = 0.3$
Ruthenium	$C_X = 0.05$
Strontium	$C_X = 0.01$
Zirconium	$C_X = 0.01$
Cerium	$C_X = 0.01$
Barium	$C_X = 0.01$

(a) Release values probably low because of chemisorption in test apparatus.

FIGURE 3.7. Cesium Release from Uranium Oxidized in Air

FIGURE 3.8. Fission Product Release from Uranium Oxidized at 1200°C

FIGURE 3.9. Iodine Release from Uranium Oxidized in Air

HEDL 8706-098.4

FIGURE 3.10. Tellurium Release from Uranium Oxidized in Air at 1200°C

HEDL 8706-098.3

Available data for fission product release from metallic uranium melted in an inert atmosphere caused by volatilization/diffusion (or "bake-out") are shown in Table 3.7.

For each fission product a correlation was developed by Birney et al. that uses the fission products vapor pressures, to formulate a temperature-release dependent relationship. The vapor pressures were obtained from Parker and Barton (1975), and fit to the form:

$$\log P = -0.05223 (A/T) + B \quad (3.5)$$

where the log is base 10, P is in mm-Hg and T is in K. The A and B coefficients are given in Table 3.8.

Lacking definitive time-dependent release data, the values shown in Table 3.7 were extrapolated linearly with time to 100 percent release. However, to correlate the data, the ratio of the vapor pressures at high temperatures relative to that at 1200°C (1473 K) were raised to the 0.7-power. Thus, the following release equation was obtained by Birney et al.:

$$R_b = .01Ct (V(T)/V_{ref})^{0.7} \quad (3.6)$$

where

R_b = fission product release fraction due to bake-out

C = constant from Table 3.8

t = time at temperature T (min)

V_{ref} = vapor pressure for a specific fission product (mm-Hg)
at the reference temperature of 1473 K (2192°F)

T = temperature (K).

TABLE 3.7. Fission Product Release Data for Metallic Uranium Melted in an Inert Atmosphere

Reference	Time at temperature (min.)	Temperature (°C)	Percent released						
			Xe-Kr	I	Te	Cs	Ru	Sr	Ba
Parker et al. (1967, p. 61)	148	1200	98	47*	0.6	2.0		0.9*	
Hilliard (1959, p. 24)	25	1215	10	41	4.2*	1.2*	0.09*	0.18	0.08*
Hilliard et al. (1961, p. 4)	2.5 to 232	425 to 1440	Min. Max. Avg.			0.04	0.008	0.008	0.01
						0.17	0.13	0.18	0.23
						0.08	0.05	0.06	0.07
Hilliard et al. (1961, p. 5-6)	2.5 to 232	425 to 1440		-50	-10	<1			
Hilliard and Reid (1962, p. 28)	3	1000 to 1400		-100					

* These data were selected and used to develop Table 4.

TABLE 3.8. Vapor Pressure Equation Coefficients

Element	A	B	log p ^a (1200 °C)
Iodine	34175	6.740	5.53
Tellurium	120810	7.817	3.53
Cesium	71275	6.679	4.15
Ruthenium	611935	10.760	-10.94
Strontium	141145	7.285	2.28
Zirconium	815110	15.730	-13.17
Cerium	443200	12.883	- 2.83
Barium	176630	8.100	1.84

From Parker and Barton (1973).

^aLog P = -0.05223 A/T + B
 where the log is base 10, P is in mm Hg,
 and T is in K.

4.0 PREPARATION OF INPUT DATA

Described below is the TRUMP-BD input format, data deck organization, and the individual input card function and variable entries. Definitions of code input and processing variables are presented in Appendix A, the Variable Glossary.

4.1 CARD INPUT FORMATS

All input data for TRUMP are in Hollerith (A), integer (I), or floating point (E or F) formats.

Hollerith data may consist of any characters in the character set recognized by the computer and available on standard computer terminals.

Integer data may consist of numbers only, preceded by a sign, and right-justified in the specified data fields.

Floating point data may include numbers, preceded by a sign, and must include a decimal point if the field is not entirely blank. The exponent to the base 10 may be included (right-justified in the specified data field), consisting of the letter E or a sign, or both, followed by numbers. Some variables used in floating point form in the program are read in with a Hollerith format, converted to floating point if a decimal point is included, or assigned some other value if no decimal point is included.

4.2 DATA DECK ORGANIZATION

The structure of the TRUMP-BD input data deck is presented below.

4.2.1 Data Decks

Each input data deck must consist of a "Problem Name Card," any number of "BLOCK Number Cards" with their accompanying "BLOCK Item" input cards, and a "Data End Card."

4.2.2 Problem Name Card

The first card of each data deck must be a "Problem Name Card." The symbol "*" must be in column 1, any desired problem identification and description in columns 2 through 71. The entire contents of the card (NAME) will appear on all output, along with a sequential problem number. Additional cards

containing comments without "*" in column 1 may precede the name card and will appear on the output.

4.2.3 BLOCK Number Cards

There are presently 10 allowed input data blocks as described in Table 4.1. Each block used must begin with a "BLOCK Number Card" and, except for BLOCK 1, must end with a blank card. The specification of data within each data block is described below.

The "BLOCK Number Card" must have the word "BLOCK" in columns 1 through 5, and the block number right-justified in columns 6 and 7. Any desired block description may be in columns 9 through 80, which will appear on the printout. Additional cards containing comments may proceed or follow any data block, as long as columns 6 and 7 are blank, and will also appear on the printout.

Data BLOCK 1 must follow the "Problem Name Card." Data BLOCK 1 may be used more than once in the data deck to change the values of parameters used for initializing data in the subsequent data blocks, such as SCALE, KO, TONE, ALONE, GONE, FONE, HONE, RONE and PONE. Thus, a data block may be subdivided into sections requiring different values of one or more of the listed parameters, and placed in the data deck with a new BLOCK 1 preceding each section. All other data blocks may be placed in any order. If more than the allowed limit of items are described for a particular block, a diagnostic statement is printed, the excess items each successively stored in the last available memory location, and the value of KWIT, the program termination indicator, set to 11. If any table length exceeds the allowed limit, the data will be incorrectly stored, and the value of KWIT set to 12. In either case, the problem will end after completion of the input and initialization phases.

If the same item is described more than once in a block, the effects will be additive in BLOCKs 5, 6, 10, or 13, but only the last description will be used in BLOCKs 2, 4, 7, 8, 9, or 12.

TABLE 4.1. TRUMP Input Data Blocks

<u>BLOCK</u>	<u>Description</u>	<u>Optional Subroutines Required</u>
1(a)(b)	Problem controls, limits, constants	GEN(c)
2(a)	Material properties	
4(a)	Node descriptions	
5	Internal thermal connections	
6	External thermal connections	SURE
7(d)	External temperatures (boundary nodes)	SURE
8	Variable heat-generation rates	GEN
9	Initial values of temperature, heat-generation rates, metal-water reactions	GEN(e)
10	Mass-flow connections, coolant boiloff	FLOW
12	Nodes with properties dependent on remote temperatures	
13	Fission Product Inventories	FISPROD

-
- (a) Required data for all problems.
 - (b) Must be read in before any other data blocks.
 - (c) Only if GONE is nonzero.
 - (d) Required if BLOCK 6 is used.
 - (e) Only if one or more GG values are nonzero.

4.2.4 Data End Card

The last card of each data deck must be a "Data End Card" with the word "ENDED" in columns 1 through 5 and "-1" in columns 6 and 7.

4.3 BLOCK ITEM DESCRIPTIONS

Input data that may be specified in each data block are summarized in this section. Formats, definitions, options, and suggested uses are described for all input data specified.

BLOCK 1. PROBLEM CONTROLS, LIMITS, AND CONSTANTS (REQUIRED)

Card A. Format (10I5, 2E10.3, 2I5). General Controls.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5)	IPRINT	Number of time steps between data output, in addition to output on first, second, and last time steps, and output controlled by TIMEP. IPRINT is not used if negative, zero, or unspecified.
(6-10)	NUM	Identification number of a node for which temperature, rate of temperature change, phase, heat-generation rate, and time will be written out after each time step. NUM will not be used if zero or unspecified.
(11-15)	KDATA	Controls options on output data, normal amount (0), minimum (-1), or maximum (1).
(16-20)	KSPEC	Node classification and difference-equation control. Normally zero or unspecified. If zero, regular nodes will be reclassified as special nodes only when necessary to maintain the stability limit above the time step, and the interpolation factor in the heat-balance difference equations may vary in the range 0.57 to 1.0. If negative, no nodes may be reclassified. If positive, all nodes will be reclassified as special nodes before the first time step. If 2, the interpolation factor will be fixed at 1.0 so that the backward difference method will be used. If 3, the interpolation factor will be fixed at 0.5 so that the central difference method will be used. Node classification may be made individually in BLOCK 4 with KS. All nodes listed in BLOCK 6 are classified as special nodes. DELTO and SMALL must be specified when KSPEC is positive.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(21-25)	MCYC	Maximum allowed number of time steps. MCYC will not be used if zero or unspecified. If negative, the problem will end after the first time step.
(26-30)	MSEC	Maximum allowed machine time, in seconds. MSEC will not be used if zero or unspecified. If negative, the problem will end after the first time step.
(31-35)	NPUNCH	Causes a final system summary of results (see Section 5.0) to be written to the main output file when the problem ends normally, if nonzero.
(36-40)	NDOT	Causes all time derivatives to be maintained at zero during the problem, if nonzero. Not normally used.
(41-45)	IRITE	***NOT USED***
(45-50)	ITAPE	***NOT USED***
(51-60)	TIMEP	Problem time interval in hours between data output, in addition to output on first, second, and last time steps, and output controlled by IPRINT. TIMEP is ignored if negative, zero, or unspecified. Output will be written in multiples of TIMEP, if possible, by adjusting the time steps in the range from SMALL to DELTO. The adjustment is also limited to a range from 2/3 to 3/2 of the time step that would otherwise be used.
(61-70)	SCALE	Scale factor. Set to 1.0 if negative, zero, or unspecified. Will be applied to all geometric input data in BLOCKs 4, 5, and 6 read in following this BLOCK 1 and preceding any other BLOCK 1 with a different scale factor. Lengths will be multiplied by SCALE, areas by SCALE ² , volumes by SCALE ³ .(a)

(a) Superscripts used here mean "squared" and "cubed."

Column	Variable	Description
(71-75)	INDISC	***NOT USED***
(76-80)	OUTDISC	Graphics post-processing dump flag: (0) no graphics dump (2) graphics dump

Card B. Format (2I5, 7E1D.3). Symmetry and Limits.

Column	Variable	Description
(1-5)	KD	Symmetry type indicator: 1 for nonsymmetric, 2 for axisymmetric, 3 for centrisymmetric. Input values of DRAD in BLOCKs 4, 5, and 6 read in after BLOCK 1 will be replaced with DRAD, 2π DRAD, and 4π DRAD ² , respectively. KD is set to 1 if unspecified or zero.
(6-10)	KT	Temperature scale indicator: This <u>MUST</u> be set to 3 (for Fahrenheit).
(11-20)	DELTO	Maximum allowed time step in hours. May be used with SMALL to limit range of time step. Not usually needed. DELTO is set to 10^{12} if unspecified or not in the range from 10^{-10} to 10^{12} . DELTO must be specified if KSPEC is positive.
(21-30)	SMALL	Minimum allowed time step in hours. May be used with DELTO to limit range of time step. Not usually needed. SMALL is set to 10^{-12} if less than 10^{-12} . If SMALL is unspecified, the program sets SMALL to 2/3 of 1% of the smallest time constant of any regular node in the system, if at least 1/4 of the nodes are regular nodes.
(31-40)	TVARY	Desired maximum temperature change in each time step. TVARY is set to 5.0 if unspecified or zero. Controls size of the time step between limits of SMALL and DELTO. Steady state cannot end the problem until the maximum temperature change is less than $0.001 \cdot TVARY$

<u>Column</u>	<u>Variable</u>	<u>Description</u>
		for two successive time steps. The convergence criteria for the iterative calculation for special nodes are a change in the weighted average temperature change of all connected special nodes of less than $5(10^{-5}) \cdot TVARY$, and in the temperature change of any finite-volume special node of less than $5(10^{-4}) \cdot TVARY$.
(41-50)	TAU	Initial problem time. Will be set to zero if unspecified (h).
(51-60)	TIMAX	Maximum allowable problem time. TIMAX will not be used if zero or unspecified. If it is negative, the problem will end after first the time step (h).
(61-70)	TMIN	Minimum allowable problem temperature. Will be set to -10^{12} if equal to or larger than TMAX. HMELT(N) in BLOCK 2 will be set to zero for any material for which TMELT(N) is less than TMIN ($^{\circ}F$).
(71-80)	TMAX	Maximum allowable problem temperature set to 10^{12} if equal to or less than TMIN. HMELT(N) in BLOCK 2 will be set to zero for any material for which TMELT(N) is greater than TMAX ($^{\circ}F$).

Card C. Format (2E10.3, 10X, 5E10.3). System Constants.

Apply only to data in data blocks read in after BLOCK 1.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	TONE	Initial temperature of all nodes for which TT is either unspecified (left blank or omitted) or set = 0.0 in BLOCK 9 ($^{\circ}F$).
(11-20)	ALONE	Initial weight fraction for all nodes for which AA is either unspecified (left blank or omitted) or set = 0.0 in BLOCK 9.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(30-40)	GONE	Constant heat generation rate in all nodes for which GG is either unspecified (left blank or omitted) or set = 0.0 in BLOCK 9, or no table of GT vs. TVARG is specified in BLOCK 8 (Btu/h-in. ³).
(40-50)	FONE	Constant mass flow rate for all mass flow connections for which FLOWN is either unspecified (left blank) or set = 0.0 in BLOCK 10 (lbm/h).
(50-60)	HONE	Heat-transfer coefficient for all external connections for which HSURE or table of HSURT vs. TVARH is either unspecified (left blank) or set = 0 in BLOCK 6 (Btu/h-in. ² -°F).
(60-70)	RONE	Radiation form factor for all external connections for which RSURE is either unspecified (left blank) or set = 0.0 in BLOCK 6.
(70-80)	PONE	Free convection exponent for all external connections for which POWER is either unspecified (left blank) or set = 0.0 in BLOCK 6.

Card D. FORMAT (2I5, 20X, 2E10.0, I10, E10.0, 2I5). Bundle Characterization and Special Output Card.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5)	IDIAG	Diagnostic printout flag: (1) standard TRUMP output (2) heat generation summary only (3) convection summary only (4) radial and axial loss summary only (5) complete diagnostic summary.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(6-10)	NCHANS	Total number of subchannels in all flow regions specified in BLOCK 10.
(31-40)	FUELR	Fuel pellet radius (in.). Used in conjunction with RODAVE (BLOCK 9, Card C) to determine volumetric heat generation rate.
(51-60)	NSPOUT	Number of special output nodes. If NSPOUT is set negative, <u>ALL</u> nodes will be written to TAPE5 at intervals determined by XSPRNT.
(61-70)	XSPRNT	Time interval between writes to TAPE3 and TAPE5 graphics output files (h).
(71-80)	SYMLT	Model symmetry multiplier for TAPE3 graphic output file dump.
(81-85)	NAXPO	Number of special output nodes for which axial temperature distributions will be written to TAPE 11.
(86-90)	NAXTIM	Numer of discrete times at which special axial output will be written to TAPE 11.

Card E. Format (8(I5,5X)). Special Output Nodes. Optional

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5)	NODOUT(1) (etc.)	Special output node number.

*** Card E read in only if NSPOUT (Card D) $\neq$ 0. ***

Card F. Format (8(I10). Special Axial Output Nodes. Optional

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	NODEAX(1) (etc.)	Special axial output nodes to be written to TAPE 11. Specify last three digits of node number. Temperatures of all axial nodes with this base node number will be written to TAPE 11.

*** Card F read in only if NAXPO (Card D) $>$ 0. ***

Card G. Format (8E10.3). Special Axial Output Times. Optional

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	AXTIM(1) (etc.)	Times at which special axial output will be written to TAPE 11 (h).

*** Card G read in only if NAXTIM (Card D) > 0.***

Card H. Format (4A5). Output Suppression Card.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5)	DATA(1)	Enter "PRT1," to suppress at each output dump: (1) a node by node material property summary (2) properties of each internal connection (3) node current heat content and temperature change information. (Note: comma required)
(6-10)	DATA(2)	Not used in current version.
(11-15)	DATA(3)	Enter "PRTS," to suppress message when a node is changed to a special node. (Note: comma required)
(16-20)	DATA(4)	Enter "PRTT," to suppress message indicating a repeated cycle. (Note: comma required)

BLOCK 2. MATERIAL DATA.

Card A. Format (A5, I5, 10X, 2I5, 5E10.3). Material Description Card.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5)	AMAT	Material name. Column 1 must not be blank.
(6-10)	MAT	Material identification number. For TRUMP-BD problems, uranium = 1, graphite = 2, Zircaloy = 100, steam or water = 10, hydrogen = 11.
(21-25)	LTABC	Number of points listed on heat-capacity table card (Card E); positive if vs. temperature, negative if vs. time, zero if only one value is specified.
(26-30)	LTABK	Number of points listed on thermal-conductivity table card (Card F); positive if vs. temperature, negative if vs. time, zero if only one value is specified.
(31-40)	DENS	Density (lbm/in. ³).
(41-50)	CAPT	Specific Heat, if constant (Btu/lbm-°F).
(51-60)	CONT	Thermal conductivity, if constant (Btu/h-in.-°F).
(61-70)	TMELT	Temperature at which latent heat HMELT is absorbed or released (°F).
(71-80)	HMELT	Latent heat effect at TMELT. Difference between heat contents as a result of phase change. HMELT will be set to zero if TMELT is not between TMIN and TMAX. See AX, BLOCK 9, Card H (Btu/lbm).
(81-85)	LTABP	Number of points listed on phase-change table card or cards; positive if vs. temperature, zero if only one phase change is specified. Enter LTABP ≥ 2 and data on Card G if more than one phase change for a material.

Card B. Format (F10.0, E10.0, 2I5). Coolant Property Card. Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	PRESS	System pressure (psia).
(11-20)	TSAT	Saturation temperature (°F).
(21-25)	NVISX(I)	Number of points in viscosity table (Card C).
(25-30)	NRHOX(I)	Number of points in density table (Card D).

*** Cards B, C, and D, should only be included for materials using identification numbers (MAT) of 10 or 11 on Card A. ***

Card C. Format (8E10.0). Coolant Viscosity Table. Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	TVIS(I,1)	Viscosity (lbm/h-ft).
(11-20)	VISTAB(I,1) (etc.)	Temperature corresponding to TVIS (°F).

*** Card C read in only if NVISX(I) (Card B) > 0. ***

Card D. Format (8E10.0). Coolant Density Table. Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	TRHO(I,1)	Density (lbm/ft ³).
(11-20)	RHOTAB(I,1)	Temperature corresponding to TRHO (°F).

*** Card D Read in only when NRHOX (Card B) > 0. ***

Note: To have coolant properties evaluated as a function of hydrogen concentration, repeat Cards B, C, and D (entering hydrogen property data) after specifying material identification number AMAT = 11 on Card A, BLOCK 2.

Card E. Format (8E10.3). Heat Capacity Table. Optional.

Column	Variable	Description
(1-10)	CAPT(1)	Heat capacity (Btu/lbm-°F).
(11-20)	TVARC(1) (etc.)	Temperature or time corresponding to CAPT(1) (°F or h).

*** Card E read in only if LTABC (Card A) $\neq$ 0. ***

Card F. Format (8E10.3). Thermal Conductivity Table. Optional.

Column	Variable	Description
(1-10)	CONT(1)	Thermal conductivity (Btu/h-in.-°F).
(11-20)	TVARK(1) (etc.)	Temperature or time corresponding to CONT(1) (°F or h).

*** Card F read in only if LTABP (Card A) $\neq$ 0. ***

Card G. Format (8E10.3). Phase Change Table. Optional.

Column	Variable	Description
(1-10)	HMELT(1)	Latent heat effect at TMELT(1) (Btu/lbm).
(11-20)	TMELT(1) (etc.)	Temperature at which latent heat HMELT(1) is absorbed or released (°F).

*** Card G read in only if LTABP (Card A) $\geq$ 2 ***

BLOCK 4. NODE DATA

Card A. Format (10X,E10.0,8X,I2,E10.0,2(8X,I2),I10). Model Description Card.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(11-20)	XINTER	Model lower elevation (in.).
(28-30)	NLEVELS	Number of axial levels in model.
(31-40)	BUNDHT	Model upper elevation (in.).
(49-50)	ILEVFG	Dryout front vs. time table flag: (0) no table (1) table supplied.
(59-60)	NTABL	Number of points in dryout front vs. time table (Card C).

Card B. Format (8E10.0). Axial Noding Descriptor Card.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	AXDIST(1) (etc.)	Axial node length (in.). Repeat up to 8 entries per card for NLEVEL entries.

Card C. Format (8E10.0). Dryout Front-Time Table. Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	WPOSIT(1)	Dryout front position at time WTIME(1) (in.).
(11-20)	WTIME(1) (etc.)	Simulation time corresponding to WPOSIT(1) (h).

*** Card C read only if NTABL (Card A) > 0. ***

Card D. Format (5I5,I2,I3,5E10.3). Node Descriptor Card.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5)	N1	Node identification number.
(6-10)	NSEQ	Number of additional identical nodes, or, if DRAD is preceded by a minus sign, nodes with DRAD values incremented by the difference between DRAD for this node and DRAD for the immediately preceding node.
(11-15)	NADD	Increment between successive values of NODE in the sequence of NSEQ + 1 nodes generated when NSEQ is used.
(16-20)	NZ	Identification number of the material of which the node is a part.
(21-25)	KS	Node type indicator. Node will be a special node if KS is nonzero. Only used when KSPEC in BLOCK 1 is negative. Not needed for zero-volume and surface nodes.
(26-27)	NPRX	Flow region associated with N1 (required for fuel, cladding, and coolant flow nodes only).
(28-30)	NPN	Node pin number if part of fuel or cladding. For nodes assigned a pin number, an output summary of the pin heat generation can be obtained (IDIAG = 2, 5, BLOCK 1, Card D). A pin number must be assigned to fuel and cladding nodes that use the fuel failure model.
(31-40)	DLONG	The product of DLONG, DWIDE, and DRAD with SCALE ³ is equal to the node volume (in. ³) if KD is 1 (BLOCK 1, Card B). For KD values of 2 or 3, the input value of DRAD is replaced with 2π DRAD, or 4π DRAD ² , respectively, before calculation of the volume. The program substitutes 10 ⁻²⁴ if NODE is zero volume, which is indicated by setting DWIDE = 0.0.
(41-50)	DWIDE	
(51-60)	DRAD	

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(61-70)	ZRT	Oxidation node thickness (in.). Input only if node will undergo oxidation. Assigned to array ZRTHIK.
(71-80)	OXA	Available oxidation area per unit length (in.). Assigned to array OXAREA.

BLOCK 5. INTERNAL THERMAL CONNECTION DATA

Card A. Format (2I5). Auto Noding Parameters.

*** NOT USED--LEAVE BLANK ***

Card B. Format (2I5,I1,I2,2I3,I1,4E10.3,20A1) Thermal Connection Descriptor Card.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5, 6-10)	N1,N2	Source and sink node numbers.
(11)	IHEAT	Heat transfer model correlation flag. Nonzero entry indicates connection type heat transfer determined from the following (see Section 3.8.1): (1) Dittus-Boelter correlation (2) Wang-Hochreiter correlation (3) N reactor gap conductance model (4) thermal bridge model (5) user-specified variable heat transfer (HINT). Note: Zero entry provides constant connection heat transfer specified in HINT.
(12-13)	NSEQ	Number of additional identical connections, or if DRAD is preceded by a minus sign, connections with DRAD values incremented by the difference between DRAD for this connection and DRAD for the immediately preceding connection.
(14-16) (17-19)	NAD1 } NAD2 }	Increments between successive values of N1 and N2, respectively, in the sequence of HSEQ + 1 connections generated when NSEQ is used.
(20)	NZ	Indicates NAD1 and NAD2 are each to be multiplied by 10NZ before use in generating a sequence of connections.

Column	Variable	Description
(21-30)	DEL1 }	Lengths, when multiplied by SCALE, of the heat conduction paths from the nodal points in N1 and N2, respectively, to the connected interface. Both should not be zero unless either HINT or RINT is specified.
(31-40)	DEL2 }	
(41-50)	DLONG }	The product of DLONG and DRAD with SCALE ² is the area, in in. ² , of the connected interface if KD is 1 (BLOCK 1, Card D). For KD values of 2 or 3, the input value of DRAD is replaced with 2 π DRAD or 4 π DRAD ² , respectively, before calculating the area.
(51-60)	DRAD }	
(61-70)	HINT	Heat transfer coefficient between the connected node surfaces. Can include effects of surface films, gas gap, or contact resistances. If HINT is not specified, it will be set to 10 ¹² if RINT is not specified, or to 10 ⁻²⁴ if RINT is specified (Btu/h-in. ² -°F).
(71-80)	RINT	Thermal radiation form factor for the connected surfaces of the nodes. If RINT is negative, the absolute value will be used as a free convection exponent.
(81-90)	HV	Heat transfer coefficient for bridge model (Btu/h-in. ² °F). Value assigned into array HINTV.
(91-100)	AV	Heat transfer area for bridge model (in. ²). Value assigned into array AREAV.
(101-110)	TV	Temperature for onset of bridge model (°F). Value assigned into array TEMPFV. TV < 0: uranium node dependent TV > 0: Zircaloy node dependent.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(111-115)	NU	Pairs of entries in user-specified variable heat transfer table. When NU is negative, values are time dependent; when NU is positive, values are temperature dependent. Value assigned into array NUSERT.

Card C. Format (8E10.0). Variable Heat Transfer Coefficient Table. Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	USERH(1,IJ)	User-specified heat transfer coefficient (Btu/h-in. ² -°F).
(11-20)	USERT(1,IJ) (etc.)	Temperature or time corresponding to USERH(1,IJ) (°F or h).

*** Card C read in only if NU (Card B) $\neq$ 0 ***

BLOCK 6. EXTERNAL THERMAL CONNECTIONS.

Card A. Format (2I5). Auto Noding Parameters.

*** NOT USED--LEAVE BLANK ***

Card B. Format (6I5, 5E10.3). External Thermal Connections.

Column	Variable	Description
(1-5)	NODS	Surface node identification number. NODS should be either a zero-volume node or a node with the nodal point on its external surface.
(5-10)	NODSB	External temperature (boundary node) identification number. Set NODSB = 1000 to get summary of "axial" boundary heat transfer, or NODSB = 2000 for "radial" boundary heat transfer summary in output file. All other values of NODSB will be grouped into the miscellaneous boundary heat transfer category.
(11-15)	NSEQ	Number of additional identical connections, or, if DRAD is preceded by a minus sign, connections with DRAD values incremented by the difference between DRAD for the connection and DRAD for the immediately preceding connection.
(15-20)	NADS	Increments between successive values of NODS and NODSB respectively, in the sequence of NSEQ + 1 connections generated when NSEQ is used.
(21-25)	NADSB	
(26-30)	LTABH	Number of tabulated convection coefficient values, negative if vs. time, positive if vs. temperature, zero if no table.
(35-40)	DLONG	Geometric factors whose product with SCALE ² is the of the external surface of NODS if KD is 1. For KD values of 2 or 3, the input value of DRAD is replaced by 2 π DRAD or 4 π DRAD ² , respectively, before calculating the area.
area (41-50)	DRAD	

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(51-60)	HSURE	Convection coefficient, if constant. HSURE is set to HONE (BLOCK 1) if not specified (left blank) or set = 0.0. (Btu/h-in. ² °F)
(61-70)	RSURE	Thermal radiation form factor. RSURE is set to RONE (BLOCK 1) if not specified (left blank) or set = 0.0.
(71-80)	POWER	Free-convection exponent. POWER is set to PONE (BLOCK 1, Card C) if not specified or set = 0.0.

Card C. Format (8E10.3). Convection Coefficient Table.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	HSURT(1)	Convection coefficient. (Btu/h-in. ² -°F).
(11-20)	TVARH(1) (etc.)	Temperature or time corresponding to HSURT(1) (°F or h).

*** Read Card D only if LTABH (Card B) ≠ 0. ***

BLOCK 7. EXTERNAL TEMPERATURE DATA.

Card A. Format (2I5, 10X, 6E10.3). Boundary Temperatures.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5)	NODB	External temperature (boundary node) identification number. Set NODB = 1000 to get summary of "axial" boundary heat transfer, or NODB = 2000 for "radial" boundary heat transfer summary in output file. All other values of NODB will be grouped into the miscellaneous boundary heat transfer category.
(6-10)	LTABT	Number of tabulated external temperature values. To obtain sinusoidal variation of external temperature with time, LTABT must be 100. Zero if no table.
(21-30)	TEMPB(1)	External temperature. Average value of sinusoidal variation, if LTABT is 100 (°F).
(31-40)	TIMEB(1)	Time corresponding to TEMPB(1). Period of sinusoidal variation, if LTABT is 100 (h).
(41-50)	TEMPB(2)	External temperature. Amplitude of sinusoidal variation, if LTABT is 100 (°F).
(51-60)	TIMEB(2)	Time corresponding to TEMPB(2). Phase advance time of sinusoidal variation, if LTABT is 100 (h). Up to three pairs of values on this card, and four pairs on each additional card required, if LTABT is not zero. Use format (8E10.3) for additional cards.
(61-70)	(etc.)	

BLOCK 8. VARIABLE HEAT-GENERATION DATA.

Card A. Format (4I5, 6E10.3). Variable Heat Generation Card.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5)	NODG	Identification number of node.
(6-10)	NSEQ	Number of additional nodes with identical variation of volumetric heat-generation rate as NODG.
(11-15)	NADG	Increment between successive values of NODG in the sequence of NSEQ + 1 nodes generated when NSEQ is used.
(16-20)	LTABG	Number of tabulated values of heat-generation rate, negative if vs. time, positive if vs. temperature. To obtain exponential decay of heat-generation rate with time, LTABG must be between -1 and 1, or unspecified, and GT(1) and TVARG(1) specified.
(21-30)	GT(1)	Volumetric heat-generation rate at TVARG(1), or at zero time (SUMTIM = 0), if exponential decay is specified. See AA (BLOCK 9, Card B), for an additional method to produce an initial pulse of heat at the beginning of a problem. (Btu/h-in. ³)
(31-40)	TVARG(1) (etc.)	Temperature or time corresponding to GT(1), or half-life of exponential decay, if the latter is specified (°F or h). Up to three pairs of values on this card, and four pairs on each additional card required. Use format (8E10.3) for additional cards.

BLOCK 9. INITIAL CONDITIONS AND CONSTANT HEAT GENERATION DATA.

Card A. Format (I5). TRUMP-BD Logic Card.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5)	LEVFLG	Logic flag: (0) standard TRUMP logic (enter Card B) (1) TRUMP-BD logic (enter Cards C through I).

Card B. Format (3I5, 5X, 2E10.3, 10X, E10.3). Initial Conditions Card.
Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5)	NOTE	Node identification number.
(6-10)	NSEQ	Number of additional nodes with identical initial conditions.
(11-15)	NADD	Increment between successive node numbers in sequence of NSEQ + 1 nodes generated when NSEQ is used.
(21-30)	TT	Initial temperature. TT is set to TONE (BLOCK 1, Card C) if not specified (°F).
(31-40)	AA	AA is set to ALONE (BLOCK 1, Card C) if not specified or set equal to 0.0. AA may be used to specify the initial weight fraction of low-temperature phase in nodes of materials with specified values of TMELT and HMELT, if columns 67 through 71 of the Problem Name Card are "A = BL9." Otherwise, the concentration will be 1.0 for initial temperature at or below TMELT and 0.0 for initial temperature above TMELT.
(51-60)	GG	Heat generation rate. GG is set to GONE (BLOCK 1, Card C) if not specified or equal to 0.0. GG is overwritten if GT vs. TVARG is specified for this node in BLOCK 8 (Btu/h-in. ³).

*** Card B only read in if LEVFLG (Card A) = 0, i.e., standard TRUMP input. ***

Card C. Format (3E10.0, 4I5, 1F5.0, 5X, F5.0, 15). Power Generation and Oxidation Description Card. Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	RODAVE(a)	Average fuel rod power (should include gamma heat term) (kW/ft-rod).
(11-20)	PGAMMA	Fraction of rod-average power which is a result of gamma heating.
(21-30)	CLADXC	Fuel rod cladding cross sectional area (in. ²).
(31-35)	NPINS	Number of fuel pins to be included in heat generation summary and identified in BLOCK 4, Card D.

(a) The volumetric heat generation rate, GG(N), applied to nodes entered on Card H is computed from:

$$GG(N) = \frac{RODAVE * (1 - PGAMMA)}{\pi * FUEL R^2} * 284.3 \quad (\text{Btu/h-in.}^3)$$

for nodes designated as fuel nodes, i.e., NGAM = 0, Card H, or

$$GG(N) = \frac{RODAVE * PGAMMA}{CLADXC} * 284.3 \quad (\text{Btu/h-in.}^3)$$

for nodes designated as gamma-heating nodes, i.e., NGAM = 1, Card H (FUEL R is defined in BLOCK 1, Card D). The local volumetric heat generation rate for a node is then modified by:

$$GG(N) = GG(N) * PAXIAL * PRADIL$$

where PAXIAL is the local axial power factor determined from the chopped-cosine or user-specified power profiles (Card F and Card G, respectively) and PRADIL is the radial power factor (Card H).

Column	Variable	Description
(36-40)	IGENFG	Variable power generation flag: (1) time-varying heat generation for boiloff simulations (0) constant heat generation (-1) time-varying heat generation for non-boiloff simulations.
(41-45)	NTABG	Number of points in power generation-time table (Card D).
(46-50)	MWRCOR	Metal-water reaction correlation flag: (-1) no oxidation modeled (0) Cathcart kinetics used for Zr-H ₂ O reactions (1) Urbanic kinetics used for Zr-H ₂ O reactions (2) Prater kinetics used for Zr-H ₂ O reactions (3) Baker-Just kinetics used for Zr-H ₂ O reactions. NOTE: Wilson kinetics are used for the uranium-oxidation reaction.
(51-55)	AXMG	Local power multiplier for dryout region. The node heat generation rate is modified by 1 + AXMG for all nodes above the dryout front. Used for boiloff simulations only.
(61-65)	TFAIL	Uranium fuel failure temperature (°F). Determines start of uranium-water oxidation. Default = 1994.0°F.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(66-70)	NUNLIM	Unlimited metal-water reaction flag: (0) metal-water reaction based on available steam (1) sets unlimited supply of steam for metal-water reactions (STEAMF(NREGION)) = 1.0E+24. (<0) simulation time (h) with unlimited steam supply for metal-water reactions. Steam supply = 0 after ABS(NUNLIM) hours.
(71-75)	NOXVAR	Pairs of entries in user-specified uranium oxidation area variation table (Card E).

*** Card C only read in if LEVFLG (Card A) = 1, i.e. TRUMP-BD input ***

Card D. Format (8E10.0). Power Generation-Time Table. Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	GMULT(1)	Power generation multiplier.
(11-20)	GTIME(1) (etc.)	Time corresponding to GMULT(1) (h).

*** Card D read in only if NTABG (Card C) > 0 and IGENFG = 0 ***

Card E. Format (8E10.0). Oxidation Area Variation Table. Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	OXMULT(1)	Uranium oxidation area multiplier.
(11-20)	OXTEMP(1) (etc.)	Temperature corresponding to OXMULT(1) (°F).

*** Card E read in only if NOXVAR (Card C) > 0 and IGENFG = 0 ***

Card F. Format (I10, 3E10.0, I5). Axial Power Profile Descriptor Card.

Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	ICOS	Axial power profile identifier: (0) power profile user-specified (Card G). (1) chopped-cosine power profile
(11-20)	PRATIO	Peak-to-average power ratio used only when ICOS = 1.
(21-30)	EZERO	Extrapolated length (in.) used only when ICOS = 1.
(31-40)	RODTOT	Total number of fuel rods in simulation, including rod fractions. Used to determine total heat generation available for coolant boiloff.
(41-45)	NTABP	Number of points in axial power profile and integral table (Card G).

*** Card F read in only if LEVFLG (Card A) = 1, i.e., TRUMP-BD input ***

Card G. Format (6E10.0). Axial Power Profile and Integral Table. Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	PHIGHT(1)	Bundle elevation (in.).
(11-20)	PMULT(1)	Axial power factor at PHIGHT(1).
(21-30)	PINT(1)	Integrated power (in.) at position PHIGHT(1). PINT(1) is computed by multiplying PHIGHT(1) by the fraction of total power generated between the inlet (i.e., bundle elevation = 0.0) and bundle elevation PHIGHT(1). Required for boiloff simulations only.

(etc.)

*** Card G read in only if NTABP (Card F) > 0. ***

Card H. Format (4I10,2E10.0,I10,E10.0,I5). Node Heat Generation and Temperature Initialization Card. Optional.

Column	Variable	Description
(1-10)	N1	Node number
(11-20)	NSEQ	Number of additional nodes with identical initial conditions.
(21-30)	NADD	Increment between successive node numbers in sequence of NSEQ + 1 nodes generated when NSEQ is used.
(31-40)	NGAM	Gamma heating flag. Indicates fuel or non-fuel node. NGAM = 0; heat generation based on RODAVE*(1-PGAMMA) value. NGAM = 1; heat generation based on RODAVE*PGAMMA.
(41-50)	PRADIL	Radial power factor.
(51-60)	TXY	Node initial temperature. Overwrites value specified by TONE (BLOCK 1, Card C) at each axial level.
(61-70)	ITXY	Initial temperature axial variation flag: (0) uniform initial axial node temperature distribution (set by TONE or TXY) (>1) number of points in temperature axial variation table. Node axial temperature distribution set by temperature axial variation table card (Card I).
(71-80)	AX	Node initial phase change mass-fraction. Mass fractions must vary between 0.0 and 1.0. Phase change progresses from AX = 1.0 at start of phase change, to AX = 0.0 at end of phase change.
(81-85)	NPCX	Phase change identifier (BLOCK 2, Card G). Use 0 for no active phase change or no phase change. If NPCX does not equal 0, then TXY must equal TMELT for the active phase change.

*** Card H read only if LEVFLG (Card A) = 1, i.e., TRUMP-BD input. ***

Card I. Format (8E10.0) Initial Temperature Axial Variation Card. Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	TDUM(1)	Node temperature (°F).
(11-20)	ZDUM(1) (etc.)	Axial position of TDUM(1) (in.).

*** Card G read only if ITXY (CARD H) > 0. ***

BLOCK 10. MASS FLOW CONNECTIONS.

Card A. Format (2I5). Auto Noding Parameters.

*** NOT USED--LEAVE BLANK ***

Card B. Format (I2,2X,I1,F5.0,7E10.0). Flow Descriptor Card.

Column	Variable	Description
(1-2)	IMASFG	Variable flow flag: (1) boiloff simulation. Boiloff will include time-varying inlet flow rate. (0) standard TRUMP flow logic used (-1) non-boiloff simulation; no dryout front assumed. Will include time-varying inlet flow rate for flow regions.
(5)	HFLAG	Hydrogen-blanketing model flag: (1) node oxidation limited as a linear function of hydrogen fraction (see Section 3.5.2.1). (0) no oxidation limiting.
*** ENTER FOLLOWING VARIABLES FOR PROBLEMS WITH A BOILOFF REGION ONLY: ***		
(6-10)	QBOIL	Sum of inlet subcooling and heat of vaporization (Btu/lbm).
(11-20)	HFG	Heat of vaporization (Btu/lbm).
(21-30)	RHOBAR	Average density below dryout front (lbm/in. ³).
(31-40)	HDO	Heat transfer length from bulk-boiling to dryout regions. HDO must be less than axial node length (in.).
(41-50)	HBULK	Value of bulk-boiling heat transfer coefficient below dryout front (Btu/h-in.-°F).
(51-60)	XINTERI	Initial position of dryout front (in.).

Card C. Region Delimiter Card

This card must precede the flow region description card (Card D). A Region Delimiter Card is read for each new flow region. The Region Delimiter Card contains the pattern "888" in columns 3-5 and 8-10.

Card D. Format (2I5,E10.0,I5,2E10.0,I5). Flow Region Descriptor Card.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5)	IBOLRGN	Region indicator flag: (-1) identifies the flow region as a boiloff region. The boiloff region <u>must</u> be the first flow region described in the BLOCK 10 input. Only one boiloff region is allowed in a simulation. (0) non-boiloff region.
(6-10)	MASFLG	Mass flow rate computation flag: (1) flow rate computed based on initial power, dryout interface and inlet conditions. Computed for boiloff region only. (0) mass flow specified with standard TRUMP flow logic. Omit remaining items on Card D; omit Card E. (-1) flow rate user-prescribed.
(11-20)	XMOOX(NREGION)	User-prescribed region mass flow rate (lbm/h).
(21-25)	NTABF(NREGION)	Number of entries in mass flow table (Card E).
(26-35)	HIDM(NREGION)	Flow region hydraulic diameter (in.).
(36-45)	FLOWY(NREGION)	Flow region cross-sectional flow area (in. ²).
(46-50)	IRHOCOL	Number of pairs of entries in variable density table for coolant density below dryout front (Card F). Enter for boiloff region simulations only. If non-zero, value of RHOBAR (Card B) will be overwritten by variable boiloff region density (Card F).

Card E. Format (8E10.) Region Mass Flow Table Card. Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	FMULT(NREGION,1)	Region flow rate multiplier
(11-20)	FTIME(NREGION,1)	Time corresponding to FMULT(NREGION,1), (h). (etc.)

*** Card E read in only if NTABF (Card D) > 0. ***

Card F. Format (8E10.0). Boiloff Region Density Table. Optional

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	RHOCOL(1)	Average coolant density below dryout front (lbm/in. ³)
(11-20)	XMS(1)	Flow region steam flow rate above dryout front (lb/h). (etc.)

*** Card F, Read in only if IRHOCOL (Card D) > 0 and IBOLRGN = -1 ***

Card G. Format (6I5,10A1,2E10.3) Mass Flow Connections

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5)	NODF1	Identification number of the source node.
(6-10)	NODF2	Identification number of the sink node. May not be a zero-volume node. Last three digits of sink node must correspond with last three digits of source node to define unique subchannel.
(11-15)	NSEQ	Number of additional identical mass flow connections.
(16-20)	NADF1	Increments between successive values of NODF1 and NODF2, respectively, in the sequence of NSEQ + 1 mass flow connections generated when NSEQ is used.
(21-25)	NADF2	
(26-30)	LTABFL	Number of tabulated values of mass flow rate, negative if vs. time, positive if vs. temperature, zero if no table. Used for standard TRUMP (MASFLG) simulations only.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(31-40)	FX	For TRUMP-BD (MASFLG = -1 or 1), fraction of region mass flow rate applied to mass flow connections N1 and N2. For standard TRUMP (MASFLG = 0), FX equals actual mass flow rate. FX is set equal to FONE from BLOCK 1.0, Card C if left blank or set equal to 0.0.
(41-50)	DELF1 }	Lengths of mass flow paths from nodal points of NODF1 and NODF2, respectively, to the connected surfaces.
(51-60)	DELF2 }	

*** Use additional Card Gs for any additional mass flow connections for subchannels in the current flow region not specified using NSEQ. ***

Card H. Format (8E10.3). Mass Flow Rate Table. Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	FLOWT(1)	Mass-flow rate.
(11-20)	TVARFL(1) (etc.)	Temperature or time corresponding to FLOWT(1) (°F or h).

*** Card H For Standard TRUMP ONLY, i.e., IMASFG (Card B) = 0. ***

BLOCK 12. REMOTE DEPENDENCE DATA

Card 1. Format (7I5). Remote Temperature Dependence Card.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5) (6-10)	NODP1 } NODP2 }	Identification numbers of the node to which the property applies and the node on whose temperature the property depends, respectively, i.e., $P(NODP1) = P[T(NODP2)]$.
(11-15)	NPROP	Property indicator: 1 for heat capacity, 2 for thermal conductivity, 6 for variable heat-generation rate, 7 for mass-flow rate, and 8 for surface convection coefficient.
(16-20)	NSEQ	Number of additional nodes with properties dependent on remote temperatures. Node and property numbers are determined by NADP1, NADP2, and NADPR.
(21-25) (26-30) (31-36)	NADP1 } NADP2 } NADPR }	Increments between successive values of NODP1, NODP2, and NPROP, respectively, in the sequence of $NSEQ + 1$ nodes with properties dependent on remote temperatures, generated when NSEQ is used.

BLOCK 13. FISSION PRODUCT INVENTORIES

Card A. Format(I5,5x,2E10.0,5X,I5). Fission Product Parameters.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-5)	NFP	Total number of fission products (maximum = 10).
(10-20)	TREFF	Reference temperature (°F) for bake-out fission product release correlation used to compute a reference vapor pressure for each fission product. For the uranium fission product release models described in Section 3.15.2, use 2192°F.
(20-30)	FPFRAC	Fraction of whole core being modeled in the simulation, in terms of core power.
(36-40)	N12WRT	Number of discrete times at which fission product release data will be written to TAPE12.

Card B. Format(A9,1x,5e10.0). Fission Product Descriptor Card.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-9)	ISOTOP	Fission product name.
(11-20)	FPIT	Total core inventory of fission product (kg).
(21-30)	AC	Coefficient used in computing vapor pressure of fission product. (see Section 3.15.2)
(31-40)	B	Coefficient used in computing vapor pressure of fission product. (see Section 3.15.2)
(41-50)	CX	Fraction of fission product released per fraction of uranium oxidized. (see Section 3.15.2)
(51-60)	C	Coefficient used in computing "bake-out" conductance of the fission product. (see Section 3.15.2)

Card B repeated for NFP number of fission products

Card C. Format(8e10.0). Print Control Table. Optional.

<u>Column</u>	<u>Variable</u>	<u>Description</u>
(1-10)	T12(1) (etc.)	Times at which fission product release output data will be written to TAPE 12 (h). Times must be read in sequential order.

***Card C read in only if N12WRT (Card A) > 0 ***

4.4 RESTART PROCEDURES

Not fully verified in TRUMP-BD

*** DO NOT USE ***

5.0 OUTPUT AND POST-PROCESSING OUTPUT FILES

5.1 OUTPUT FILE

The TRUMP-BD standard data output file (OUTPUT) differs significantly from the standard TRUMP output, due primarily to TRUMP-BD's extended capabilities.

At the top of the TRUMP-BD output a mirror "image" of the input file is written. This image can be used to check the exact contents of the input files and serves as a user's aid for diagnosing errors that result from incorrect formatting of the input file. The mirror image of the input also provides added traceability for quality assurance purposes.

Following this image is a processed listing of all input-derived quantities such as node volumes, connection areas, fission product inventories, input table slopes, comments concerning special input options, or input errors. Unlike the image input listing, nodes and connections implicitly defined using input variable NSEQ (Section 4.0) are explicitly listed here. The processed input provides confirmation to the user that the input data deck has been entered as intended.

After both the image input and processed input are written to the OUTPUT file, the input parameter list which governs array sizes within the code (Section 8.0) is written. This list can be used as a reference when the user suspects an execution error is due to an undersized array.

As with standard TRUMP, simulation results are written at the first, second, and last time steps, as well as at time intervals TIMEP(a) and time step intervals IPRINT (BLOCK 1, Card A). Also, at time intervals XSPRNT (BLOCK 1, Card D), temperatures (XUTOUT), phase change mass fractions (AOUT), and current phase change indexes (NPCOUT) are written to the output file for each special output node (NODOUT). Input variable KDATA (BLOCK 1, Card A) controls the type and quantity of standard TRUMP data written out, but does not control output unique to TRUMP-BD. The "Output Suppression Card" (BLOCK 1, Card F) provides an additional means of limiting extraneous standard TRUMP output.

(a) See Section 4.0 for information on input variables and Appendix A for definitions of all variables discussed in this section.

Each standard print interval is preceded by a line identifying the version of TRUMP-BD used, and the input deck title card. The output banner card has been expanded to include:

- coolant pressure (PRESS, pisa) and saturation temperature (TSAT, °F)
- integrated axial power at coolant boiloff interface (PIGRAL, kW)
- boiloff region mass flow rate multiplier (FFACTR)
- the axial level of dryout front (NBOIL)
- the axial elevation of the dryout front, "x interface" (WLEVEL, in.)
- the model "lower bound", or elevation (XINTER, in.)
- average rod linear heat generation rate (RODAVE, kW/ft-rod)

Directly beneath each output banner, the current maximum Zircaloy (CLADMX, material 100) and uranium (FUELMX, material 1) temperatures are given, along with the axial level and fuel pin numbers at which they are occurring and the simulation time in seconds (SUMSEC).

For all but the first time step print interval, an oxidation summary for each metal-water reaction node is written out. Included for each metal-water reaction node (identified in BLOCK 4, Card D) are:

- heat generation due to oxidation (QZRH2O, kW)
- heat generation due to fission or decay heat(a) (QFISON, kW)
- total heat generation (QGEN, kW)
- node unoxidized metal thickness remaining (ZRLEFT, in.)
- the amount of steam available for oxidation (STEAMF, kg/s)
- hydrogen fraction in the adjacent coolant flow region (HFRACF)
- the integrated hydrogen release rate up to that node in the table (HREL, kg/s).

A second oxidation summary, directly following the one described above, prints summary information for each axial level. Included are:

(a) Energy production other than metal-water reaction.

- total heat generation due to oxidation (kW)
- total heat generation due to oxidation of Zircaloy (QZRAX, kW)
- total heat generation due to oxidation of uranium (QUAX, kW)
- the average remaining thickness of Zircaloy nodes (AVEDX, in.)
- the average remaining thickness of uranium nodes (AVEUDX, in.).

The total hydrogen release rate (HFLOWR) for the time step and integrated hydrogen release over the transient (HFLOWT) appear at the bottom of this second oxidation summary.

Additional TRUMP-BD diagnostic summary information will be written to the output file depending on the value of IDIAG (BLOCK 1, Card D). The options are:

- IDIAG = 1, no additional diagnostic information
- = 2, pin heat generation summary only
- = 3, variable internal connection and convection summary only
- = 4, radial and axial loss summary only
- = 5, complete diagnostic summary (all of above, plus heat balance/heat generation summary, fission product release summary, and phase change summary).

If fuel pins (NPN) are specified (BLOCK 4, Card D) and IDIAG is 2 or 5, a "Pin Heat Generation and State Summary" is written out during the third print interval and thereafter. In addition, for axial levels at which pin failure has occurred during the transient, information is written identifying (by pin number):

- the time of failure at each axial level (FAILT, h)
- the oxidation area multiplier applied to fuel node (OXPINM)
- the maximum fuel pin temperature thus far in the simulation (TPINMAX, °F)
- the current pin temperature (TPIN, °F).

Total heat generation for each pin (QPIN), total fuel node failures (NFAIL), total pin failures (NFAILP), total heat generated by metal-water reactions

(QZRTOT, kW), total heat generated due to nuclear heating (QFISON, kW), and the total heat generated (GS, kW) are also written.

If variable internal thermal connections between nodes or convection heat transfer is being modeled and IDIAG is 3 or 5, a "Variable Internal Thermal Connection and Convection Summary" is written to the output file during the third print interval and thereafter. Included in this summary is the current value of conductance (HINT) for each variable internal thermal, the total losses (QCHAN) in each coolant subchannel, and for boiloff problems, and the energy required for vaporization of liquid coolant (PIGRAV). TRUMP-BD computes subchannel convection losses for source/sink nodes (BLOCK 10, Card F), whose node "base" numbers (three right-most digits) are identical. If this node numbering methodology is not used, the convection summary output may be in error.

If connections to external boundary nodes are specified (BLOCK 6) and IDIAG is 4 or 5, an "Axial and Radial Heat Loss Summary" is provided, in which each boundary node (NODS) and its associated external node (NODSB) is listed, along with the heat loss or gain attributable to that connection during the current time step. The total axial, radial, and miscellaneous heat losses are written beneath the individual connection heat losses. The axial heat loss (QAXTOT, kW) is the sum of heat losses to external boundary node 1000 (i.e., NODSB = 1000); the radial heat loss (QRADT, kW) is the sum of heat losses to external boundary node 2000 (i.e., NODSB = 2000); and the miscellaneous heat loss (QMISCT, kW) is the sum of heat losses to any other external boundary nodes.

When IDIAG = 5, a summary of all heat generation and heat losses is given, along with a total system energy balance. Items included (in order) are:

- the heat generation due to metal-water reactions (both uranium and Zircaloy) during the time step (QZRTOT, kW)
- the heat generation due to fission (QFISONT, kW)
- the sum of QZRTOT + QFISON (kW)
- total radial heat loss or gain (QRADT, kW)
- total axial heat loss or gain (QAXTOT, kW)

- the heat loss due to vaporization of coolant during a boiloff simulation (PIGRAV, kW)
- total convective heat removal (QCONVT, kW)
- the total system heat loss, i.e., the sum of QRADT + QAXTOT + PIGRAV + QMISCT (kW).

The relative percent of the heat generation and removal terms and an overall system heat balance follow this summary.

Provided IDIAG = 5 and fission product releases are being modeled the following fission product release data will be written for each fission product:

- fuel node number (NODE)
- node integral release due to oxidation (FPRELO, kg)
- node integral release due to bake-out (FPRELB, kg)
- node total integral release (FPREL, kg)
- node release rate due to oxidation (FPDTO, kg/min)
- node release rate due to bake-out (FPDTB, kg/min)
- node total release rate (FPDT, kg/min)
- total model integrated release (FPMRL, kg)
- total model integrated release due to bake-out (FPMRLB, kg)
- total model integrated release due to oxidation (FPMRLO, kg)
- total model release rate (FPMDT, kg/min)
- total model release rate due to bake-out (FPMDTB, kg/min)
- total model release rate due to oxidation (FPMDTO, kg/min).

Finally, when IDIAG = 5, a phase change summary is given for nodes made of materials that can undergo phase changes during the simulation (BLOCK 2, Card G). Each node is listed, along with its current temperature, change in mass fraction of the lower temperature phase during the time step (DA), time rate of change of mass fraction of the lower temperature phase (DDA), the

active phase change index (NPC), and the mass fraction of the lower temperature phase (A).

Upon completion of the simulation, a "Final System Summary" is written provided NPUNCH is specified as non-zero in BLOCK 1, Card A. The final temperatures (T, °F) and heat generation rates (GX, kW) are included in this summary for each node (NODE). For metal-water reaction nodes, the final thickness (THX, in.), oxidation area (OXA, in.²), and initial thickness are also included.

As with standard TRUMP, at the completion or termination of the problem the following additional data are written out: 1) the problem-end sentinel (KWIT) and its definition, and 2) the elapsed machine time, in seconds, since the beginning of the problem.

Excerpts from a typical TRUMP-BD OUTPUT file, including data through the first time step (KCYC = 1) and the "Final System Summary" are included in Appendix B as OUT.OD.

5.2 GRAPHICAL OUTPUT FILES

In addition to the TRUMP-BD output file described above, the user may specify that graphics "dump" files be created during execution. These additional files contain output data from the simulation formatted so as to be readable by DISPLOT, a post-processing routine(a) that allows x-y plots to be produced on a variety of plotting devices. The graphics dump files are arranged in row/column format; the DISPLDT graphics routine can plot any two columns of data on a plot. Multiple curves on a plot can also be accommodated.

5.2.1 TAPE3

When the user specifies OUTDISC = 2 (BLOCK 1, Card A), a "system summary" file named TAPE3 is created during execution which contains the following information, written out at each time interval XSPRNT:

- simulation time (SUMSEC, s)
- maximum Zircaloy temperature (CLADMX, °F)

(a) DISPLOT3: An All-Purpose, Generalized Plotting Routine. Wildung, N. J., Pacific Northwest Laboratories

- maximum uranium temperature (FUELMX, °F)
- nuclear power heat generation rate (QFISON*SYMLT, kW)
- metal-water reaction power (QZRTOT*SYMLT, kW)
- ratio of metal-water reaction power to nuclear power (PER)
- total radial heat losses (QRADT*SYMLT, Btu/h)
- integrated hydrogen release (HFLOWR*2.2*SYMLT, lbm)(a)
- exit hydrogen fraction (HFRACF)
- exit hydrogen flow rate (HFLOWR*7936.24*SYMLT, lbm/h)(b)
- integrated hydrogen release from uranium (HFROMUT*2.2*SYMLT, lbm)
- integrated hydrogen release from Zircaloy (HFROMZT*2.2*SYMLT, lbm).

When NFP > 0, values of whole tube fission product release are also written to TAPE3 for each fission product. These data include:

- total tube integrated release (FPMRL*SYMLT*2.2, lbm)
- total tube integrated release due to bake-out (FPMRLB*SYMLT*2.2, lbm)
- total tube integrated release due to oxidation (FPMRLO*SYMLT*2.2, lbm)
- total tube release rate (FPMDT*SYMLT*2.2/60., lbm/h)
- total tube release rate due to bake-out (FPMDTB*SYMLT*2.2/60., lbm/h)
- total tube release rate due to oxidation (FPMDTO*SYMLT*2.2/60., lbm/h)

A copy of a typical TAPE3 is included in Appendix B as TAPE3.OF.

5.2.2 TAPE5

When the user specifies OUTDISC = 2 (BLOCK 1, Card A) a special output node temperature file named TAPE5 is created that contains either temperatures for each special output node (NODOUT) or all node temperatures (when NSPOUT is specified as negative). This data is written out at each time interval XSPRNT.

A header to a typical TAPE5, with a portion of the typical data, is included in Appendix B as TAPE5.OD.

5.2.3 TAPE11

When the user specifies a positive integer value for NAXTIM (BLOCK 1, Card D), a TAPE11 is created that contains axial information written out at

-
- (a) Conversion from kg to lbm.
 - (b) Conversion from kg/s to lbm/h.

AXTIM(1),...AXTIM(NAXTIM) times (BLOCK 1, Card G). For each axial level in the input model, this information includes

- total heat generation rate due to metal-water reactions (QZRAX*SYMLT, kW)
- percent of original total thickness of all Zircaloy nodes (material = 100) that remains unoxidized (PERZLFT)
- percent of original total thickness of all uranium nodes (material = 1) that remains unoxidized (PERULFT)
- radial heat loss (QRADDX*SYMLT, kW)
- leaving hydrogen fraction for each flow region (XH2LEV)
- leaving hydrogen fraction for entire axial level (HFRCLVL).

In addition, temperatures for specified identical nodes (NODEAX) at similar axial levels will also be written to TAPE11 if NAXPO is specified as a positive integer in BLOCK 1, CARD D.

A header to a typical TAPE11, with a portion of the typical data, is included in Appendix B as TAPE11.0D.

5.2.4 TAPE12

The TAPE12 output file provides fission product data based on location, written out at T12(1)....T12(N12WRT) times (BLOCK 13, Card C). Among the data provided on TAPE12 is:

- node numbers (NODE) and temperatures (T, °F) for each Zircaloy volume node by order of its axial level and adjacent coolant flow region
- tube integral hydrogen release, by axial level and coolant flow region (HTUBE, kg)
- tube integral release of each fission product due to bake-out, by axial level and coolant flow region (FPRB, kg)
- tube integral release of each fission product due to oxidation, by axial level and coolant flow region (FPRO, kg)
- tube integral release of each fission product, by axial level and coolant flow region (FPR, kg)

6.0 SAMPLE PROBLEM

This section documents a sample problem using TRUMP-BD to analyze the transient response of N Reactor during a station blackout accident. The model chosen was constructed from a modified version of the half-length process tube model (HLM) developed for the hydrogen mitigation design basis accident scenario of the N Reactor (Heard et al. 1987). This problem was chosen because numerous features of TRUMP-BD are demonstrated, including metal-water reactions of Zircaloy cladding and uranium fuel, mass flow convective heat transport, and internal heat generation due to fission heating.

A description of the N Reactor is presented in Section 6.1. The modeling methodology employed in developing the HLM is presented in Section 6.2. Section 6.3 describes sample lines from the input, and Section 6.4 briefly discusses results. Appendix B provides copies of the INPUT file and excerpts from the OUTPUT file, along with excerpts from the post-processing files TAPE3, TAPE5, and TAPE11.

6.1 DESCRIPTION OF N REACTOR

N Reactor, a 4000 MWt, graphite-moderated light-water reactor, employs concentric cylindrical uranium metal fuel that is clad with Zircaloy-2. The reactor core comprises mechanically identical fuel columns arranged horizontally within a cube composed of interlocking graphite blocks. The fuels vary with respect to uranium-235 enrichment; three enrichments are employed throughout the core. Each fuel column is situated in the central 34.8 ft of a Zircaloy-2 process tube that is connected to the manifolds of the reactor coolant system. A total of 1003 horizontally oriented process tubes, arranged in an array of 32 rows and 34 vertical columns, with 21 process tubes omitted from each corner, comprise the core. The cuboid-shaped core is surrounded by a graphite reflector, a borated-steel thermal shield, and a concrete biological shield.

Interlocking graphite blocks form the neutron moderator. The graphite blocks are arranged in alternate horizontal layers with the blocks from alternate layers performing different functions; one layer houses the process tubes, while the next houses the graphite and shield cooling system (GSCS) tubes. The interlocking graphite moderator block arrangement may be more

clearly understood from the stack configuration shown in Figure 6.1. The graphite matrix voids (approximately 30% of the volume) are filled with recirculating helium.

The GSCS tubes alternate between filler blocks along the axial length of the process tube. Only the central axial region of the core (73% of the fuel length) contains provisions for GSCS tubes, whereas no GSCS cooling exists within the end regions of the core. For the station blackout model, the GSCS system was assumed inoperable.

N Reactor's fuel columns are made from individual fuel elements placed end-to-end and self-supported in the pressure tube. The fuel elements are 20-in. to 24.-in. long concentric cylinders that are manufactured by coextrusion of the metallic uranium fuel and Zircaloy-2 cladding, thereby producing a strong metallurgical bond. Welded Zircaloy end closures complete the fuel element encapsulation. The combined fuel and process tube configuration forms three essentially continuous coolant passages; two annular and one cylindrical. A transverse cross section of the fueled process tube is shown in Figure 6.2.

6.2 MODELING METHODOLOGY

A description of the TRUMP-BD input model and the modeling of the station blackout accident are presented below.

6.2.1 The Half-Length Model

The N Reactor graphite moderator block matrix structure is composed of repetitive substructures, or "unit cells." A unit cell is defined by several planes of symmetry that exist within the moderator configuration. The unit cell encompasses both cooled and uncooled filler blocks, and may be repeated to model the entire heated length of a single process tube. The one-quarter symmetry of the unit cell ignores the slight asymmetries that exist between the top and bottom keyed sections of the GSCS filler blocks. For computational purposes, the unit cell was subdivided into two axial sections along the process tube length: a cooled filler block and an uncooled filler block (Figures 6.3 and 6.4, respectively). These subdivisions form the building blocks for constructing a model that spans half the process tube length, i.e.,

FIGURE 6.1. N Reactor Core and Reflector Geometry

FIGURE 6.2. Transverse Cross Section and Nodalization of the Fueled Process Tube

FIGURE 6.3. TRUMP-BD Nodalization--Cooled Filler Blocks Axial Segment

NOT TO SCALE

FIGURE 6.4. TRUMP-BD Nodalization--Uncooled Filler Block Axial Segment

half-length model (HLM). The exception to the building-block structure occurs in the transition and reflector regions of the core, where one-quarter symmetry, axial segments were tailored to the graphite geometry. The HLM segmented into unit cell sections, along with the reflector and transition region, appears in Figure 6.5.

Three-dimensional nodalization of the HLM building blocks entailed specification of node volumes, heat transfer paths, and material properties. Node volumes for the cooled and uncooled filler blocks are indicated in Figures 6.3 and 6.4. The reflector block and transition block nodalizations, while not shown, reflect the degree of node volume refinement shown for the unit cells. In the graphite regions, cylindrical nodes were assigned in regions dominated by radial heat conduction and Cartesian nodes were assigned for the remaining regions. The degree of refinement in nodalization represents a balance between computation effort and accuracy. Adiabatic boundary conditions are applied to the unit cell's planes of symmetry.

The extrusion-fabricated graphite exhibits anisotropic thermal conductivity. Property variations that are dependent on extrusion direction were accounted for by applying a multiplication factor to node thermal connection lengths when considering conduction transverse to the extrusion direction. Contact resistances were computed from as-built gap widths and were incorporated into the model for heat transfer between the process tube graphite block and the filler graphite blocks. Temperature-dependent conduction heat transfer coefficients, again based on as-built dimensions, were applied across two helium-filled gaps: between the process tube and graphite and between the GSCS tube and graphite. Radiation heat transfer was explicitly modeled across helium-filled regions between the process tube and the graphite blocks. All surfaces were considered gray and diffuse, and symmetry planes were approximated as diffuse reflectors. The helium was considered optically thin, i.e., a nonparticipating media. Except for the exchange between cooled and uncooled filler blocks, radiation exchange was restricted to radial directions.

FIGURE 6.5. Axial Segmentation of the Half-Length Process Tube

Hydrogen evolution was assumed to follow the parabolic kinetics developed by Wilson et al. (1966) and Baker and Just (1962) for the uranium steam reaction and the Zircaloy steam reaction, respectively. As a conservatism, an unlimited steam supply was assumed available for oxidation. In addition, no convective heat removal was modeled.

Fuel failure, which relates directly to the amount of uranium metal available for oxidation, was determined based on fuel cladding temperatures. A fuel failure temperature of 1900°F was chosen based on out-of-pile tests of N Reactor fuel elements. Fuel lengths defined for the HLM corresponded to the node axial lengths, e.g., generally 4 in. N Reactor fuel is actually extruded, and cut into 20-in. to 24-in. lengths, however. Fuel failures reported for the HLM, therefore, will not reflect the actual number of ruptured fuel elements. The multitude of fuel loading possibilities complicated the modeling of distinct fuel elements; therefore, the fuel was assumed to be a continuous column with respect to axial conduction, but segmented into axial lengths with respect to fuel failures. Fuel failures of the inner and outer concentric fuel elements were individually tracked. The uranium area accessible for oxidation was maintained at a constant 25% of the surrounding cladding area.

6.2.2 Station Blackout Accident Scenario Modeling

The core coolant system flow transient during the station blackout accident scenario at N Reactor was simulated using RELAP5 (Ransom et al. 1983). The most conservative fluid conditions predicted by the RELAP5 simulation were incorporated into the TRUMP-BD HLM model for the convective modeling of heat transport in the coolant flow passages. The decay heat generation versus time, initial average power, and power deposition were based on a best-estimate data for the "spike region," peak-power tube in the core (the N Reactor fuel loading was segregated into three distinct regions: spike, central, and fringe).

The RELAP5 model predicted three modes of heat removal by the coolant in the flow channel after scram and prior to reflooding of the emergency core cooling system (ECCS); 1) film boiling, 2) nucleate boiling, and then 3) steam cooling. The HLM model was developed to simulate only film boiling and steam cooling; no credit was taken for the temporary return to nucleate boiling. Furthermore, the most conservative conditions predicted by RELAP5 for the

portions of the transient when steam cooling and film boiling occur were used for the HLM boundary conditions.

The times at which film boiling and steam cooling occur during the transient were determined using RELAP5 plots of vapor void fraction and mass quality for each flow channel of the process tube at the second axial junction. The onset of film boiling (used as time = 0.0 in the HLM simulation) was assumed to occur at the time at which the void fraction and mass quality initially rise sharply from zero (Appendix C, Figures C.1 through C.3). Using a digitizer, the average time at which this occurred was found to be 114 s. The transition time from boiling to steam cooling was taken as the earliest time at which the void fractions for all three process tube flow channels were simultaneously equal to 1.0. This time was found to be 914 s. after scram.

Mass flow rates predicted by RELAP5 fluctuate dramatically over the transient. Because the HLM models two distinct heat transfer modes (steam cooling and film boiling), constant values of mass flow rates for each channel were obtained from the RELAP5 plots (Figures C.4 through C.6). These mass flow rates were chosen to approximate the value predicted by RELAP5 during the portion of the transient when each flow regime was occurring. Because each process tube in the RELAP5 model is actually equal to 100 tubes, the mass flow rates were first divided by 100, and then quartered to account for the quarter symmetry used in the HLM.

The least-favorable values of pressure (Figure C.7) and void fraction (Figures C.8 through C.10) were needed for the film boiling portion of the transient. A constant coolant temperature equal to the saturation temperature was used to evaluate fluid properties. These values were used along with the mass flow rate to calculate a single heat transfer coefficient for each flow channel (assumed constant over the process tube length).

Likewise, a least-favorable pressure was used to determine fluid properties needed to calculate steam cooling heat transfer coefficients. It was assumed that the inlet steam temperature was equal to the corresponding saturation temperature. Also, because TRUMP-80 assumes constant fluid density when calculating convective heat transport, steam density was based on the average superheated temperature along the tube length rather than the corresponding saturated value to ensure conservative input.

Two different film boiling heat transfer correlations (Dougall-Rohsenow 1963, Grenoveld 1969) were examined for application to N Reactor geometry and thermal-hydraulic conditions. For each correlation, heat transfer coefficients were calculated for each of the three flow channels in the HLM process tube. Film boiling coefficients evaluated from the Dougall-Rohsenow correlation were found to be ~50% lower than those from Grenoveld. In spite of its less conservative values, the Grenoveld correlation was selected for use in these scoping studies because it was derived in part from horizontal tube data (Dougall-Rohsenow is for vertical orientations only). A sensitivity study was also completed demonstrating that the correlations are most sensitive to the vapor void fraction.

During the steam cooling portion of the transient the Dittus-Boelter correlation was used to calculate a heat transfer coefficient for each channel.

6.3 DISCUSSION OF TYPICAL INPUT LINES

Since the model used for the process tube during the station blackout is actually two HLMS, two inputs are used: one for the inlet half, and one for the outlet half. The discussion that follows is based on data in the input file (IRSLBOD) that is used for the inlet half of the process tube. A complete copy of this input file is included in Appendix B.

BLOCK 1, Card D

5 5 .9892 40 0.01667 4 3 3

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
IDIAG	5	1-5	Diagnostic flag; all TRUMP-BD summary output will be generated and printed to OUTPUT at TIMEP time intervals (Card A).

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
NCHANS	5	6-10	The total number of process tube flow regions includes three regions for axial coolant flow channels plus for GSCS flow channels.
FUELR	0.9892	31-40	The fuel pellet radius is arbitrary as long as PRADIL, the radial power factors for nodes (see typical input in BLOCK 9, Card H below), are computed using the same value for FUELR.
NSPOUT	40	51-60	The number of special output nodes is listed on Card E.
XSPRNT	0.01667	61-70	Every 0.01667 simulation hours summary information and special node temperatures are written to TAPE3 and TAPE5, respectively.
SYMLT	4	71-80	The HLM accounts for only one quarter of the process tube. This symmetry multiplier is applied to hydrogen and power generation variables written to TAPE3 to give "whole-tube" results.
NAXPO	3	81-85	Three special axial nodes, NODEAX(1), NODEAX(2), and NODEAX(3), are listed on Card F. This variable simply tells TRUMP-BD that three are listed.
NAXTIM	3	86-90	This variable tells TRUMP-BD that special axial output data, including temperatures of each special axial node in array NODEAX, will be written out at three times, AXTIM(1), AXTIM(2), and AXTIM(3), specified on Card G.

BLOCK 2, Card A

u=mtl 1 15 4 .683

3

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
AMAT	U-MTL	1-5	Uranium is the material name.
MAT	1	6-10	The material identification number for uranium nodes must be 1 for oxidation logic to work.
LTABC	15	21-25	Fifteen pairs of values for uranium heat capacity (CAPT) versus temperature (TVARC) are given on Card E. Interpolation between these values will be performed in Subroutine THERM each time step to update uranium heat capacity.
LTABK	4	26-30	Four pairs of values of uranium thermal conductivity (CONT) versus temperature (TVARK) are given on Card F. Interpolation between these values will be performed in Subroutine THERM each time step to update uranium thermal conductivity.
LTABP	3	81-85	Three phase changes are specified for uranium on Card G. The phase changes will occur at temperatures TMELT, and will have latent heats HMELT.

BLOCK 4, Card A

0.00 57 236.5 0 0 57 57

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
XINTER	0.00	11-20	The first axial level is designated to start at 0.00 in.
NLEVELS	57	28-30	The total number of axial levels in the HLM is 57.
BUNDHT	236.5	31-40	The total length of all 57 axial levels is 236.5 in.
ILEVFG	0	49-50	No boiloff simulation is being modeled; therefore this value is 0.
NTABL	0	59-60	No boiloff simulation is being modeled; therefore this value is 0.

BLOCK 4, Card D (Reference Figure 6.2)

6001 6 2000 1 1 1 .0954 1.0 4.0 .175 .037

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
N1	6001	1-5	This is the first node described by this card. Node 6001 is the innermost of two nodes defined for the inner fuel at axial level "6".
NSEQ	6	6-10	Six additional identical nodes beside 6001 are specified by this card.

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
NADD	2000	11-15	The node identification number for each additional node specified on this card is incremented by 2000 over the last value, i.e., 8001,10001,12001,14001,16001 and 18001 are the additional nodes created by TRUMP-BD after this card.
NZ	1	16-20	This value identifies nodes described on this card as being made of uranium, since the value "1" was used in BLOCK 2, Card A (described above).
NPRX	1	26-27	Flow region 1 is the innermost of the three axial coolant flow regions. In the HLM all uranium nodes whose identification numbers end with "001" are for the innermost node of the inner fuel, and thus are adjacent to flow region 1 (see Figure 6.2). NOTE: BLOCK 10 input is arranged so the first flow region read in corresponds to this one.
NPN	1	28-30	The inner uranium fuel annulus in the HLM is defined as pin number "1" (the outer uranium fuel annulus is pin number "2"). All fuel and cladding nodes that make up a given fuel pin should have the appropriate value of NPN included here.
DLONG	0.0954	31-40	The node cross-sectional area is 0.0954 in. ² .
DWIDE	1.0	41-50	The assigned node width is 1.0 in.
DRAD	4.0	51-60	The axial node length 4.0 in. The product of DLONG, DWIDE, and DRAD is therefore the node volume.

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
ZRT	0.175	61-70	The oxidation thickness of the node is measured "radially".
OXA	0.037	71-80	A geometric factor (in this case, 10% of the circumferential arc at the cladding-fuel interface for "001" inner fuel nodes) used in conjunction with the time-dependent uranium oxidation area multipliers (BLOCK 9, Card E) to determine the available uranium oxidizable area. This area is the product $AXDIST \cdot OXAREAM \cdot OXA$.

BLOCK 5, Card A (Reference Figure 6.2)

6308 64015 6 2 23 0.0 0.0 .376 4.0 1.e-12 -4

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
N1	6308	1-5	The source node for the first thermal connection defined by this Card A.
N2	6401	6-10	The first sink node (connected to N1) described by this Card A. Note that this card connects the innermost Zircaloy surface node at a given axial level to its adjacent innermost flow channel node. This thermal connection is used to model heat transport to the coolant during the steam cooling portion of the station blackout transient.
IHEAT	5	11	A value of 5 indicates that HINT for the thermal connections described on this card will be variable, with values assigned in a table in the input (i.e., TRUMP-BD correlations will not be used to calculate HINT, as would be the case if IHEAT were 1-4).
NSEQ	6	12-13	Six additional pairs of thermal connections will be described with this Card A.
NAD1	2	14-16	The increment between successive values of N1 for each additional thermal connection described on this card.
NAD2	2	17-19	The increment between successive values of N2 for each additional thermal connection described on this card.

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
NZ	3	20	NAD1 and NAD2 will be multiplied by 10^{NZ} . Therefore, the six additional thermal connections described on this card will be 8308-8401, 10308-10401, ...etc.
DEL1	0.0	21-30	Since "308" nodes are Zircaloy surface nodes, this distance is always zero. However, because HINT is user specified, input values of DEL1 and DEL2 are <u>not</u> used.
DEL2	0.0	31-40	Not used, because HINT is user-specified.
DLONG	0.376	41-50	The length of the circumferential arc described at the interface between the two nodes is 0.376 in.
DWIDE	4.0	51-60	The axial length of the two nodes. The product of DLONG*DWIDE is the total heat transfer surface area between the two nodes.
HINT	1.e-12	61-70	Since film boiling is the heat transfer mode modeled initially, the HINT for this connection is initially zero. However, since zero results in an execution error, 1.e-12 is used (i.e., a <u>small</u> number).
NU	-4	111-115	HINT values change with time; NU tells TRUMP to read four pairs of USERH vs. USERT values from Card C, which follows this card immediately.

BLOCK 5, Card C

1.e-12	0.	1.e-12	.220	.583	.222	.583	10.
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As was described in Section 6.2.2, film boiling is modeled during the first portion of the transient (up to 0.220 h) in the coolant flow passages. After 0.220 h, steam cooling is modeled. Zircaloy cladding surface nodes are connected in BLOCK 5 to flow nodes for steam cooling phase, and in BLOCK 6 to external boundary nodes for the film boiling phase (see below). Since steam cooling is not modeled at the beginning of the transient, HINT is initially input as zero(a). From the RELAP5 results, steam cooling is predicted to start at 0.220 hours into the transient, and continues for the remainder of the transient (up to 0.801667 hours, the value of TIMAX in BLOCK 1, Card B). HINT during this portion of the transient is therefore reset to the value in the USERH versus USERT table for this time (0.583 Btu/h-in.²-°F).

(a) TRUMP-BD uses a value of 1.0E-24 rather than zero to avoid a floating point execution error.

BLOCK 6, Card B

6308 1000 51 1000 0 -4 .376 4.0

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
NODS	6308	1-5	This surface node is for the inner cladding surface for the inner fuel.
NODSB	1000	6-10	The external temperature (boundary node) to which NODS is thermally connected is 1000. This connection is used to model heat transport to the coolant during film boiling.
NSEQ	51	11-15	Fifty-one additional pairs of external thermal connections will be described by this card.
NADS	1000	15-20	Increment to successive values of NODS in each additional external thermal connection described by this card. Thus, nodes 7308 through 57308 all connect to external boundary 1000 identically to the 6308-1000 connection.
LTABH	-4	26-30	HSURE changes with time; thus a table of HSURT vs. TVARH is needed (Card C). LTABH = -4 indicates 4 pairs of values will be provided, and TAVRH is time-dependent.
DLONG	0.376	35-40	The length of the circumferential arc at the interface between the two nodes is 0.376 in.
DRAD	4.0	41-50	The product of DLONG*DRAD is the total heat transfer surface area between the two nodes.

BLOCK 6, Card C

.172 0. .172 .220 0. .222 0. 10.

Film boiling is only modeled during the first portion of the transient by specifying a non-zero HSURT ($0.172 \text{ Btu/h-in.}^2\text{-}^\circ\text{F}$) up to 0.220 h, and 0.0 after that time. HSURE is set to these HSURT values at the appropriate times during the simulation.

BLOCK 7, Card A

3000

324.9

External node 3000 is connected to each of zero volume nodes 401, 402, and 403 in BLOCK 6. These nodes are in turn connected to flow nodes at the first (entering) axial level, 1401, 1402, and 1403, respectively. Through these connections the entering steam temperature into the three HLM coolant flow channels is set at 324.9°F, the value on the above card. This temperature corresponds to the saturation temperature of the steam at the pressure predicted by RELAP5.

BLOCK 9, Card C

173.2400 .0000 .0279 2 -1 20 3 1900. 1 4

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
RODAVE	173.2400	1-10	The average nuclear power generated per axial foot during normal operation of the peak tube in the spike fuel enrichment zone of the N Reactor is 144.0 kW/ft. For this simulation, this value was increased by 20%.
PGAMMA	0.0000	11-20	Estimates of radial energy deposition by material type used in the setup of the HLM were given as fractions of the total heat generation--not as separate components for gamma heating, fissioning, etc. Thus, to simplify input model setup, the explicit separation of the gamma heating component has been ignored.
CLADXC	0.0279	21-30	Since a gamma heat generation component is not being explicitly modeled, i.e., PGAMMA = 0, this variable need not have been specified.
NPINS	2	31-35	Two fuel pins (inner annulus "1", outer annulus "2") are modeled in the HLM process tube.
IGENFG	-1	36-40	Time varying heat generation due to decay nuclear heat is being modeled in a non-boiloff simulation.
NTABG	20	41-45	Twenty pairs of GMULT vs. GTIME are provided on Card D. CARD D values represent fractions of the original fission power generation, i.e., the decay heat generation after SCRAM.

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
MWCOR	3	46-50	Baker-Just kinetics will be used to model metal-water reactions of Zircaloy.
TFAIL	1900.	61-65	The assumed failure temperature of fuel elements is input here.
NUNLIM	1	66-70	As a conservatism, an unlimited supply of steam is assumed to be available to any node undergoing oxidation during the simulation.
NOXVAR	4	71-75	Four pairs of OXMULT vs. OXTEMP entries will be specified on Card E. Based on the maximum uranium temperature for each fuel pin at each axial level, an appropriate OXMULT value will be interpolated and applied to uranium nodes <u>after</u> fuel failure to determine what percentage of the total available oxidation area for the uranium node (OXA from BLOCK 4) is available for oxidation.

BLOCK 9, Card F

0 1.384

30

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
ICOS	0	1-10	Since ICOS = 0, an axial power profile, Card G, must be provided to account for nuclear heat variation along the axial length of the HLM process tube.
PRATIO	1.384	11-20	This variable is only used for problems with a chopped cosine (ICOS = 1) specified power profile, and could have been omitted here.

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
EZERO	-	21-30	This variable is only used for problems with a chopped cosine (ICOS = 1) specified power profile, and therefore has been omitted here.
NTABP	30	41-50	Thirty points are given in the axial power factor (PMULT) versus axial distance (PHIGHT) table on Card G.

BLOCK 9, Card G

64.50 0.8895 1.0 72.50 1.0358 1.0

The axial distance from each axial level to the HLM inlet is computed using data from BLOCK 4, Card B. By interpolation of these distances in the PMULT versus PHIGHT table specified using Card G, the axial power factor for each node is determined^(a). Note that variable PINT, given as 1.0 for both locations on the Card G shown above, is used only for boiloff simulations, and could have been omitted here.

BLOCK 9, Card H

5001 52 1000 0 .8411 700.

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
N1	5001	1-10	Node number.
NSEQ	52	11-20	Fifty-two additional inner uranium fuel nodes have identical initial conditions as 5001. They are specified using this card.
NADD	1000	21-30	Increments between successive additional nodes specified on this card, i.e., nodes 6001,7001...57001 will be assigned conditions identical to 5001 in this case.

(a) Shown on the sample input line above are PMULT values of 0.0 (unfueled region) at PHIGHT locations 0.00 and 26.20 in.

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
NGAM	0	31-40	Gamma heating is not explicitly modeled.
PRADIL	0.8411	41-50	The radial power factor accounts for the portion of the total nuclear heat that is produced in node "001" at each axial level.
TXY	700.	51-60	This initial temperature is based on data that provide an estimate of inner uranium fuel temperatures during normal (non-accident) operating conditions.

To simplify input file creation, variables AX and NPCX are omitted from Card H because no phase changes have occurred prior to the start of the simulation. Therefore, TRUMP-BD initializes their values as zero.

Calculation of PRADIL

Using the value of FUELR input in BLOCK 2, Card D, the radial power factor, PRADIL, is calculated using

$$PRADIL = \left[PI * (FUELR^{**2}) * 0.26\% \right] / A$$

where PI = 3.141593

0.26% = fraction of total nuclear heat deposited in the inner fuel annulus

A = radial cross-sectional area of inner fuel (0.9544 in.²)

FUELR = fuel pellet radius (specified in BLOCK 1, Card D).

BLOCK 10, Card B

-1 0

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
IMASFG	-1	1-2	The problem has no boiloff, and uses TRUMP-BD logic to specify flow regions. Thus, IMASFG = -1.
HFLAG	0	5	Hydrogen blanketing of oxidizing nodes will <u>not</u> be modeled. Because NUNLIM = 1 in BLOCK 9, Card C and HFLAG = 1, the supply of steam to fuel oxidizing nodes is assumed continuous and unlimited.

BLOCK 10, Card D

-1 20.43 .045

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
IBOLRGN	0	1-5	The flow region is a non-boiloff region.
MASFLG	-1	6-10	A user specified flow rate for this flow region (XMDOX) will be used by TRUMP-BD.
XMDOX	20.43	11-20	From RELAP5 data for the innermost axial coolant flow channel, the average flow rate during the steam cooling portion of the transient is 20.43 lbm/h.

BLOCK 10, Card F

401 1401 56 1000 1000 1.0 0.0 1.0

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
NODF1	401	1-5	The identification number of the source node is input here. Node 401 is a zero-volume node at the inlet to the innermost coolant flow channel. Node 401 is also connected to external node 3000 (see BLOCK 7, Card A above).
NODF2	1401	6-10	The identification number of the sink node is input here.
NSEQ	56	11-15	Fifty-six additional identical connections will be defined by this card.
NADF1	1000	16-20	NODF1 will be incremented by 1000 for each successive mass-flow connection specified by this card.
NADF2	1000	21-25	NODF2 will be incremented by 1000 for each successive mass-flow connection specified by this card. Thus, this card connects 401-1401, 1401-2401, 2401-3401...56401-57401, or the entire inner flow channel of the HLM model.
FX	1.0	26-30	100% of the flow region's mass-flow rate runs through these connections. For this model, no "subchannels" have been defined--the flow region and the subchannel are identical.
DELF1	1.0	41-50	The weighting factor for the differencing scheme used by TRUMP-BD for NODF1.

<u>VARIABLE</u>	<u>INPUT VALUE</u>	<u>COLUMNS</u>	<u>DESCRIPTION</u>
DELF2	1.0	51-60	The weighting factor for the differencing scheme used by TRUMP-80 for NODF2. As specified here, a central differencing scheme will be employed, since the two are weighted equally.

6.4 SIMULATION RESULTS

A brief discussion of the results from the inlet and outlet simulations is presented below.

6.4.1 Inlet Half

The primary concern in the station blackout simulation is the peak temperatures. Because of the high heat generation rates in (and relatively slow heat transfer paths from) the fuel annuli, the peak temperatures during the transient were found to always occur in the fuel or its associated cladding. A temperature history of the inlet half of the process tube, generated using data written to TAPE5 during execution (see Appendix B, TAPE5.0D), is given in Figure 6.6 for inner and outer fuel annuli at axial levels 44 and 57. Axial level 44 corresponds to the location of peak power generation along the length. Because the coolant saturation temperature and heat transfer coefficients remained constant along the entire length of each flow channel during film boiling, the peak temperatures for the first portion of the transient were found to occur at level 44.

Axial level 57 is the exit from the inlet half (i.e., the midpoint of the entire process tube). Nuclear heat generation is lower at this level than at level 44, so temperatures at this level are lower during film boiling. During steam cooling, the steam is heated to progressively higher temperatures as it travels down the flow channels. These higher steam temperatures act to shift the location of the peak temperatures to level 57 during the steam cooling.

This shift in peak temperature is better demonstrated by Figure 6.7, which compares the axial variation in outer fuel node temperature at three different

FIGURE 6.6. Inner and Outer Fuel Predicted Temperature Histories at Axial Levels 44 and 57--N Reactor Station Blackout (Inlet Half)

FIGURE 6.7. Outer Fuel Predicted Axial Temperature Distribution at 500, 1000, and 2886 s--N Reactor Station Blackout (Inlet Half)

times during the transient; 500 s. (film boiling), 1000 s. (just after steam cooling begins), and seconds (end of transient). This plot was generated from data written to TAPE11 during execution, a copy of which is included in Appendix B as TAPE11.OD.

During both film boiling and steam cooling positions of the transient, peak temperatures occur early and then gradually descend. This rollover occurs because of the continual decay in nuclear heat generation as the simulation progresses.

Excerpts from the OUTPUT file are in Appendix B as OUT.OD. Included in OUTPUT are portions of the processed INPUT from file IRSLBOD, and results for the first time step (KCYC = 1), the final time step and the final system summary.

6.4.2 Outlet Half

Inlet steam temperatures during steam cooling for the outlet half of the process tube varied, based on temperatures leaving the inlet half. Thus, the results for the inlet half were inserted directly into BLOCK 6 of file IRSLB0F, used as the INPUT file for the outlet half simulation (see Appendix B for a copy of file IRSLB0F).

Temperature histories for the peak inner and outer fuel elements for the outlet half model (IRSLB0F) are given in Figure 6.8. As can be seen when comparing Figure 6.8 with 6.6, peak temperatures are higher during steam cooling in the outlet half of the process tube than in the inlet half. This is due to the high temperatures of steam entering the outlet half.

As can be seen in Figure 6.8, fuel temperatures in the outlet half exceed 1300°F during much of the steam cooling portion of the transient. Thus, TRUMP-BD metal-water reaction logic is used for this simulation to model Zircaloy oxidation (see Section 3.5.2.1) in the pertinent nodes. Time histories depicting the integrated hydrogen production and the hydrogen production rate (single process tube) associated with this oxidation are given in Figures 6.9 and 6.10, respectively. These figures were generated using data written to TAPE3 during execution, stored as TAPE3.0F in Appendix B.

FIGURE 6.8. Peak Inner and Outer Fuel Predicted Temperature Histories--
N Reactor Station Blackout (Outlet Half)

FIGURE 6.9. Predicted Hydrogen Released--N Reactor Station Blackout (Outlet Half)

FIGURE 6.10. Predicted Hydrogen Release Rate--N Reactor Station Blackout (Outlet Half)

7.0 CODE VALIDATION

TRUMP-BD predictions have been assessed against a fairly limited data set; however, the assessment has included key aspects of the code's predictive capabilities. The primary use of the TRUMP-BD code has been for safety analysis and test operational guidance for the Coolant Boilaway and Damage Progression Program (Lanning et al. 1986 a, b, c; Hesson et al. 1985), an internationally sponsored series of tests investigating the behavior of severe accidents in LWRs. These tests are conducted in the National Research Universal (NRU) Reactor, Nuclear Laboratories, Chalk River, Canada, as part of the U.S. Nuclear Regulatory Commission's Severe Fuel Damage/Source Term Program. The code is currently being used for safety analysis and test operations conducted for Full-Length High-Temperature Experiment 6, expected to be performed in the future, in the NRU Reactor.

The code modifications made to create TRUMP-BD were made as required to perform the thermal-hydraulic and safety analyses for the various programs and were not part of a major effort to develop a code for public release and use. Therefore, there has been no concerted effort to perform extensive validation assessments as might be required for licensing-related programs. The validation assessments that have been performed involve comparisons of several pre- and post-test predictions with actual NRU test data(a). This evaluation is required by the Canadian Nuclear Safety Advisory Committee (NSAC) prior to granting approval for conducting future experiments in the NRU Reactor. In addition, the NSAC committee as well as the staff from the Nuclear Safety and Technology Branch at the Chalk River Nuclear Laboratories, perform a detailed review of the code predictions of the experiment prior to granting approval. This review focuses on several key parameters calculated by the code:

- peak cladding temperature and cladding temperature distributions as a function of time
- hydrogen release rate and integrated release
- chemical energy release
- component temperatures and radial heat loss rate

(a) Tests MT-4A, FLHT-2, FLHT-4.

- thickness of metal consumed
- bundle exit hydrogen fraction
- coolant boilaway rate and liquid level.

Approval for all proposed tests have been granted by NSAC based on evaluation of the code predictions, which includes the comparison with previous test data, and additional safety analysis. In general, the code pre-test calculations have been successful in predicting the behavior of these complex integral fuel damage tests. Overall, the predictions are conservative relative to the test data. The formal review process required for approval for testing in the NRU Reactor should be considered as part of the validation assessment.

8.0 CODE DIMENSIONING

The TRUMP-BD code, with minor exceptions, is dimensioned with FORTRAN PARAMETER statements. Parameter values are assigned in the main program and every subroutine. The PARAMETER statements precede all array dimension declarations within the main program and subroutines. The variables designated as parameters in TRUMP-BD have short implicit integer variable names (2 to 3 letters/numbers) beginning with the letter "m". Once assigned within a program or subroutine a parameter value may never be reassigned during execution. To limit the number of parameters to a minimum, arrays with similar dimensioning requirements are sized according to a single common parameter. For example, the parameter m4 that defines the maximum number of nodes is an appropriate dimension limit for the array that corresponds node index with node number and the arrays that contain the node dimensions. The current version of TRUMP-BD uses the parameters numbered sequentially from m1 to m15, the parameters alphabetically sequenced from ma to me and mg to ml, and the parameter mg. Generally, the parameters numbered m1 to m12 relate to their respective input block numbers. That is, parameter m4 defines the maximum number of nodes--information read in through BLOCK 4 input.

The size of the entire data field in the current version of TRUMP-BD equals 683,430 words, wherein the dimensioned arrays account for 630,170 words. The dimensioned arrays, therefore, currently occupy 92.2% of the data memory. Proper selection of parameter sizes to fit the specific problem will result in efficient code execution in terms of memory requirements. Efficient memory declarations translate directly into computer cost savings because most computer billing algorithms include surcharges on excessive memory use.

The following is a brief description of each of the parameters used in TRUMP-BD to dimension arrays. Throughout the TRUMP-BD code, various variables are checked to protect the user from under-dimensioning a problem with respect to the input requirements. These checks are reserved for rather gross dimensioning errors. It is possible to oversize minor parts of the program without being detected by a parameter check. Generally, if a problem size error is found in a parameter check, the parameter, a "KWIT" number, and the input BLOCK number will be written to the output file and the program execution halted. A listing of parameters, their current assigned value, and a summary

of the various checks performed with each parameter is presented in Table 8.1. This survey should prove valuable in tracking down dimensioning problems that are identified with a parameter check. the following situation illustrates a parameter check.

Parameter m4, which defines the maximum number of nodes, was assigned a value of 50. An input file was created with 106 nodes in BLOCK 4. The parameter check for m4 in subroutine THERM would find that $106 > 50$, assign a "KWIT" number of 11, write "MORE THAN ALLOWED--50 ITEMS IN BLOCK 4," and halt program execution. A "KWIT" number of 11 informs the user that there is a problem with the input data. To remedy this particular error, the parameter m4 would need to be increased to at least 106, although some margin, e.g., 20%, is desirable to prevent the necessity for recompilations for small variations in the problem dimensions.

TABLE 8.1. Parameter Descriptions

- m1: Defines: plot times to a terminal screen; currently inactive.
Current value: 1
Parameter checks: none
- m2: Defines: the maximum number of material types.
Current value: 10
Parameter checks: number of materials > m2
subroutine THERM, KWIT = 11, BLOCK 2
- m3: Defines: the maximum number of reactants; currently inactive.
Current value: 1
- m4: Defines: the maximum number of nodes.
Current value: 1801
Parameter checks: number of nodes > m4
subroutine THERM, KWIT = 11, BLOCK 4

number of initial conditions > m4
subroutine TALLY, KWIT = 11, BLOCK 9

number of axial levels > m4
subroutine TALLY, KWIT = 11, BLOCK 9
- m5: Defines: the maximum number of internal thermal connections.
Current value: 4201
Parameter checks: number of internal thermal connections > m5
subroutine FINK, KWIT = 11, BLOCK 5
- m6: Defines: the maximum number of external thermal connections.
Current value: 300
Parameter checks: number of external thermal connections > m6
subroutine SURE, KWIT = 11, BLOCK 6
- m7: Defines: the maximum number of boundary nodes.
Current value: 8
Parameter checks: number of boundary nodes > m7
subroutine SURE, KWIT = 11, BLOCK 7
- m8: Defines: the maximum number of nodes with variable internal heat generation.
Current value: 200
Parameter checks: number of nodes with variable heat generation > m8
subroutine GEN, KWIT = 11, BLOCK 8

- m9: Defines: the maximum table lengths in BLOCKs 2, 3, 6, 7, 8, and 10; currently inactive for dimensioning arrays but actively used in parameter checks (see mg below).
 Current value: 120
 Parameter checks: conductivity table length > m9
 subroutine THERM, KWIT = 12, BLOCK 2

 capacitance table length > m9
 subroutine THERM, KWIT = 12, BLOCK 2

 internal heat generation table length > m9
 subroutine GEN, KWIT = 12, BLOCK 8

 variable mass flow rate table length > m9
 subroutine FLOW, KWIT = 12, BLOCK 10

 variable external convection coefficients table > m9
 subroutine SURE, KWIT = 12, BLOCK 6

 variable external temperature table length > m9
 subroutine SURE, KWIT = 12, BLOCK 7
- m10 or ma: Defines: the maximum number of mass flow connections. m10 is used in parameter checks, whereas ma is used for dimensioning arrays.
 Current value: 251
 Parameter checks: number of flow regions > m10
 subroutine FLOW, KWIT = 11, BLOCK 10
- m11 or mb: Defines: the maximum number of flow regions. m11 is inactive, whereas mb is used for dimensioning arrays.
 Current value: 10
 Parameter checks: none
- m12 or mc: Defines: the maximum number of axial levels and the number of nodes with properties dependent on remote temperatures. m12 is related to the nodes with properties dependent on remote temperatures, whereas mc is related to the number of axial levels.
 Current value: 60
 Parameter checks: number of nodes with properties dependent on remote temperatures > m12
 subroutine THERM, KWIT = 11, BLOCK 12

 number of axial levels > mc
 subroutine THERM, KWIT = 5, BLOCK 4

9.0 REFERENCES

- Baker, L., and L. C. Just. 1962. Studies of Metal-Water Reactions at High Temperature; Experimental and Theoretical Studies of Zirconium-Water Reaction. ANL-6548, Argonne National Laboratory, Argonne, Illinois.
- Birney, K. R., and A. W. Cronenberg. 1988. Oxidation of N Reactor Fuel Under High-Temperature Accident Conditions. WHC-SP-0017-2, Westinghouse Hanford Company, Richland, Washington.
- Birney, K. R., D. B. Bechtold, and T. B. McCall. 1988. Correlations for Fission Product Release from N Reactor Fuel Under High-Temperature Accident Conditions. WHC-SP-0017-3, Westinghouse Hanford Company, Richland, Washington.
- Birney, K. R. and A. W. Cronenberg. 1988. Oxidation of N Reactor Fuel Under High Temperature Accident Conditions. WHC-SP-0017-2, Westinghouse Hanford Company. Richland, Washington.
- Cunningham, J. P., and H. C. Yeh. 1973. "Experiments and Void Correlation for PWR Small-Break LOCA Conditions." Trans. Am. Nucl. Soc. 17:269
- Cathcart, J. V., et al. 1977. Summary Zirconium Metal-Water Oxidation Kinetics IV. ORNL/NUREG-17, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
- Dougall, R. S., and W. M. Rohsenow. 1963. Film Boiling on the Inside of Vertical Tubes with Upward Flow of the Fluid at Low Qualities. MIT Report Number 9079-26, Massachusetts Institute of Technology, Cambridge, Massachusetts.
- Edward, A. L. 1972. TRUMP: A Computer Program for Transient and Steady-State Temperature Distributions in Multi-Dimensional Systems. UCRL-14754 REV 3, Lawrence Livermore Laboratory, Livermore, California.
- Groeneveld, D. C. 1969. An Investigation of Heat Transfer in the Liquid Deficient Regime. AECL-3281.
- Heard, F. J., D. M. Ogden, N. J. Lombardo, and M. D. White. 1987. N Reactor Safety Enhancement--Final Report--Hydrogen Generation and Thermal Analysis for the Hydrogen Mitigation Design Basis Accident. HEDL-TC-2677/UN1-4472, UNC Nuclear Industries, Richland, Washington.
- Hesson, G. M., et al. 1985. Coolant Boilaway and Damage Progression Program Full Length High Temperature Tests--Final Safety Analysis for FLHT-2 Experiment. PNL-5547, Pacific Northwest Laboratory, Richland, Washington.
- Lanning, D. D., and N. J. Lombardo. 1987. Final Safety Analysis Report for Full Length High Temperature Experiment 5. PNL-6117, Pacific Northwest Laboratory, Richland, Washington.

- Lanning, D. D., G. M. Hesson and N. J. Lombardo. 1986a. Full-Length High-Temperature Tests--Preliminary Safety Analysis for FLHT-4 Experiment. PNL-5770, Pacific Northwest Laboratory, Richland, Washington.
- Lanning, D. D., and N. J. Lombardo. 1986b. Final Safety Analysis Report for Full-Length High-Temperature Experiment 4. PNL-5869, Pacific Northwest Laboratory, Richland, Washington.
- Lanning, D. D., and N. J. Lombardo. 1986c. Preliminary Safety Analysis Report for Full-Length High-Temperature Experiment 5. PNL-5949, Pacific Northwest Laboratory, Richland, Washington.
- Prater, J. T., and E. L. Courtright. 1986. High Temperature Oxidation of Zircaloy-4 in Steam and Steam/Hydrogen Environments. PNL-5558, NUREG/CR-4476, Pacific Northwest Laboratory, Richland, Washington.
- Parker, G. W. and C. J. Barton. 1973. "Fission-Product Release." Chapter 18 of The Technology of Nuclear Reactor Safety, Vol. 2, "Reactor Materials and Engineering," edited by T. J. Thompson and J. G. Beckerley, the MIT Press, Cambridge, Massachusetts, pp. 525-618.
- Ranson, V. H., et al. 1983. RELAP5/MOD2 Code Manual. EG&G-SAAM-6377, Idaho National Engineering Laboratory, Idaho Falls, Idaho.
- Urbanic, V. F., and T. R. Heidrick. 1978. "High Temperature Oxidation of Zircaloy-2 and Zircaloy-4 in Steam." J. Nucl. Mater. 75:251.
- Wilke, C. R. 1950. J. Chem. Phys. 18:517-519.
- Wilson, J. F., R. T. Grenda and J. F. Patterson. 1962. "The Velocity of Rising Steam in a Bubbling Two-Phase Mixture." Trans. Am. Nucl. Soc. 5:151-152.
- Wilson, R. E., et al. 1966. "Geothermal Reaction of Uranium with Steam Between 400 and 1600°C." Nuclear Science and Engineering. 25(2):109-115.
- Wong, S. and L. E. Hochreiter. 1981. Analysis of the FLECHT-SEASET Unblocked Bundle Steam Cooling and Boiloff Tests. NUREG/CR-1533, EPRI NP-1460, Electric Power Research Institute.
- Zuber, N., and J. A. Findlay. 1965. "Average Volume Concentration in Two-Phase Flow Systems." ASME J. of Heat Transfer. pp. 453-468.

APPENDIX A
VARIABLE GLOSSARY

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VARIABLE GLOSSARY

A(m4,m2)	Mass fraction of lower temperature phase.
AA(m4,m2)	Temporary input value of A(m4,m2).
AC(mn)	Constant used in computing vapor pressure for each fission product.
ACONST	Oxidation kinetics constant.
ADD	Difference between successive values of DRAD in a sequence of nodes or connections produced by NSEQ.
ALONE	Default input value of A(m4,m2).
AMAT(m2)	Descriptive name for material with number MAT(m2).
AOUT(mj)	Special output of mass fraction of lower temperature phase.
AREA(m5)	Interface Area Between NOD1(m5) and NOD2(m5), equals (GEOM*DLONG*DRAD**KSYM)*SCALE**2. See KD.
AREAS(m6)	Area of NODS(m6) exposed to boundary node NODSB(m6), equals (GEOM*DLONG*DRAD**KSYM)*SCALE**2. See KD.
AREAV(me)	bridged effective heat transfer area (in. ²) for a variable thermal connection.
AVEDX(mc)	Average (mean) thickness of all oxidizing Zircaloy nodes indexed by axial level (in.).
AVEUDX(mc)	Average (mean) thickness of all oxidizing uranium nodes indexed by axial level (in.).
AX	Temporary value of A(m4,m2).
AXDIST(mc)	Node axial length (in.).
AXDISTM	Node axial length in meters.
AXMG	User defined power multiplier, applied to nodes above the dryout front, boiloff simulations only.
AXTIM(m2)	Times during simulation at which axial plot data is to be written to TAPE 11 (see BLOCK 1).
AXTIMS(m2)	Same as AXTIM(m2).

B(mn)	Constant used in computing vapor pressure for each fission product.
BCONST	Oxidation kinetics constant.
BET	Value of a tabulated property, used to find change.
BIG	Constant, with value 0.99999999E12.
BUNDHT	Model height (length) (in.).
C(mn)	Constant used in computing bake-out conductance variable HBAKE(m4,mn) for each fission product.
CAP(m4)	Heat capacity of NODE(m4) at temperature T(m4).
CAPMS	Total heat capacity of a material.
CAPS	Total heat capacity of system.
CAPT(mg,m2)	Heat capacity of MAT(m2) at TVARC(mg,m2).
CCONST	Oxidation kinetics constant.
CLADMX	Maximum of all Zircaloy cladding node temperatures.
CLADXC	Clad cross-sectional area (in.), used to compute gamma heating volumetric heat rate.
CON(m4)	Thermal conductivity of NODE(m4) at temperature T(m4).
CONE	Value given a non-decimal 8CD number NXX in PATCH.
CONT(mg,m2)	Thermal conductivity of material MAT(m2) at temperature TVARK(mg,m2).
CORR	Energy content of material at 0 DEG, relative to TVARC(1).
CX(mn)	Fraction of fission product released per fraction of uranium oxidized.
D1	Temporary value of DELF1(N).
D2	Temporary value of DELF2(N).
DA(m4)	Change in mass fraction of lower temperature phase.
DAX	Change in A(m4,m2) due to phase change.
DDA(m4)	Time rate of change in mass fraction of lower temperature phase or temporary value of estimated temperature change from phase change.

DDT(m4)	Estimated rate of change of T(m4) in next time step.
DEL1(m5)	Average length of heat flow path from nodal point in NOD1(m5) to interface with NOD2(m5). See SCALE.
DEL2(m5)	Average length of heat flow path from nodal point in NOD2(m5) to interface with NOD1(m5). See SCALE.
DELF1(ma)	Relative distance from nodal point of NODF1(ma) to mass flow interface with NODF2(ma), converted to weight factor $DELF2(ma)/(DELF1(ma) + DELF2(ma))$ after input.
DELF2(ma)	Relative distance from nodal point of NODF2(ma) to mass flow interface with NODF1(ma), converted to weight factor $DELF1(ma)/(DELF1(ma) + DELF2(ma))$ after input.
DELT	Time step, controlled by TVARY, DELTO, DELTMX, TIMEP, and TIMAX. Also see KS, KSPEC.
DELTG	Last accepted time step completed.
DELTMX	Maximum allowable time step.
DELTO	Maximum allowable time step. Blank = 1.0E12. Must be specified if KSPEC is positive.
DELTS	Last time step completed.
DELTSS	Last accepted time step completed before DELTS.
DENS(m2)	Density of material with number MAT(m2).
DEX	Temporary value of DDT(m4).
DEXA	Temporary value of DDA(m4).
DF(m4)	Net heat flow into NODE(m4) in time step DELT.
DFI(m5)	Heat flow from NOD2(m5) to NOD1(m5) in time step DELT.
DFLOT	Time for mass flow into a node to equal the node mass.
DFS(m6)	Heat flow from NODSB(m6) to NODS(m6) in time step DELT.
DLONG	Average length of a node in BLOCK 4, an interface in BLOCK 5, or a surface in BLOCK 6. See DRAD.
DMETAL	Amount of metal consumed via oxidation(kg/s).

DRAD	Mean axial length ($KD = 1$), or mean radius ($KD = 2$ or 3) of a node in BLOCK 4, an interface in BLOCK 5, or a surface in BLOCK 6. See NSEQ for use of a negative value.
DRADS	Value of DRAD for node for connection last read in.
DS	Sum of mass flow paths DELF1(ma) and DELF2(ma).
DT(m4)	Change in temperature in NODE(m4) in time step DELT.
DT12	Positive temperature difference between two nodes.
DTEMP	Maximum temperature change in time step DELTS.
DTHIK(m4)	Change in a node's oxidation thickness over the last time step (m).
DTIME	Time step in seconds.
DTMAX	Maximum change in any tabulated property, in equivalent temperature or TVARY*(percent change), or NUTMAX*TVARY, if NUTMAX iterations were done, or $0.025*NUTS*TVARY$, whichever is largest, in time step DELTS.
DTMAXS	Value of DTMAX for time step DELTS.
DTX	Temporary value of the absolute temperature difference between a node temperature and a phase change temperature.
DTXP	Temporary value of the absolute temperature difference between a node temperature and a phase change temperature.
DUDT	Fraction of fuel oxidized per minute in a fuel node.
DWIDE	Average width of a node in BLOCK 4. See DRAD.
EMAX	Largest change in the calculated temperature change of any finite-volume special node in one iteration. Must be less than $10.0*ERRS*TVARY$ for convergence.
EOF	Indicates an end-of-file has been read, if positive.
ERROR(m4)	New estimated change in heat flow into NODE(m4).
ERRORX(m4)	Last estimated change in heat flow into NODE(m4).
ERRS	Maximum allowable fraction of TVARY for the change in the calculated average temperature change of interconnected special nodes in one iteration, for convergence.
ESUM	Change in the calculated total heat content of interconnected special nodes in one iteration.

EX	Extrapolation of temperature or time for table lookup, or a correction to the temperature change of a special node for one iteration step.
EXHFRAC	Exit hydrogen fraction (mass weighted average over all flow regions).
EXITSTM	Exit coolant mass flow rate (sum of all flow regions).
EZERO	Extrapolated length for chopped-cosine power profiles (in.).
F(m4)	Total heat flow into NODE(m4) at SUMTIM.
F1(mg)	Temporary name of first item of input table pair.
F2(mg)	Temporary name of second item of input table pair.
F3(mg)	Temporary name of slope between input table pairs.
FAILT(mc,mh)	Time in hours at which a uranium fuel pin at a given axial level exceeds TFAIL, the fuel failure temperature.
FB(m7)	Total heat added to system from boundary node NODB(m7).
FFACTR	Coolant mass flow rate multiplier used for boiloff flow regions only.
FI(m5)	Total heat flow from NOD2(m5) to NOD1(m5) at SUMTIM.
FIN	Dummy list argument used for write statements with no list.
FISAV	Fission power linear heat rate (kW/ft), excludes gamma heating.
FIZZ(m4)	An array that contains array location indexes for fission product variables.
FLAPS(ma)	Total mass flow from NODF1(ma) to NODF2(ma) at SUMTIM.
FLEX	Final correction to heat flux between nodes.
FLEX1	Heat content of mass flow source NODE.
FLEX2	Heat content of mass flow sink NODE.
FLINT(m4)	Net mass flow rate into NODE(m4) during time step.
FLIPS(m4)	Net total mass flow into NODE(m4) up to SUMTIM.
FLOPS(m4)	Net total mass flow out of NODE(m4) up to SUMTIM.

FLOUT(m4)	Net mass flow rate out of NODE(m4) during time step.
FLOWN(ma)	Mass flow rate from NODF1(ma) to NODF2(ma). May be negative to indicate flow in opposite direction. If not specified, FONE will be used by program.
FLOWT(mg,ma)	Mass flow rate from NODF1(ma) to NODF2(ma) at TVARFL(mg,ma), may be negative to indicate flow in opposite direction.
FLOWX(ma)	Mass flow from NODF1(ma) to NODF2(ma) during time step.
FLOWY(mb)	Array containing the coolant flow regions' cross-sectional areas (BLOCK 10).
FLOWYT	Total model flow area (in. ²).
FLUX	Net total heat flow into all nodes in system.
FLUXS	Net total heat flow into system from boundary nodes.
FONE	Flow rate for any mass flow connections with FLOWN(ma) blank in any BLOCK 10 read in after BLOCK 1.
FOR	Interpolation factor between temperatures at the beginning and end of the time step. FOR is set to 1.0 for the first time step and after rejected time steps. For other time steps, FOR is 1.0 if KSPEC is 2, 0.5 if KSPEC is 3, or between 0.57 and 1.0, depending on RAST.
FORD	Factor for estimating changes, = FOR*DELT or 0.5*DELT.
FPC(md,mn)	Current fission product inventories in each fuel node (kg).
FPDT(md,mn)	Total release rate of each fission product from each fuel node (kg/min).
FPDTB(md,mn)	Release rate of each fission product from each fuel node due to bake-out (kg/min).
FPDTO(md,mn)	Release rate of each fission product from each fuel node due to oxidation (kg/min).
FPFRAC	Fraction of whole core being modeled in TRUMP-BD simulation, in terms of core power.
FPI(md,mn)	Initial fission product inventories in each fuel node (kg).
FPIT(mn)	Total inventory of each fission product in the core in kg.
FPMDT(mn)	Total model release rate of each fission product (kg/min).

FPMDTB(mn)	Model total release rate of each fission product due to bake-out (kg/min).
FPMDTO(mn)	Model total release rate of each fission product due to oxidation (kg/min).
FPMRL(mn)	Total model integrated release of each fission product due to in kg.
FPMRLB(mn)	Model integrated release of each fission product due to bake-out in kg.
FPMRLO(mn)	Model integrated release of each fission product due to oxidation in kg.
FPREL(md,mn)	Total integrated release of each fission product by each fuel node in kg.
FPRELB(md,mn)	Integrated release of each fission product by each fuel node due to bake-out in kg.
FPRELO(md,mn)	Integrated release of each fission product by each fuel node due to oxidation in kg.
FS(m6)	Total heat flow from NODSB(m6) to NODS(m6) at SUMTIM.
FUELMX	Maximum of all uranium fuel node temperatures.
FUELR	Fuel pellet radius (in.), used to compute volumetric heat generation rate.
FX	Average rate of heat flow across a connection.
FX1	Average mass flow rate into NODE(m4) up to SUMTIM.
FX2	Average mass flow rate out of NODE(m4) up to SUMTIM.
FXH2	Steam limiting constant applied to oxidation kinetics, reduces reaction rate based on hydrogen concentration (HFLAG must be set = 1 for this model to function).
FXY (mb)	Array containing the flow regions flow rate multipliers.
G(m4)	Heat generation rate in NODE(m4).
GAMAVE	Gamma heating linear heat rate (kW/ft).
GAP	Fuel-clad gap thickness (in.).
GENS	Net total amount of heat generated in system.

GEOM	Geometric factor, 1.0 for KD = 1, $2.0 \cdot \text{PI}$ for KD = 2, and $4.0 \cdot \text{PI}$ for KD = 3 (PI = 3.14159265).
GFACTR	Heat generation multiplier, used for boiloff flow regions.
GG(m4)	Initial heat generation rate in NODE(m4). Blank = GONE.
GONE	Constant heat generation rate assigned to all nodes in any BLOCK 4 read in after BLOCK 1, and substituted for any unspecified GG(m4) in any BLOCK 9 read in after BLOCK 1. Will not be used for nodes listed in BLOCK 8.
GS	Net total heat generation rate in system.
GX	Temporary value of GG(m4).
H(m4)	Heat added to NODE(m4) up to SUMTIM.
HBAKE	Fraction of each fission product released per minute due to bake-out in a fuel node.
HBULK	Value of bulk boiling heat transfer coefficient (BLOCK 10), used for boiloff problems.
HDO	Heat transfer length from bulk boiling to dryout front regimes (in.). HDO must be less than the minimum node's axial length (BLOCK 10).
HEAT	Sensible heat content of system at SUMTIM.
HEFT(m4)	Mass of NODE(m4).
HEFTMS	Total mass of a material.
HEFTS	Total mass of system.
HEIGHT(mc)	Array containing the distance from each axial level's centroid to XINTER.
HEX	Heat transferred between NODES in time delt.
HFG	Heat of vaporization (Btu/lbm), boiloff simulation only.
HFLAG	Steam limiting model flag; HFLAG: (0) no steam limiting (1) oxidation kinetics limited by hydrogen concentration in flow channel adjacent to oxidizing node (limiting model assumes hydrogen generation rate is also linear function of hydrogen concentration).
HFLOW(mb)	Array of mass flow rates of hydrogen at each axial level.

HFRACt(md)	Array of hydrogen partial pressure in values adjacent to metal-water reaction nodes.
HFRCVLV(mc)	Array of hydrogen partial pressures at each axial level based on the total flow in all model flow regions.
HFROMU	Total bundle hydrogen flow rate due to uranium oxidation.
HFROMUT	Integrated hydrogen release rate from uranium oxidation (kg).
HFROMZ	Hydrogen release rate from zirconium oxidation (kg/s).
HFROMZT	Integrated hydrogen release rate from zirconium oxidation (kg).
HIDM(mb)	Array of coolant flow regions' hydraulic diameters.
HINT(m5)	Interface conductance between nodes NOD1(m5) and NOD2(m5). Blank = 1.0E12 if RINT is blank, 1.0E-24 if RINT not blank.
HINTS	Input value of HINT(m5).
HINTV(me)	Bridged effective heat transfer coefficient (Btu/h-in. ² -°F) for variable heat transfer connection "me".
HMELT(m2,m2)	latent heat of phase change (Btu/lbm).
HMELTX(m2,m2)	Temporary latent heat of phase change (Btu/lbm).
HMX	Temperature change equivalent to latent heat effect.
HONE	Surface conductance for any external connections with HSURE(m6) blank, in a BLOCK 6 read in after BLOCK 1.
HOXD	Fraction of each fission product released per minute due to oxidation in a fuel node.
HREL(md)	Array containing integrated hydrogen release rates. These rates represent the sum total integrated release for all metal-water reaction nodes up to the one indexed by "md."
HRELTOT(mc,mb)	Integrated hydrogen release by level and flow region.
HSUM	Total heat capacity of all special nodes which have internal connections with other special nodes.
HSURE(m6)	Surface conductance between NODS(m6) and NODSB(m6).
HSURT(mg,m6)	Surf. cond. of NODS(m6) at TVARH(mg,m6). Blank = HONE.
HX	Temporary value of HSURE(m6).

IBLOCK	BLOCK number; IBLOCK: (1) for controls, limits, and constants (2) for materials (4) for nodes (5) for internal thermal connections (6) for external thermal connections (7) for boundary nodes (8) for variable heat generation nodes (9) for initial conditions and TRUMP-BD heat generation (10) for mass flow connections (12) for nodes with remote property dependence.
IBLOCL	Value for IBLOCK on data end card.
IBDLRGN(mb)	An array of coolant flow region type indicator flags (BLOCK 10).
ICOLM(m2,mc)	A "pointer" array used to identify the index for each node at an axial level that is specified as a node whose temperature will be written to TAPE 11.
IDEPL(mb)	Steam depletion flags for each flow region; 0 = steam available, > 0 steam depleted.
IDIAG	Output diagnostic flag.
IFIZZ	Variable used to control entry location in subroutine FISPROD when KCYC = -1.
IGENFG	Time-dependent heat generation flag.
IHCOMB	Binary mixture (hydrogen and steam) property flag.
IHTCOR(me)	Variable heat transfer correlation type for variable heat transfer connection index "me".
IJ	The index number of a temperature dependent internal thermal connection.
IPRINT	*** NOT USED ***
IRITE	*** NOT USED ***
ISOTOP(mn)	Descriptive name for fission product, input in BLOCK 13.
ISTATE(mc,mh)	An array of fuel pin states ("intact" or "failed") for each pin at each axial level.
ITEMS(n)	Number of cross-referenced items in data BLOCK n.

ITST(mb,mc)	An array of temperatures of coolant flow regions at each axial level.
IVARH(me)	A thermal connection index array for variable heat transfer connections.
K	*** NOT USED ***
KCYC	Indicates problem is in data input phase (if -1), or in initialization phase, including initial time step of 1.E-12 (if 0), or the number of time steps completed.
KD	Geometric symmetry indicator; KD: (1) for nonsymmetric (2) for axisymmetric (3) for centrisymmetric. Used to control calculation of node volumes and connection areas for BLOCKs 4, 5, and 6 read in after BLOCK 1.
KDATA	Controls amount of standard TRUMP data on printouts, minimum if negative, normal if zero, and maximum if positive.
KDATAX	Input value of KDATA.
KGOOD	Number of successive time steps not repeated, or not involving changes to special nodes, after 2nd.
KNOCK	Number of thermal connections between pairs of special nodes.
KNOFL	Number of mass flow connections between pairs of special nodes.
KS	Indicates that NOOE(m4) is a special node. See KSPEC.
KSECS	Machine time charged to the problem, in seconds, measured from just before reading the problem name card for each data deck.
KSPEC	Node classification and difference equation control, specified in BLOCK 1.
KSYM	Symmetry factor, 1 if KD is 1 or 2, 2 if KD is 3.
KWIT	Indicates: (-1) time step to be repeated (1) SUMTIM exceeds TIMAX (2) node temperature over TMAX (3) node temperature under TIMIN (5) input error (6) *CHECK card read in (7) KCYC over MCYC (8) KSECS over MSEC (9) missing BLOCK 2 or 4

- (10) iteration convergence failure
- (11) number of BLOCK items too large
- (12) table length over M9.

LABEL	Indicates table headings to be rewritten, if nonzero.
LBH	Indicates input data field for HINT(m5) is blank if zero.
LBR	Indicates input data field for RINT(m5) is blank if zero.
LIST	Input array which must be recalculated in subroutine REFER.
LISTR	Array containing numbers to which array list refers.
LISTX	Input values of array list.
LP	Temporary special output node counter/controller.
LTAB	Absolute value of a table length.
LTABC(m2)	Number of pairs of entries in this table of heat capacity CAPT(mg,m2) vs. temperature (or time) TVARC(mg,m2) for material MAT(m2). LTABC is negative for time table, positive for temperature table.
LTABFL(ma)	Number of pairs of entries in table of FLOWT(mg,ma) vs. TVARFL(mg,ma), for flow mass connection NODF1(ma) to NODF2(ma). LTABFL is negative for time table, positive for temperature table.
LTABG(m8)	Number of pairs of entries in this table of GT(mg,m8) vs. TVARG(mg,m8) for NODG(m8). LTABG is negative for time table, positive for temperature table, -1, 0, or 1 for exponentially decaying heat generation with rate GT(1,N) at time 0, half-life TVARG(1,N).
LTABH(m6)	Number of pairs of entries in table of heat transfer coefficient HSURT(mg,m6) vs. time (or temperature) TVARH(mg,m6) for NODS(m6)-NODSB(m6) connection. LTABH is negative for time table, positive for temperature table.
LTABK(m2)	Number of pairs of entries in table of CONT(mg,m2) vs. TVARK(mg,m2) for MAT(m2). LTABK is negative for time table, positive for temperature table.
LTABP(m2)	Number of temperature-latent heat pairs in phase change table: use 0 to indicate a single-phase change in the input file; for materials with single-phase changes LTABP(m2) is converted to 1 upon code initialization.

LTABT(m7)	Number of pairs of entries in the table of temperature TEMPB(mg,m7) vs. time TIMEB(mg,m7), for external boundary node NODB(m7).
M	Unit number used in write statements to OUTPUT.
MAR	Size of array LISTR in subroutine REFER.
MASFLG	Mass flow rate computation flag (BLOCK 10).
MAT(m2)	Array containing the identification numbers for materials defined in BLOCK 2.
MAVEDX(mc)	Array containing the current number of oxidizing uranium nodes for each axial level.
MAX	Size of arrays LIST and LISTX in subroutine REFER. Highest index of part of table being searched.
MCYC	Maximum allowed number of time steps (limit on KCYC). Negative will stop problem at end of first time step, zero or blank is ignored.
MF	Total number of times DTEMP or DTMAX has exceeded TVARY in time steps for which DELT was equal to SMALL.
MID	Central index of part of table being searched.
MIN	Lowest index of part of table being searched.
MOD	Character in column 8 of BLOCK number card, blank for deleting old items and adding new items, /A/ for saving old items and adding new items, /B/ for modifying old items and adding new items.
MODS	Indicates MOD is A (+1), B (-1), or neither (0).
MS	Number of time steps for which DELT was equal to DELTMX and DTEMP and DTMAX were less than TVARY, since last regular node was reclassified as a special node.
MSEC	Maximum allowed use of machine time, in seconds. Negative will stop problem at end of first time step; zero or blank is ignored.
MSS	Total number of times DTEMP and DTMAX were less than TVARY in time steps for which DELT was equal to DELTMX.
MWR	Number of metal-water reaction nodes.
MWRCOR	Zirconium - hydrogen reaction correlation type.

MWRSU(mc,mb,ml)	Node index for all fuel nodes adjacent to each flow region at each axial level.
MWRSURF(mc)	Array containing the number of metal-water reaction surface nodes at each axial level.
NADD	Difference between successive values of NODE in sequence.
MWRSZ(mc,mb,ml)	Node index for all Zircaloy volume nodes adjacent to each flow region at each axial level.
N12WRT	Number of times during simulation at which fission product release data will be written to TAPE12 (BLOCK 13).
NAD1	Difference, after multiplication by 10^{**NZ} , between values of NAD1 in sequence of connections.
NAD2	Difference, after multiplication by 10^{**NZ} , between values of NAD2 in sequence of connections.
NADF1	Difference between successive values of NODF1 in sequence.
NADF2	Difference between successive values of NODF2 in sequence.
NADFR	Difference between successive values of NPROP in sequence.
NADG	Difference between successive values of NODG in sequence.
NADP1	Difference between successive values of NODP1 in sequence.
NADP2	Difference between successive values of NODP2 in sequence.
NADS	Difference between successive values of NODS in sequence.
NADSB	Difference between successive values of NODSB in sequence.
NAME	71-character title on problem name card; must be an *.
NAMES	Problem name at time last data end card was read in.
NAVEDX(mc)	Number of zirconium nodes undergoing oxidation in axial level "mc".
NAXPO	Number of nodes (specified in BLOCK 1) for which axial plot information is to be written to TAPE 11.
NAXTIM	Number of times (specified in BLOCK 1) for which axial plot information is to be written to Tape 11.
NB	Input unit number for BLOCK items.
NB1	Integer which SEEK1 or SEEK2 is to search for.

NB2	Integer which SEEK2 is to search for, along with NB1.
NBOIL	Axial level of dryout front.
NBURN	Number of metal-water reaction nodes fully consumed.
NC	Array subscript of NXX in patch.
NCHANS	Number of channels for convection summary output.
NCHECK	Indicates /*check/ card read in, if non-zero.
NCOLMS	The number of columns of data written to TAPE 11, for each axial level. $NCOLMS = (NAXPO + 5 + NREGON) * NAXTIM + 1$.
NCX2(m5)	Input value of NOD2(m5).
NDOT	Indicates time derivatives DDT(N), DDA(N), DDB(N) will be used (NDOT = 0), or maintained at 0.0 (NDOT $\neq$ 0).
NEWBL	Number of times data BLOCK has been read in. 1000 is added each time a referenced BLOCK is read in.
NEWS	Number of regular nodes made special in one time step.
NFP	Total number of fission products. maximum = 10.
NFR(m4)	An array indexing coolant flow regions with metal-water reaction nodes.
NIT	Number of nodes with initial values TT, AA, BB, GG.
NLEVELS	Number of axial levels in model.
NLEVTOT	Total number of axial levels in model.
NMAT	Number of materials described in input BLOCK 2.
NMELT	Number of materials with latent heat of phase change.
NMELT	Number of materials with at least one phase change.
NOD1(m5)	Number of internal or surface node connections to NOD2(m5).
NOD2(m5)	Number of internal or surface node connections to NOD1(m5).
NODB(m7)	An array containing the node number of each specified boundary node.
NODBS	Number of boundary nodes.
NODE(m4)	An array containing the node numbers for each node.

NODEAX(m2)	Nodes for which axial plot information is to be written to TAPE 11.
NODER	Number of nodes in restart file.
NODES	Number of nodes described in input BLOCK 4.
NODF1(ma)	Number of node from which mass flows to NODF2(ma).
NODF2(ma)	Number of node to which mass flows from NODF1(ma).
NODG(m8)	Number of a node with variable heat generation.
NODMAT(m4)	Identification number of the material in NODE(m4).
NODMS	Total number of nodes of a material.
NODOUT(mj)	Number of special output nodes that will have their temperatures written to TAPE 5, and temperatures and current phase change information to OUTPUT at XSPRNT time intervals.
NODP1(m4)	Node for which T(NODP2(m4)) determines property NPROP(m4).
NODP2(m4)	Node whose temperature determines property NPROP(m4) of NODP1(m4).
NODS(m6)	Number of surface node connected to NODSB(m6).
NODSB(m6)	Number of boundary node connected to NODS(m6).
NOFLOW	Number of mass flow connections.
NOGEN	Number of nodes with heat generation.
NOPOWS POWER(m6).	Number of surface-boundary connections with non-zero
NORAD	Number of node connections with non-zero RINT(m5).
NORADS	Number of surface-boundary connections with non-zero RSURE(m6).
NOSCON	Number of external connections.
NOSPEC	Number of special nodes in system.
NOTE(m4)	An array containing node numbers for those nodes with initial conditions specified by TT, AA, and GG.
NOW	Indicates printouts are being produced for the time step just completed, if nonzero.

NOX1(m5)	Input value of NOD1(m5).
NOXE(m4)	Input value of NOTE(m4).
NOXF1(ma)	Input value of NODF1(ma).
NOXF2(ma)	Input value of NODF2(ma).
NOXG(m8)	Input value of NODG(m8).
NOXMAT(m4)	Input value of NODMAT(m4).
NOXP1(m4)	Input value of NODP1(m4).
NOXP2(m4)	Input value of NODP2(m4).
NOXSB(m6)	Input value of NODSB(m6).
NOXVAR	Number of points in uranium variable oxidation area table.
NPC(m4)	Active phase change index.
NPCOUT(mj)	Special output of active phase change index.
NPCX	Temporary value of active phase change index.
NPINNO(m4)	Number of fuel pin associated with NODE(m4).
NPROP(m4)	Number of property evaluated at temperature of node NODP2(m4), used for node NOPR1(m4). NPROP is (1) for CAPT (2) for CONT (3) for QT (4) for ZT (5) for ET (6) for GT (7) for FLOWT (8) for HSURT.
NPUNCH	Indicates final values of T, A, B, and constant values of G, will be punched in the format of BLOCK 9 when the problem is ended or interrupted, to allow a continuation problem to be run.
NQUIT	Logic variable used in determining the active phase change index.
NREACT	Equals nmelt for problems without the TRUMP chemical reaction coding.
NREGION	Number of flow regions in model.

NRHOX	Number of points in density table for coolant.
NSEQ	Number of BLOCK items to be generated in addition to the line item described. Node numbers will be incremented by NADD, NAD1, NAD2, NADS, NADSB, etc., as applicable, and if DRAD is preceded by a minus sign, DRAD values will be incremented by the difference between DRAD and the value of DRAD for the preceding BLOCK item.
NSPOUT	Number of special output nodes.
NSURF(mc)	Number of metal-water reaction node surfaces at axial level "mc."
NSURFR(mb,mc)	An array containing the number of metal-water reaction nodes adjoining each flow region at each axial level.
NSURFU(mc,mb)	Number of fuel nodes adjacent to each flow region at each axial level.
NSURFZ(mc,mb)	Number of Zircaloy volume nodes adjacent to each flow region each at axial level.
NTABF(mb)	An array containing the number of entries in coolant mass flow table for each flow connection "mb" (BLOCK 10).
NTABG	Number of entries in power vs. time table.
NTABLE	Total number of tables in input data.
NTABS	Number of nodes with remotely dependent properties.
NTYPE(m4)	Node type, (0) regular (1) surface (2) zero-volume (3) special (4) KSPEC = 0 converted special (5) KSPEC = 1 converted special (5).
NUM	Number of a node for which T, DDT, A, B, G, and SUMTIM will be written to OUTPUT every time step. This is in addition to the data written out for all nodes at intervals controlled by IPRINT and TIMEP.
NUMX	Input value of NUM.
NUNLIM	Unlimited steam supply for oxidation flag.
NUSERT(me)	Number of pairs of entries in user specified variable heat transfer table.

NUTMAX	Maximum allowable number of iterations of the heat balance equations for inter-connected special nodes (80).
NUTS	Number of iterations completed before convergence. Will cause next time step to be reduced if more than 40.
NUTSUM	Total number of iterations used in problem.
NUTX	Maximum number of iterations used in any time step.
NVARC	Number of materials with variable heat capacity.
NVARDX	Axial length noding flag. Equals number of entries in axial noding descriptor card (BLOCK 4, Card C).
NVARFL	Number of mass flow connections with variable flow.
NVARG	Number of nodes with variable heat generation (from BLOCK 8, standard TRUMP).
NVARH	Number of surface nodes with variable surface cond.
NVARK	Number of materials with variable thermal conductivity.
NVART	Number of boundary nodes with variable temperature.
NVISX	Number of points in coolant viscosity table.
NXX(N)	A BCD number to be tested for a decimal point in PATCH.
NZ	Indicates NAD1, NAD2 are to be multiplied by 10^{**NZ} .
NZDEP(mb)	Axial level at which steam used for oxidation has been completely depleted in flow region mb.
NZR(md)	Node number of a fully oxidized node.
NZRIDX(mb,mc)	Index to keep track of last metal-water reaction node read in from input for flow region "mb" at axial level "mc."
OUTDISC	restart/graphics post-processing dump flag; OUTDISC: (0) no restart or graphics dump (1) restart dump only (2) restart and graphics dump.
OXAREAM(md)	Uranium node oxidation area multiplier.
OXAREM(m4)	Area containing the available oxidation surface areas for each metal-water reaction node.
OXMULT(mg)	Oxide area multiplier applied at temperature OXTEMP(mg).
OXPINM(mc,mh)	Uranium oxidation area multiplier.

OXTEMP(mg)	Temperature at which OXMULT(mg) is applied.
PAXIAL	Axial power factor applied to a node.
PDUMP(ma,mc)	Array into which TAPE 11 data are stored, used when axial plots of node temperatures, hydrogen release, oxidation heat generation, etc., are going to be graphed. PDUMP is dimensioned for "mc" axial levels and "ma" number of columns of output values for each axial level. See variable NCOLMS.
PERULFT(mc)	The percent of unoxidized uranium at each axial level.
PERZLFT(mc)	The percent of unoxidized Zircaloy at each axial level.
PGAMMA	Fraction of rod average power (RODAVE) due to gamma heating.
PHIGHT(mg)	Fuel bundle axial elevations used when specifying axial power factors (BLOCK 9).
PIGRAL	Integrated axial power at dryout front, used in boiloff simulations.
PIX	Number of time steps estimated to remain before TIMAX reaches an integral multiple of TIMEP.
PMULT(mg)	Power factor at bundle axial elevation PHIGHT(mg), used when specifying axial power factors (BLOCK 9).
PONE	Free convection exponent for any external connection with POWER(m6) blank, in any BLOCK 6 read in after BLOCK 1.
POUT	Floating point value given a BCD number NXX in patch.
POWER(m6)	Free convection exponent for external connection between NODS(m6) and NODSB(m6), used in equation of form $HSURE*(T1 - T2)**POWER$; Blank = PONE.
POWTOT	Total initial heat generation rate of fuel nodes.
PRATIO	Peak-to-average bundle axial power ratio.
PRESS	Pressure corresponding to coolant property data (PSIA).
QAXTOT	Total model axial heat loss rate to external nodes.
QBOIL	Energy required to vaporize 1 lbm of inlet coolant ($H_{fq} + H_{subcool}$) (Btu/lbm).
QCHAN(mi)	An array of total convective heat transfer rates for each flow channel (kW).

QCONV(ma)	An array of convection heat transfer rates between each flow connection (kW).
QCONVT	Total convection heat removal rate (kW).
QDAMP	Zirconium-steam reaction damper, based on available steam.
QDAMPU	Uranium-steam reaction damper, based on available steam.
QFISON	Total fission heat generation rate (kW).
QPIN(mh)	An array of total heat generation rates in each fuel pin (kW).
QRADDX(mc)	The radial heat losses to boundary node 2000 at each axial level.
QRADT	Total radial heat loss (kW).
QUAX(mc)	Energy release from uranium-steam reaction at discrete radial cross sections along fuel bundle length.
QUFRAC	Ratio of uranium oxidation to total oxidation power on a plane.
QUPLN(mg,mc)	Sum of the total uranium oxidation energy release at each axial level for each flow region.
QZRAX(mc)	An array of total heat generation rates due to oxidation at each axial level.
QZRH2O(m4)	An array of the heat generation rates occurring in each metal-water reaction node.
QZRINT	Integrated metal-water reaction energy release (kW) over transient.
QZRTOT	Total metal-water reaction energy release in a time step.
RAD	Radiation coefficient at node connections.
RADIUS(m4)	Radius of NODE(m4), DRAD*SCALE in BLOCK 4.
RAT1	Value of TVARY/DTEMPT in time step DELTS.
RAT2	Value of TVARY/DTEMPT in time step DELTSS.
RATE	Average rate of heat flow into node or system.
RATG	Value of TVARY/DTEMPT in time step DELTG.
RATIO	Ratio of DELT to DELTS, before restricting DELT to limits SMALL and DELTMX.

RHO(m4)	Density of node "m4" in lbm/ft^3 .
RHOBAR	Average density of coolant below dryout front in boiloff simulations.
RHOTAB	Density value.
RINT(m5)	Radiation view factor for connection between NOD1(m5) and NOD2(m5), including effects of geometry and surface emissivity. If negative, a positive value used as free convection exponent, $\text{HINT} * (T1 - T2)^{**}\text{RINT}$.
RINTC	Free convection exponent derived from RINT.
RINTR	Radiation transport coefficient derived from RINT.
RODAVE	Average nodal power for model (kW/ft).
RODRAD	Outer radius of a fuel pellet (input in inches, converted to meters).
RODTOT	Total number of fuel rods in model (boiloff simulations only).
RONE	Radiation view factor for any external connection with RSURE(m6) blank, in any BLOCK 6 read in after BLOCK 1.
RSURE(m6)	Radiation view factor for external connection between NODS(m6) and NODSB(m6), including effects of geometry and surface emissivity. Blank = RONE.
SCALE	Linear scale factor used in calculating all lengths, areas, and volumes for BLOCKs 4, 5, and 6 read in after BLOCK 1.
SET	Time or temperature for table look-up.
SETD	Factor determining exponential decay of heat generation (BLOCK 8).
SETS	Factor determining exponential decay of heat generation (BLOCK 8).
SIGMA	Stephan-Bolzman constant for thermal radiation.
SLIM(m4)	Maximum stable time step for a regular NODE(m4). SLIM equals $\text{CAP}(\text{m4})/\text{ZIP}(\text{m4})$.
SLOPS	Ratio of maximum rates of temperature change in time steps DELTS and DELTSS, $(\text{RAT1} * \text{DELTS})/(\text{RAT2} * \text{DELTSS})$.

SMALL	Minimum allowable time step. Blank = 1.E-12, later replaced with 0.01*DELTMX, as long as at least 1/4 of the nodes are regular nodes.
SMALT	Input value of SMALL or 1.0E-12, whichever is larger.
SPEED	Factor controlling acceleration of iteration method (0.2).
STEAMF(mb)	The steam flow rates available for oxidation in each flow region (kg/s).
STEMFLOW(md)	The local steam flow rates available for oxidation for each metal-water reaction node (kg/s).
SUMSEC	Total problem time in seconds, starting after TAV, going to a maximum of TIMAX.
SUMTIM	Total problem time, starting at TAU. Limit is TIMAX.
SYMLT	Symmetry factor for model, applied to applicable variables written to TAPE3.
T(m4)	Temperature in NODE(m4). See tone, TT(m4).
T12(mk)	Times in hours during simulation at fission product release data will be written to TAPE12 (BLOCK 13).
TB(m7)	Temperature at boundary node NODEB(m7).
TBASE	Temperature difference between scale in use and absolute scale, 460.0 for KT = 3 (i.e., Fahrenheit scale--used in all TRUMP-BD simulations).
TBS(m7)	Average value of TB(m7) in a time step.
TDUM (mg)	Nodal temperature at bundle axial elevation ZDUM (mg). When axial temperature variation option is selected (BLOCK 9).
TEMPAD	Average temperature of system (constant CAP(m4)).
TEMPB(2,m7)	Amplitude of variation of TB(m7), if LTABT(m7) is 100.
TEMPB(m1,m7)	Average value of TB(m7), if LTABT(m7) is 100.
TEMPB(mg,m7)	Temperature at boundary node NODEB(m7) at TIMEB(mg,m7).
TEMPER	Change in average temperature of a system due to net surface flux.
TEMPFV (me)	Temperature criteria for bridging (°F) for variable heat transfer connections with IHEAT = 4 (BLOCK 5) TEMPFV < 0; criteria based on uranium temperature TEMPFV > 0; criteria based on zirconium temperature

TEMPLE	Change in average temperature due to heat generation.
TFAIL	Zirconium cladding melt temperature (°F)
TIM	Remaining time between SUMTIM and next higher integer multiple of TIMEP for which a printout will be made.
TIMAX	Maximum allowed problem time (upper limit on SUMTIM). A negative value will stop the problem at end of first time step; a zero or blank is ignored.
TIMEB(1,m7)	Sine wave period of TB(m7), if LTABT(m7) is 100.
TIMEB(1,m7)	Sine wave advance time of TB(mN), if LTABT(m7) is 100.
TIMEB(mg,m7)	Time at which boundary node NODB(m7) is at TEMPB(mg,m7).
TIMESP	Elapsed time between special node output/graphics dump
TIMS	Remaining time between SUMTIM and next higher integer multiple of TIMEP.
TMAX	Maximum allowable temperature. Replaced with 1.0E12 if not larger than TMIN.
TMAX1	Maximum temperature in system at SUMTIM.
TMELT(m2,m2)	Temperature of phase change.
TMIN	Minimum allowable temperature. Replaced with -1.0E12 if not less than TMAX.
TMIN1	Minimum temperature in system at SUMTIM.
TMS	Average temperature of a material (constant CAP(m4)).
TOPE	Initial temperature assigned to all nodes in any BLOCK 4 read in after BLOCK 1, and substituted for unspecified TT(N) in any BLOCK 9 read in after BLOCK 1.
TPIN(mc,mh)	Minimum temperature of all nodes at an axial level identified as belonging to a fuel pin.
TPINMAX(mc,mh)	Maximum temperature of TPIN (mc,mh) during transient.
TRAN(m5)	Thermal conductance between NOD1(m5) and NOD2(m5).
TRANS(m6)	Thermal conductance between NODS(m6) and NODSB(m6).
TREFF	Reference temperature used to compute a reference vapor pressure for bake-out fission product correlation (°F).

TRHO	Temperature associated with density value RHOTAB (°F).
TSAT	Saturation temperature (°F).
TSTMAV(mb,mc)	Average coolant temperature for each axial level in each flow region.
TT(m4)	Initial temperature of node NOTE(m4). Blank = TONE.
TTMELT(m2,m2)	Temperature at which MAT(m2) has latent heat HMELT(m2,m2).
TVARC(mj,m2)	Temperature or time at which MAT(m2) has CAPT(mg,m2).
TVARFL(mg,ma)	Temperature or time at which FLOWN(ma) is FLOWT(mg,ma).
TVARG(1,m8)	Half-life of heat generation in NODG(m8,) when LTAGB(mg,m8) is 0.
TVARH(mg,m6)	Temperature or time at which NODS(m6) has HSURT(mg,m8).
TVARK(mg,m2)	Temperature or time which MAT(m2) has CONT(mg,m2).
TVARY	Temperature accuracy control. Time steps adjusted to keep maximum temperature change near TVARY, and no more than 2.0*TVARY.
TVIS	Temperature associated with viscosity value VISTAB (°F).
USERH(mg,me)	User specified variable heat transfer coefficient for variable connections, (Btu/h-in. ² -°F).
USERT(mg,me)	User specified temperature (or time) at which corresponding USERH(mg,me) is used for variable heat transfer connections (°F).
UTHCON(mc)	Sum total thickness of consumed (oxidized) uranium at each axial level.
UTHIC(mc)	Sum total thickness of all uranium oxidation nodes at each axial level.
VISTAB	Coolant viscosity table values.
VO(mn)	Reference vapor pressure for each fission product used for bake-out fission product release correlation (mm Hg).
VOL(m4)	Volume of NODE(m4), based on input in BLOCKs 1 and 4, equals (GEOM*DWIDTH*DLONG*DRAD**KSYM)*SCALE**3.
VOLMS	Total volume of a material.
VOLS	Total volume of all nodes in system.

W(m4)	Sensible and latent heat content of NODE(m4).
WLEVEL	Dryout front elevation during coolant boiloff simulation (in.)
WMS	Total heat content of a material.
WT(mg,m2)	Sens. heat content of MAT(m2) at TVARC(mg,m2).
XA	Fraction of fuel-clad area debonded.
XH2(mb)	Partial pressure of hydrogen leaving each flow region.
XH2LEV(mb,mc)	Average hydrogen concentrations leaving each flow region at each axial level.
XINQ	Total heat input into system (sum of QZRINT + QFISON).
XINTER	Model starting axial position (e.g., lowest elevation in vertical models, etc.).
XINTERI	Initial dryout front position (boiloff simulations only).
XXXE	Xenon thermal conductivity (Btu/h-in.-°F).
XMDOX(mb)	Coolant mass flow rates in each flow region.
XOUTQ	Total model heat loss rate to external nodes.
XOUTQ	Sum of system heat losses (axial, radial, and miscellaneous conduction and convection).
XSPRNT	Special node output/graphics dump print interval (h).
ZDUM(mg)	Bundle axial positions, (distances from XINTER) used when specifying initial node axial temperature variation (BLOCK 9).
ZIP(m4)	Overall conductance for NODE(m4), equal to sum of conductances of all internal and external thermal connections to NODE(m4), and conductances of all mass flow connections leading into NODE(m4).
ZRLEFT(md)	Unoxidized metal remaining for each oxidizable node.
ZRNOXE(md)	Node index for oxidizable nodes.
ZRTHIC(mc)	Sum total thickness of all Zircaloy oxidation nodes at each axial level.
ZRTHIK(md)	Initial thickness available for oxidation for a node, input in inches, converted to meters.
ZTHCON(mc)	Sum total thickness of consumed (oxidized) Zircaloy at each axial level.

APPENDIX B

SAMPLE PROBLEM INPUT/OUTPUT FILES

APPENDIX B
SAMPLE PROBLEM INPUT/OUTPUT FILES

<u>FILE NAME</u>	<u>DESCRIPTION</u>	<u>PAGE</u>
IRSLBOD	Station blackout single process tube inlet half input deck	B.1
OUT.OD	Excerpts from OUTPUT file for simulation using IRSLBOD input deck	B.18
	Beginning of processed input (BLOCK 1)	B.18
	BLOCK 2--processed input	B.19
	Top portion BLOCK 4 processed input	B.21
	Top portion BLOCK 5 processed input	B.23
	Top of variable internal thermal connection portion of Block 5 processed input	B.24
	Top portion BLOCK 6 processed input	B.26
	BLOCK 7 processed input	B.27
	Top portion BLOCK 9 processed input	B.27
	Top portion BLOCK 10 processed input	B.29
	Initialization (kcyc = 0) time step	B.32
	Time step 1 (kcyc = 1)	B.34
	Final time step (kcyc = 1610)	B.36
	Top portion of final system summary	B.61
TAPE5.OD	Header to TAPE5 file from simulation using IRSLBOD input deck	B.62
TAPE11.OD	Header to TAPE11 file from simulation using IRSLBOD input deck	B.68
TAPE3.OF	TAPE3 file from simulation using IRSLBOF input deck	B.76

*ver2.17 trump bd full power spiked hot channel reflood station blackout (hygen.tpbdbnchmrk.sample)
 block 1 problem controls, limits and constants

1	9	-1	1	5	0	.0333333	1.0	0	2
1	9	1.e+12	1.e-12	5	0	.801667	.80	0	.6500
450.	5			.9892		40	0.01667	4	3 3
5001	10001	14001	18001	22001	30001	38001	44001		
46001	54001	5003	10003	14003	18003	22003	30003		
38003	44003	46003	54003	5306	10306	14306	18306		
22306	30306	38306	44306	46306	54306	5101	10101		
53003	57001	57003	53001	50001	50003	42001	42003		
001	003	306							
.083333	.277777	.80166							
prt1,prt2,prts,prtt,									

block 2 material properties

u-mtl	1	15	4	.683					3
	.0313	100.	.0313	1242.	.0313	1242.1	.0314	1242.5	
	.0390	1252.	.0390	1252.1	.0390	1420.	.0335	1420.1	
	.0335	1430.	.0335	1430.1	.0335	1994.	0.048	1994.1	
	0.048	2020.	.0480	2020.1	.0480	5000.			
	1.317	200.	1.458	600.	1.688	1000.	1.833	1400.	
	4.906	1247.	8.278	1425.	2.2861	2007.			
graph	2	5	0	.0614		1.712			
	.22	80.3	.32	260.3	.37	932.	.42	1500.	
	0.504	10000.0							
zr-cl	100	8	13	2.3737e-1					
	.067	81.	.072	261.	.079	693.	.090	1503.	
	.085	1787.	.085	3000.	.086	4000.	.087	5000.	
	6.2500e-1	261.	7.5417e-1	693.	1.0225	1503.	1.0392	1544.	
	1.0550	1580.	1.0708	1616.	1.1033	1688.	1.1208	1724.	
	1.1383	1760.	1.1525	1787.	2.0875	2800.	4.1856	4000.	
	5.9340	5000.							
steam	10	14	14	6.940e-4					
	200.	380.	14	0					
	.0385	380.0	.0505	600.0	.0724	1000.0	.1052	1600.0	
	.1271	2000.0	.1490	2400.0	.1599	2600.0	.1708	2800.0	
	.1818	3000.0	.1927	3200.0	.2037	3400.0	.2146	3600.0	
	.0215	4400.	.0293	5000.					
	.4372	380.0	.3270	600.0	.2321	800.0	.1630	1000.0	
	.1365	1200.0	.1174	1400.0	.1097	1600.0	.1030	2000.0	
	.0971	2400.0	.0918	3000.0	.0870	3400.0	.0827	3600.0	
	.0691	4400.	.0615	5000.					
	.6620	380.0	.520	600.0	.520	1000.0	.5750	1600.0	
	.6060	2000.0	.6500	2400.0	.6700	2600.0	.6900	2800.0	
	.7050	3000.0	.7250	3200.0	.7450	3400.0	.7600	3600.0	
	.8124	4400.	.8640	5000.					
	.0016	380.0	.0022	600.0	.0035	1000.0	.0057	1200.0	
	.0071	2000.0	.0083	2400.0	.0088	2600.0	.0092	2800.0	
	.0094	3000.0	.0096	3200.0	.0095	3400.0	.0093	3600.0	
	.0062	4400.	.0012	5000.					

block 4 node descriptors

		0.00	57	236.5	0	0	57	57
10.00	9.500	3.000	3.000	3.000	4.00	4.00	4.00	4.00
4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
6001	6 2000	1	1 1	.0954	1.0	4.0	.175	.037
6002	6 2000	1	2 1	.143	1.0	4.0	.175	.100
6003	6 2000	1	2 2	.236	1.0	4.0	.1585	.134
6004	6 2000	1	3 2	.276	1.0	4.0	.1585	.191

6301	6	2000	100	1	.00784	1.0	4.0	.02	.376
6302	6	2000	100	2	.02943	1.0	4.0	.03	1.005
6303	6	2000	100	2	.027	1.0	4.0	.02	1.336
6304	6	2000	100	3	.0471	1.0	4.0	.025	1.905
6305	6	2000	100		0.0	0.0	4.0	0.0	0.0
6311	6	2000	100		0.0	0.0	4.0	0.0	0.0
6310	6	2000	100		0.0	0.0	4.0	0.0	0.0
6309	6	2000	100		0.0	0.0	4.0	0.0	0.0
6308	6	2000	100		0.0	0.0	4.0	0.0	0.0
6306	6	2000	100	3	.6521	1.0	4.0	.27875	2.121
6307	6	2000	100		0.0	0.0	0.0		
6401	6	2000	10	1	.045	1.0	4.0		
6402	6	2000	10	2	.2469	1.0	4.0		
6403	6	2000	10	3	.2767	1.0	4.0		
6100	6	2000	2		0.0	0.0	0.0		
6101	6	2000	2		4.40e-1	2.973e+0	4.0		
6102	6	2000	2		1.02e+0	3.661e+0	4.0		
6103	6	2000	2		1.929	5.283e-1	4.0		
6110	6	2000	2		1.75e+0	.563	8.0		
6111	6	2000	2		1.75e+0	.563	8.0		
6112	6	2000	2		1.75e+0	.375	8.0		
6113	6	2000	2		1.25e+0	.375	8.0		
6114	6	2000	2		0.0	0.0	0.0		
6104	6	2000	2		0.0	0.0	0.0		
22001	8	4000	1	1 1	.0954	1.0	4.0	.175	.037
22002	8	4000	1	2 1	.143	1.0	4.0	.175	.100
22003	8	4000	1	2 2	.236	1.0	4.0	.1585	.134
22004	8	4000	1	3 2	.276	1.0	4.0	.1585	.191
22301	8	4000	100	1	.00784	1.0	4.0	.02	.376
22302	8	4000	100	2	.02943	1.0	4.0	.03	1.005
22303	8	4000	100	2	.027	1.0	4.0	.02	1.336
22304	8	4000	100	3	.0471	1.0	4.0	.025	1.905
22305	8	4000	100		0.0	0.0	4.0	0.0	0.0
22311	8	4000	100		0.0	0.0	4.0	0.0	0.0
22310	8	4000	100		0.0	0.0	4.0	0.0	0.0
22309	8	4000	100		0.0	0.0	4.0	0.0	0.0
22308	8	4000	100		0.0	0.0	4.0	0.0	0.0
22306	8	4000	100	3	.6521	1.0	4.0	.27875	2.121
22307	8	4000	100		0.0	0.0	0.0		
22401	8	4000	10	1	.045	1.0	4.0		
22402	8	4000	10	2	.2469	1.0	4.0		
22403	8	4000	10	3	.2767	1.0	4.0		
22100	8	4000	2		0.0	0.0	0.0		
22101	8	4000	2		4.40e-1	2.973e+0	4.0		
22102	8	4000	2		1.02e+0	3.661e+0	4.0		
22103	8	4000	2		1.929	5.283e-1	4.0		
22110	8	4000	2		1.75e+0	.563	8.0		
22111	8	4000	2		1.75e+0	.563	8.0		
22112	8	4000	2		1.75e+0	.375	8.0		
22113	8	4000	2		1.25e+0	.375	8.0		
22114	8	4000	2		0.0	0.0	0.0		
22104	8	4000	2		0.0	0.0	0.0		
7001	5	2000	1	1 1	.0954	1.0	4.0	.175	.037
7002	5	2000	1	2 1	.143	1.0	4.0	.175	.100
7003	5	2000	1	2 2	.236	1.0	4.0	.1585	.134
7004	5	2000	1	3 2	.276	1.0	4.0	.1585	.191
7301	5	2000	100	1	.00784	1.0	4.0	.02	.376
7302	5	2000	100	2	.02943	1.0	4.0	.03	1.005
7303	5	2000	100	2	.027	1.0	4.0	.02	1.336
7304	5	2000	100	3	.0471	1.0	4.0	.025	1.905
7305	5	2000	100		0.0	0.0	4.0	0.0	0.0
7311	5	2000	100		0.0	0.0	4.0	0.0	0.0
7310	5	2000	100		0.0	0.0	4.0	0.0	0.0
7309	5	2000	100		0.0	0.0	4.0	0.0	0.0
7308	5	2000	100		0.0	0.0	4.0	0.0	0.0
7306	5	2000	100	3	.6521	1.0	4.0	.27875	2.121

7307	5	2000	100			0.0	0.0	0.0		
7401	5	2000	10	1		.045	1.0	4.0		
7402	5	2000	10	2		.2469	1.0	4.0		
7403	5	2000	10	3		.2767	1.0	4.0		
7100	5	2000	2			0.0	0.0	0.0		
7101	5	2000	2			4.40e-1	2.973e+0	4.0		
7102	5	2000	2			1.02e+0	3.661e+0	4.0		
7103	5	2000	2			1.929	5.283e-1	4.0		
7110	5	2000	2			1.75e+0	.563	8.0		
7111	5	2000	2			1.75e+0	.563	8.0		
7112	5	2000	2			1.75e+0	.375	8.0		
7113	5	2000	2			1.25e+0	.375	8.0		
7104	5	2000	2			0.0	0.0	0.0		
7114	5	2000	2			0.0	0.0	0.0		
21001	9	4000	1	1	1	.0954	1.0	4.0	.175	.037
21002	9	4000	1	2	1	.143	1.0	4.0	.175	.100
21003	9	4000	1	2	2	.236	1.0	4.0	.1585	.134
21004	9	4000	1	3	2	.276	1.0	4.0	.1585	.191
21301	9	4000	100	1		.00784	1.0	4.0	.02	.376
21302	9	4000	100	2		.02943	1.0	4.0	.03	1.005
21303	9	4000	100	2		.027	1.0	4.0	.02	1.336
21304	9	4000	100	3		.0471	1.0	4.0	.025	1.905
21305	9	4000	100			0.0	0.0	4.0	0.0	0.0
21311	9	4000	100			0.0	0.0	4.0	0.0	0.0
21310	9	4000	100			0.0	0.0	4.0	0.0	0.0
21309	9	4000	100			0.0	0.0	4.0	0.0	0.0
21308	9	4000	100			0.0	0.0	4.0	0.0	0.0
21306	9	4000	100	3		.6521	1.0	4.0	.27875	2.121
21307	9	4000	100			0.0	0.0	0.0		
21401	9	4000	10	1		.045	1.0	4.0		
21402	9	4000	10	2		.2469	1.0	4.0		
21403	9	4000	10	3		.2767	1.0	4.0		
21100	9	4000	2			0.0	0.0	0.0		
21101	9	4000	2			4.40e-1	2.973e+0	4.0		
21102	9	4000	2			1.02e+0	3.661e+0	4.0		
21103	9	4000	2			1.929	5.283e-1	4.0		
21104	9	4000	2			0.0	0.0	0.0		
21110	9	4000	2			1.75e+0	.563	8.0		
21111	9	4000	2			1.75e+0	.563	8.0		
21112	9	4000	2			1.75e+0	.375	8.0		
21113	9	4000	2			1.25e+0	.375	8.0		
21114	9	4000	2			0.0	0.0	0.0		
19001	9	4000	1	1	1	.0954	1.0	4.0	.175	.037
19002	9	4000	1	2	1	.143	1.0	4.0	.175	.100
19003	9	4000	1	2	2	.236	1.0	4.0	.1585	.134
19004	9	4000	1	3	2	.276	1.0	4.0	.1585	.191
19301	9	4000	100	1		.00784	1.0	4.0	.02	.3765
19302	9	4000	100	2		.02943	1.0	4.0	.03	1.005
19303	9	4000	100	2		.027	1.0	4.0	.02	1.336
19304	9	4000	100	3		.0471	1.0	4.0	.025	1.905
19305	9	4000	100			0.0	0.0	4.0	0.0	0.0
19311	9	4000	100			0.0	0.0	4.0	0.0	0.0
19310	9	4000	100			0.0	0.0	4.0	0.0	0.0
19309	9	4000	100			0.0	0.0	4.0	0.0	0.0
19308	9	4000	100			0.0	0.0	4.0	0.0	0.0
19306	9	4000	100	3		.6521	1.0	4.0	.27875	2.121
19307	9	4000	100			0.0	0.0	0.0		
19401	9	4000	10	1		.045	1.0	4.0		
19402	9	4000	10	2		.2469	1.0	4.0		
19403	9	4000	10	3		.2767	1.0	4.0		
19100	9	4000	2			0.0	0.0	0.0		
19101	9	4000	2			4.40e-1	2.973e+0	4.0		
19102	9	4000	2			1.02e+0	3.661e+0	4.0		
19103	9	4000	2			1.929	5.283e-1	4.0		
19104	9	4000	2			0.0	0.0	0.0		
19120	9	4000	2			6.00e-1	.542	8.0		

19121	9	4000	2		8.750e-1	1.310	8.0		
19122	9	4000	2		1.75e+0	.625	8.0		
19123	9	4000	2		1.00e+0	.469	8.0		
19124	9	4000	2		0.0	0.0	0.0		
19125	9	4000	2		0.0	0.0	0.0		
19126	9	4000	100		0.0	0.0	8.0		
19127	9	4000	100	4	1.250e-2	2.896e-1	8.0	1.250e-2	2.847e-1
19128	9	4000	100	4	1.250e-2	2.798e-1	8.0	1.250e-2	2.749e-1
19129	9	4000	100		0.0	0.0	8.0		
19404	9	4000	10	4	.0962	1.0	8.0		
401	3	1	10		0.0	0.0	0.0		
20001	9	4000	1	1 1	.0954	1.0	4.0	.175	.037
20002	9	4000	1	2 1	.143	1.0	4.0	.175	.100
20003	9	4000	1	2 2	.236	1.0	4.0	.1585	.134
20004	9	4000	1	3 2	.276	1.0	4.0	.1585	.191
20301	9	4000	100	1	.00784	1.0	4.0	.02	.3765
20302	9	4000	100	2	.02943	1.0	4.0	.03	1.005
20303	9	4000	100	2	.027	1.0	4.0	.02	1.336
20304	9	4000	100	3	.0471	1.0	4.0	.025	1.905
20305	9	4000	100		0.0	0.0	4.0	0.0	0.0
20311	9	4000	100		0.0	0.0	4.0	0.0	0.0
20310	9	4000	100		0.0	0.0	4.0	0.0	0.0
20309	9	4000	100		0.0	0.0	4.0	0.0	0.0
20308	9	4000	100		0.0	0.0	4.0	0.0	0.0
20306	9	4000	100	3	.6521	1.0	4.0	.27875	2.121
20307	9	4000	100		0.0	0.0	0.0		
20401	9	4000	10	1	.045	1.0	4.0		
20402	9	4000	10	2	.2469	1.0	4.0		
20403	9	4000	10	3	.2767	1.0	4.0		
20100	9	4000	2		0.0	0.0	0.0		
20101	9	4000	2		4.40e-1	2.973e+0	4.0		
20102	9	4000	2		1.02e+0	3.661e+0	4.0		
20103	9	4000	2		1.929	5.283e-1	4.0		
20104	9	4000	2		0.0	0.0	0.0		
20120	9	4000	2		6.00e-1	.542	8.0		
20121	9	4000	2		8.750e-1	1.310	8.0		
20122	9	4000	2		1.75e+0	.625	8.0		
20123	9	4000	2		1.00e+0	.469	8.0		
20124	9	4000	2		0.0	0.0	0.0		
20125	9	4000	2		0.0	0.0	0.0		
20126	9	4000	100		0.0	0.0	8.0		
20127	9	4000	100	4	1.250e-2	2.896e-1	8.0	1.250e-2	2.847e-1
20128	9	4000	100	4	1.250e-2	2.798e-1	8.0	1.250e-2	2.749e-1
20129	9	4000	100		0.0	0.0	8.0		
20404	9	4000	10	4	.0962	1.0	8.0		
5108	0	0	2		2.30	1.50	0.0		
5118	0	0	2		1.70	1.50	0.0		
5128	0	0	2		1.70	3.00	0.0		
2108	0	0	2		2.30	1.50	0.0		
2118	0	0	2		1.70	1.50	0.0		
2128	0	0	2		1.70	3.00	0.0		
4108	0	0	2		2.30	5.50	0.0		
4118	0	0	2		3.00	5.50	0.0		
5001	0	0	1	1 1	.0954	1.0	3.0	.175	.037
5002	0	0	1	2 1	.143	1.0	3.0	.175	.100
5003	0	0	1	2 2	.236	1.0	3.0	.1585	.134
5004	0	0	1	3 2	.276	1.0	3.0	.1585	.191
5301	0	0	100	1	.00784	1.0	3.0	.02	.376
5302	0	0	100	2	.02943	1.0	3.0	.03	1.005
5303	0	0	100	2	.027	1.0	3.0	.02	1.336
5304	0	0	100	3	.0471	1.0	3.0	.025	1.905
5305	0	0	100		0.0	0.0	3.0	0.0	0.0
5308	0	0	100		0.0	0.0	3.0	0.0	0.0
5311	0	0	100		0.0	0.0	3.0	0.0	0.0
5310	0	0	100		0.0	0.0	3.0	0.0	0.0
5309	0	0	100		0.0	0.0	3.0	0.0	0.0

5306	0	0	100	3	.6521	1.0	3.0	.27875	2.121
5307	0	0	100		0.0	0.0	0.0		
5401	0	0	10	1	.045	1.0	3.0		
5402	0	0	10	2	.2469	1.0	3.0		
5403	0	0	10	3	.2767	1.0	3.0		
5100	0	0	2		0.0	0.0	0.0		
5101	0	0	2		4.40e-1	2.973e+0	3.0		
5102	0	0	2		1.02e+0	3.661e+0	3.0		
5103	0	0	2		1.929	5.283e-1	3.0		
5110	0	0	2		1.75e+0	.563	8.0		
5111	0	0	2		1.75e+0	.563	8.0		
5112	0	0	2		1.75e+0	.375	8.0		
5113	0	0	2		1.25e+0	.375	8.0		
4402	0	0	10	2	.2469	1.0	3.0		
4401	0	0	10	1	.045	1.0	3.0		
4305	0	0	100		0.0	0.0	3.00		
4306	0	0	100	3	0.6521	1.0	3.00	0.27875	2.121
4307	0	0	100		0.0	0.0	3.00		
4100	0	0	2		0.0	0.0	3.00		
4101	0	0	2		1.308	1.0	3.00		
4102	0	0	2		2.616	1.0	3.00		
4103	0	0	2		0.224	1.0	3.00		
4104	0	0	2		0.375	1.0	3.00		
4105	0	0	2		0.202	1.0	3.00		
4403	0	0	10	3	.2767	1.0	3.0		
3403	0	0	10	3	.2767	1.0	3.0		
3402	0	0	10	2	.2469	1.0	3.0		
3401	0	0	10	1	.045	1.0	3.0		
3305	0	0	100		0.0	0.0	3.00		
3306	0	0	100	3	0.6521	1.0	3.00	0.27875	2.121
3307	0	0	100		0.0	0.0	3.00		
3100	0	0	2		0.0	0.0	3.00		
3101	0	0	2		1.308	1.0	3.00		
3102	0	0	2		2.616	1.0	3.00		
3103	0	0	2		0.224	1.0	3.00		
3104	0	0	2		0.375	1.0	3.00		
3105	0	0	2		0.202	1.0	3.00		
2403	0	0	10	3	.2767	1.0	9.5		
2402	0	0	10	2	.2469	1.0	9.5		
2401	0	0	10	1	.045	1.0	9.5		
2305	0	0	100		0.0	0.0	9.5		
2306	0	0	100	3	0.6521	1.0	9.5	0.27875	2.121
2307	0	0	100		0.0	0.0	9.5		
2100	0	0	2		0.0	0.0	9.5		
2101	0	0	2		2.210	1.0	9.5		
2102	0	0	2		0.516	1.0	9.5		
2103	0	0	2		1.350	1.0	9.5		
2104	0	0	2		2.145	1.0	9.5		
2105	0	0	2		2.505	1.0	10.0		
2106	0	0	2		1.515	1.0	10.0		
2107	0	0	2		3.495	1.0	10.0		
1401	0	0	10	1	.045	1.0	10.0		
1403	0	0	10	3	.2767	1.0	10.0		
1402	0	0	10	2	.2469	1.0	10.0		
1305	0	0	100		0.0	0.0	10.0		
1306	0	0	100	3	0.6521	1.0	10.0	0.27875	2.121
1307	0	0	100		0.0	0.0	10.0		
1100	0	0	2		0.0	0.0	10.0		
1101	0	0	2		2.448	1.0	10.0		
1102	0	0	2		0.0	0.0	10.0		
1103	0	0	2		0.0	0.0	10.0		
1104	0	0	2		0.406	1.0	10.0		
1105	0	0	2		1.222	1.0	10.0		
1106	0	0	2		2.145	1.0	10.0		
1107	0	0	2		2.505	1.0	10.0		
1108	0	0	2		1.515	1.0	10.0		

-4
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-4
-4
25

7301	70010	5	2	23	.01	.0875	.408	4.0	694.4	
7001	7002	5	2	23	.0875	.0875	.683	4.0		
7002	73020	5	2	23	.0875	.015	.957	4.0	694.4	
7303	70030	5	2	23	.01	.07925	1.367	4.0	694.4	
7003	7004	5	2	23	.07925	.07925	1.616	4.0		
7004	73040	5	2	23	.07925	.0125	1.865	4.0	694.4	
7308	7301	5	2	23	0.0	.01	.376	4.0		
7308	74015	5	2	23	0.0	0.0	.376	4.0	1.e-12	-4
	1.e-12				1.e-12	.220	.583	.222	.583	10.
7309	7302	5	2	23	0.0	.015	1.005	4.0		
7309	74025	5	2	23	0.0	0.0	1.005	4.0	1.e-12	-4
	1.e-12				1.e-12	.220	.497	.222	.497	10.
7310	7303	5	2	23	0.0	.010	1.336	4.0		
7310	74025	5	2	23	0.0	0.0	1.336	4.0	1.e-12	-4
	1.e-12				1.e-12	.220	.497	.222	.497	10.
7311	7304	5	2	23	.125	1.905	4.0			
7311	74035	5	2	23	0.0	0.0	1.905	4.0	1.e-12	-4
	1.e-12				1.e-12	.220	.408	.222	.408	10.
7305	74035	5	2	23	0.0	0.0	2.121	4.0	1.e-12	-4
	1.e-12				1.e-12	.220	.408	.222	.408	10.
7305	7306	5	2	23	0.0	.139375	2.121	4.0		
7306	7307	5	2	23	.139375	0.	2.5584	4.0		
7307	71005	5	2	23	0.	0.	2.5584	4.0	.5738	25
	0.1650	80.6			0.1717	116.6	0.1782	152.6	0.1847	188.6
	0.1912	224.6			0.1976	260.6	0.2107	332.6	0.2252	404.6
	0.2400	476.6			0.2565	548.6	0.2719	620.6	0.2906	710.6
	0.3060	800.6			0.3214	890.6	0.3380	980.6	0.3688	1160.6
	0.3996	1340.6			0.4282	1520.6	0.4579	1700.6	0.5163	2060.6
	0.5735	2420.6			0.6275	2780.6	0.7089	3320.6	0.8135	4040.6
	0.9368	4940.6								
7100	7101	5	2	23	0.	3.77e-1	2.63	4.0		
7101	7102	5	2	23	3.77e-1	9.133e-1	3.318	4.0		
7102	7103	5	2	23	8.88e-1	6.17e-1	2.442	4.0		
7102	7110	5	2	23	4.30e-1	1.51e+0	.563	8.0	3.47e+0	
7103	7111	5	2	23	8.07e-1	1.56e+0	.563	8.0	3.47e+0	
7103	7113	5	2	23	6.45e-1	0.531	.469	8.0	5.0e-1	
7110	7111	5	2	23	0.75e+0	0.75e+0	.656	8.0		
7111	7112	5	2	23	0.75e+0	0.5e+0	.656	8.0		
7112	7113	5	2	23	1.51e+0	1.08e+0	.375	8.0		
7102	7104	5	2	23	0.430	0.0	1.50	1.00		
7103	7104	5	2	23	0.870	0.0	2.50	1.00		
7110	7114	5	2	23	2.580	0.0	1.75	1.50		
7111	7114	5	2	23	2.580	0.0	1.75	1.50		
7112	7114	5	2	23	2.580	0.0	1.75	1.00		
7301	8301	5	2	23	1.5	1.5	7.840e-3	1.0		
7302	8302	5	2	23	1.5	1.5	2.943e-2	1.0		
7303	8303	5	2	23	1.5	1.5	2.703e-2	1.0		
7304	8304	5	2	23	1.5	1.5	4.712e-2	1.0		
7306	8306	5	2	23	1.5	1.5	6.521e-1	1.0		
7001	8001	5	2	23	1.5	1.5	9.539e-2	1.0		
7002	8002	5	2	23	1.5	1.5	1.435e-1	1.0		
7003	8003	5	2	23	1.5	1.5	2.365e-1	1.0		
7004	8004	5	2	23	1.5	1.5	2.759e-1	1.0		
7101	8101	5	2	23	1.5	1.5	1.308e+0	1.0		
7102	8102	5	2	23	1.5	1.5	3.734e+0	1.0		
7103	8103	5	2	23	1.5	1.5	1.011e+0	1.0		
7110	8110	5	2	23	2.58	2.58	1.75	1.50		
7111	8111	5	2	23	2.58	2.58	1.75	1.50		
7112	8112	5	2	23	2.58	2.58	1.75	1.00		
7113	8113	5	2	23	2.58	2.58	1.25	1.00		
22301220010	8	4	43		.01	.0875	.408	4.0	694.4	
2200122002	8	4	43		.0875	.0875	.683	4.0		
22002223020	8	4	43		.0875	.015	.957	4.0	694.4	
22303220030	8	4	43		.01	.07925	1.367	4.0	694.4	
2200322004	8	4	43		.07925	.07925	1.616	4.0		
22004223040	8	4	43		.07925	.0125	1.865	4.0	694.4	

2230822301	8	4	43	0.0	.01	.376	4.0				
22308224015	8	4	43	0.0	0.0	.376	4.0	1.e-12			-4
1.e-12				0.	1.e-12	.220	.583	.222	.583	10.	
2230922302	8	4	43	0.0	.015	1.005	4.0				
22309224025	8	4	43	0.0	0.0	1.005	4.0	1.e-12			-4
1.e-12				0.	1.e-12	.220	.497	.222	.497	10.	
2231022303	8	4	43	0.0	.010	1.336	4.0				
22310224025	8	4	43	0.0	0.0	1.336	4.0	1.e-12			-4
1.e-12				0.	1.e-12	.220	.497	.222	.497	10.	
2231122304	8	4	43	0.0	.125	1.905	4.0				
22311224035	8	4	43	0.0	0.0	1.905	4.0	1.e-12			-4
1.e-12				0.	1.e-12	.220	.408	.222	.408	10.	
22305224035	8	4	43	0.0	0.0	2.121	4.0	1.e-12			-4
1.e-12				0.	1.e-12	.220	.408	.222	.408	10.	
2230522306	8	4	43	0.0	.139375	2.121	4.0				
2230622307	8	4	43	.139375	0.	2.5584	4.0				
22307221005	8	4	43	0.	0.	2.5584	4.0			.5738	25
0.1650		80.6	0.1717	116.6	0.1782	152.6	0.1847	188.6			
0.1912		224.6	0.1976	260.6	0.2107	332.6	0.2252	404.6			
0.2400		476.6	0.2565	548.6	0.2719	620.6	0.2906	710.6			
0.3060		880.6	0.3214	890.6	0.3380	980.6	0.3688	1160.6			
0.3996		1340.6	0.4282	1520.6	0.4579	1700.6	0.5163	2060.6			
0.5735		2420.6	0.6275	2780.6	0.7089	3320.6	0.8135	4040.6			
0.9368		4940.6									
2210022101	8	4	43	0.	3.77e-1	2.63	4.0				
2210122102	8	4	43	3.77e-1	9.133e-1	3.318	4.0				
2210222103	8	4	43	8.88e-1	6.17e-1	2.442	4.0				
2210222110	8	4	43	4.30e-1	1.51e+0	.563	8.0	3.47e+0			
2210322111	8	4	43	8.07e-1	1.56e+0	.563	8.0	3.47e+0			
2210322113	8	4	43	6.45e-1	0.531	.469	8.0	5.0e-1			
2211022111	8	4	43	0.75e+0	0.75e+0	.656	8.0				
2211122112	8	4	43	0.75e+0	0.5e+0	.656	8.0				
2211222113	8	4	43	1.51e+0	1.08e+0	.375	8.0				
2210222104	8	4	43	0.430	0.0	1.50	1.00				
2210322104	8	4	43	0.470	0.0	2.50	1.00				
2211022114	8	4	43	2.580	0.0	1.75	1.50				
2211122114	8	4	43	2.580	0.0	1.75	1.50				
2211222114	8	4	43	2.580	0.0	1.75	1.00				
1810419104	9	4	43	0.0	0.0	4.00	1.00			0.0820	
1810419124	9	4	43	0.0	0.0	4.00	1.00			0.2359	
1810418114	9	4	43	0.0	0.0	4.00	1.00			0.2986	
1910419124	9	4	43	0.0	0.0	4.00	1.00			0.2986	
1811419104	9	4	43	0.0	0.0	4.00	1.75			0.1349	
1811419124	9	4	43	0.0	0.0	4.00	1.75			0.2683	
1830119301	9	4	43	2.5	2.5	7.840e-3	1.0				
1830219302	9	4	43	2.5	2.5	2.943e-2	1.0				
1830319303	9	4	43	2.5	2.5	2.703e-2	1.0				
1830419304	9	4	43	2.5	2.5	4.712e-2	1.0				
1830619306	9	4	43	2.5	2.5	6.521e-1	1.0				
1800119001	9	4	43	2.5	2.5	9.539e-2	1.0				
1800219002	9	4	43	2.5	2.5	1.435e-1	1.0				
1800319003	9	4	43	2.5	2.5	2.365e-1	1.0				
1800419004	9	4	43	2.5	2.5	2.759e-1	1.0				
1810119101	9	4	43	2.5	2.5	1.308e+0	1.0				
1810219102	9	4	43	2.5	2.5	3.734e+0	1.0				
1810319103	9	4	43	2.5	2.5	1.011e+0	1.0				
21301210010	9	4	43	.01	.0875	.408	4.0		694.4		
2100121002	9	4	43	.0875	.0875	.683	4.0				
21002213020	9	4	43	.0875	.015	.957	4.0		694.4		
21303210030	9	4	43	.01	.07925	1.367	4.0		694.4		
2100321004	9	4	43	.07925	.07925	1.616	4.0				
21004213040	9	4	43	.07925	.0125	1.865	4.0		694.4		
2130821301	9	4	43	0.0	.01	.376	4.0				
21308214015	9	4	43	0.0	0.0	.376	4.0	1.e-12			-4
1.e-12				0.	1.e-12	.220	.583	.222	.583	10.	
2130921302	9	4	43	0.0	.015	1.005	4.0				

21309214025	9	4	43	0.0	0.0	1.005	4.0	1.e-12		-4
1.e-12			0	1.e-12	.220	.497	.222	.497	10.	
2131021303	9	4	43	0.0	.010	1.336	4.0			
21310214025	9	4	43	0.0	0.0	1.336	4.0	1.e-12		-4
1.e-12			0	1.e-12	.220	.497	.222	.497	10.	
2131121304	9	4	43	0.0	.125	1.905	4.0			
21311214035	9	4	43	0.0	0.0	1.905	4.0	1.e-12		-4
1.e-12			0	1.e-12	.220	.408	.222	.408	10.	
21305214035	9	4	43	0.0	0.0	2.121	4.0	1.e-12		-4
1.e-12			0	1.e-12	.220	.408	.222	.408	10.	
2130521306	9	4	43	0.0	.139375	2.121	4.0			
2130621307	9	4	43	.139375	0.	2.5584	4.0			
21307211005	9	4	43	0.	0.	2.5584	4.0			
0.1650	80.6	0.1717	116.6	0.1782	152.6	0.1847	188.6			
0.1912	224.6	0.1976	260.6	0.2107	332.6	0.2252	404.6			
0.2400	476.6	0.2565	548.6	0.2719	620.6	0.2906	710.6			
0.3060	800.6	0.3214	890.6	0.3380	980.6	0.3688	1160.6			
0.3996	1340.6	0.4282	1520.6	0.4579	1700.6	0.5163	2060.6			
0.5735	2420.6	0.6275	2780.6	0.7089	3320.6	0.8135	4040.6			
0.9368	4940.6									
2110021101	9	4	43	0.	3.77e-1	2.63	4.0			
2110121102	9	4	43	3.77e-1	9.133e-1	3.318	4.0			
2110221103	9	4	43	8.88e-1	6.17e-1	2.442	4.0			
2110221110	9	4	43	4.30e-1	1.51e+0	.563	8.0	3.47e+0		
2110321111	9	4	43	8.07e-1	1.56e+0	.563	8.0	3.47e+0		
2110321113	9	4	43	6.45e-1	0.531	.469	8.0	5.0e-1		
2111021111	9	4	43	0.75e+0	0.75e+0	.656	8.0			
2111121112	9	4	43	0.75e+0	0.5e+0	.656	8.0			
2111221113	9	4	43	1.51e+0	1.08e+0	.375	8.0			
2110221104	9	4	43	0.430	0.0	1.50	1.00			
2110321104	9	4	43	0.870	0.0	2.50	1.00			
2111021114	9	4	43	2.580	0.0	1.75	1.50			
2111121114	9	4	43	2.580	0.0	1.75	1.50			
2111221114	9	4	43	2.580	0.0	1.75	1.00			
2130122301	8	4	43	1.5	1.5	7.840e-3	1.0			
2130222302	8	4	43	1.5	1.5	2.943e-2	1.0			
2130322303	8	4	43	1.5	1.5	2.703e-2	1.0			
2130422304	8	4	43	1.5	1.5	4.712e-2	1.0			
2130622306	8	4	43	1.5	1.5	6.521e-1	1.0			
2100122001	8	4	43	1.5	1.5	9.539e-2	1.0			
2100222002	8	4	43	1.5	1.5	1.435e-1	1.0			
2100322003	8	4	43	1.5	1.5	2.365e-1	1.0			
2100422004	8	4	43	1.5	1.5	2.759e-1	1.0			
2110122101	8	4	43	1.5	1.5	1.308e+0	1.0			
2110222102	8	4	43	1.5	1.5	3.734e+0	1.0			
2110322103	8	4	43	1.5	1.5	1.011e+0	1.0			
2111022110	8	4	43	2.58	2.58	1.75	1.50			
2111122111	8	4	43	2.58	2.58	1.75	1.50			
2111222112	8	4	43	2.58	2.58	1.75	1.00			
2111322113	8	4	43	2.58	2.58	1.25	1.00			
19301190010	9	4	43	.01	.0875	.408	4.0	694.4		
1900119002	9	4	43	.0875	.0875	.683	4.0			
19002193020	9	4	43	.0875	.015	.957	4.0	694.4		
19303190030	9	4	43	.01	.07925	1.367	4.0	694.4		
1900319004	9	4	43	.07925	.07925	1.616	4.0			
19004193040	9	4	43	.07925	.0125	1.865	4.0	694.4		
1930819301	9	4	43	0.0	.01	.376	4.0			
19308194015	9	4	43	0.0	0.0	.376	4.0	1.e-12		-4
1.e-12	0.	1.e-12	.220	.583	.222	.583	10.			
1930919302	9	4	43	0.0	.015	1.005	4.0			
19309194025	9	4	43	0.0	0.0	1.005	4.0	1.e-12		-4
1.e-12	0.	1.e-12	.220	.497	.222	.497	10.			
1931019303	9	4	43	0.0	.010	1.336	4.0			
19310194025	9	4	43	0.0	0.0	1.336	4.0	1.e-12		-4
1.e-12	0.	1.e-12	.220	.497	.222	.497	10.			
1931119304	9	4	43	.125	1.905	4.0				

19311194035	9	4	43	0.0	0.0	1.905	4.0	1.e-12		-4
1.e-12				0.	1.e-12	.220	.408	.222	.408	10.
19305194035	9	4	43	0.0	0.0	2.121	4.0	1.e-12		-4
1.e-12				0.	1.e-12	.220	.408	.222	.408	10.
1930519306	9	4	43	0.0	.139375	2.121	4.0			
1930619307	9	4	43	.139375	0.	2.5584	4.0			
19307191005	9	4	43	0.	0.	2.5584	4.0		.5738	25
0.1650		80.6		0.1717	116.6	0.1782	152.6	0.1847	188.6	
0.1912		224.6		0.1976	260.6	0.2107	332.6	0.2252	404.6	
0.2400		476.6		0.2565	548.6	0.2719	620.6	0.2906	710.6	
0.3060		800.6		0.3214	890.6	0.3380	980.6	0.3688	1160.6	
0.3996		1340.6		0.4282	1520.6	0.4579	1700.6	0.5163	2060.6	
0.5735		2420.6		0.6275	2780.6	0.7089	3320.6	0.8135	4040.6	
0.9368		4940.6								
1910019101	9	4	43	0.	3.77e-1	2.63	4.0			
1910119102	9	4	43	3.77e-1	9.133e-1	3.318	4.0			
1910219103	9	4	43	8.88e-1	6.17e-1	2.442	4.0			
1910219104	9	4	43	4.30e-1	0.	1.50	1.0			
1910319104	9	4	43	8.07e-1	0.	2.50	1.0			
1912519120	9	4	43	0.	5.16e-1	.306	8.0			
1912019121	9	4	43	5.16e-1	8.60e-1	.778	8.0			
1912119122	9	4	43	1.18e+0	1.08e+0	.875	8.0			
1912219123	9	4	43	1.51e+0	1.08e+0	.156	8.0			
1912219124	9	4	43	1.08e+0	0.0	.875	8.0			
1912119123	9	4	43	1.18e+0	1.08e+0	.219	8.0			
1910219121	9	4	43	4.58e-1	1.18e+0	.328	8.0	3.47e+0		
1910219122	9	4	43	4.58e-1	1.51e+0	.234	8.0	3.47e+0		
1910319121	9	4	43	7.79e-1	1.18e+0	.328	8.0	3.47e+0		
1910319122	9	4	43	7.79e-1	1.51e+0	.234	8.0	3.47e+0		
1910319123	9	4	43	6.45e-1	5.31e-1	.469	8.0	5.0e-1		
19125191265	9	4	43	0.0	0.0	3.00e-1	8.0		0.601	25
0.5157		80.6		0.5367	116.6	0.5570	152.6	0.5772	188.6	
0.5975		224.6		0.6175	260.6	0.6584	332.6	0.7038	404.6	
0.7499		476.6		0.8015	548.6	0.8497	620.6	0.9082	710.6	
0.9563		880.6		1.0045	890.6	1.0561	980.6	1.1524	1160.6	
1.2488		1340.6		1.3382	1520.6	1.4311	1700.6	1.6134	2060.6	
1.7923		2420.6		1.9609	2780.6	2.2154	3320.6	2.5422	4040.6	
2.9275		4940.6								
1912619127	9	4	43	0.0	6.250e-3	2.945e-1	8.0			
1912719128	9	4	43	6.250e-3	6.250e-3	2.847e-1	8.0			
1912819129	9	4	43	6.250e-3	0.0	2.749e-1	8.0			
1930120301	9	4	43	1.5	1.5	7.840e-3	1.0			
1930220302	9	4	43	1.5	1.5	2.943e-2	1.0			
1930320303	9	4	43	1.5	1.5	2.703e-2	1.0			
1930420304	9	4	43	1.5	1.5	4.712e-2	1.0			
1930620306	9	4	43	1.5	1.5	6.521e-1	1.0			
1900120001	9	4	43	1.5	1.5	9.539e-2	1.0			
1900220002	9	4	43	1.5	1.5	1.435e-1	1.0			
1900320003	9	4	43	1.5	1.5	2.365e-1	1.0			
1900420004	9	4	43	1.5	1.5	2.759e-1	1.0			
1910120101	9	4	43	1.5	1.5	1.308e+0	1.0			
1910220102	9	4	43	1.5	1.5	3.734e+0	1.0			
1910320103	9	4	43	1.5	1.5	1.011e+0	1.0			
1912020120	9	4	43	.8170	.8170	.6000	4.000			
1912120121	9	4	43	2.064	2.064	.7600	4.000			
1912320123	9	4	43	2.580	2.580	1.250	1.000			
20301200010	9	4	43	.01	.0875	.408	4.0	694.4		
2000120002	9	4	43	.0875	.0875	.683	4.0			
20002203020	9	4	43	.0875	.015	.957	4.0	694.4		
20303200030	9	4	43	.01	.07925	1.367	4.0	694.4		
2000320004	9	4	43	.07925	.07925	1.616	4.0			
20004203040	9	4	43	.07925	.0125	1.865	4.0	694.4		
2030820301	9	4	43	0.0	.01	.376	4.0			
20308204015	9	4	43	0.0	0.0	.376	4.0	1.e-12		-4
1.e-12		0.		1.e-12	.220	.583	.222	.583	10.	
2030920302	9	4	43	0.0	.015	1.005	4.0			

20309204025	9	4	43	0.0	0.0	1.005	4.0	1.e-12		-4
1.e-12				0.	.220	.497	.222	.497	10.	
2031020303	9	4	43	0.0	.010	1.336	4.0			-4
20310204025	9	4	43	0.0	0.0	1.336	4.0	1.e-12		
1.e-12				0.	1.e-12	.220	.497	.222	.497	10.
2031120304	9	4	43		.125	1.905	4.0			-4
20311204035	9	4	43	0.0	0.0	1.905	4.0	1.e-12		
1.e-12				0.	1.e-12	.220	.408	.222	.408	10.
20305204035	9	4	43	0.0	0.0	2.121	4.0	1.e-12		-4
1.e-12				0.	1.e-12	.220	.408	.222	.408	10.
2030520306	9	4	43	0.0	.139375	2.121	4.0			
2030620307	9	4	43	.139375	0.	2.5584	4.0			
20307201005	9	4	43	0.	0.	2.5584	4.0			25
0.1650				80.6	0.1717	116.6	0.1782	152.6	0.1847	.5738
0.1912				224.6	0.1976	260.6	0.2107	332.6	0.2252	188.6
0.2400				476.6	0.2565	548.6	0.2719	620.6	0.2906	404.6
0.3060				800.6	0.3214	890.6	0.3380	980.6	0.3688	710.6
0.3996				1340.6	0.4282	1520.6	0.4579	1700.6	0.5163	1160.6
0.5735				2420.6	0.6275	2780.6	0.7089	3320.6	0.8135	2060.6
0.9368				4940.6						4040.6
2010020101	9	4	43	0.	3.77e-1	2.63	4.0			
2010120102	9	4	43	3.77e-1	9.133e-1	3.318	4.0			
2010220103	9	4	43	8.88e-1	6.17e-1	2.442	4.0			
2010220104	9	4	43	4.30e-1	0.	1.50	1.0			
2010320104	9	4	43	8.07e-1	0.	2.50	1.0			
2012520120	9	4	43	0.	5.16e-1	.306	8.0			
2012020121	9	4	43	5.16e-1	8.60e-1	.778	8.0			
2012120122	9	4	43	1.18e+0	1.08e+0	.875	8.0			
2012220123	9	4	43	1.51e+0	1.08e+0	.156	8.0			
2012220124	9	4	43	1.08e+0	0.0	.875	8.0			
2012120123	9	4	43	1.18e+0	1.08e+0	.219	8.0			
2010220121	9	4	43	4.58e-1	1.18e+0	.328	8.0	3.47e+0		
2010220122	9	4	43	4.58e-1	1.51e+0	.234	8.0	3.47e+0		
2010320121	9	4	43	7.79e-1	1.18e+0	.328	8.0	3.47e+0		
2010320122	9	4	43	7.79e-1	1.51e+0	.234	8.0	3.47e+0		
2010320123	9	4	43	6.45e-1	5.31e-1	.469	8.0	5.0e-1		
20125201265	9	4	43	0.0	0.0	3.00e-1	8.0		0.601	25
0.5157				80.6	0.5367	116.6	0.5570	152.6	0.5772	188.6
0.5975				224.6	0.6175	260.6	0.6584	332.6	0.7038	404.6
0.7499				476.6	0.8015	548.6	0.8497	620.6	0.9082	710.6
0.9563				800.6	1.0045	890.6	1.0561	980.6	1.1524	1160.6
1.2488				1340.6	1.3382	1520.6	1.4311	1700.6	1.6134	2060.6
1.7923				2420.6	1.9609	2780.6	2.2154	3320.6	2.5422	4040.6
2.9275				4940.6						
2012620127	9	4	43	0.0	6.250e-3	2.945e-1	8.0			
2012720128	9	4	43	6.250e-3	6.250e-3	2.847e-1	8.0			
2012820129	9	4	43	6.250e-3	0.0	2.749e-1	8.0			
2010421104	9	4	43	0.0	0.0	4.00	1.00		0.0820	
2010421114	9	4	43	0.0	0.0	4.00	1.00		0.2359	
2010420124	9	4	43	0.0	0.0	4.00	1.00		0.2986	
2110421114	9	4	43	0.0	0.0	4.00	1.00		0.2986	
2012421104	9	4	43	0.0	0.0	4.00	1.75		0.1349	
2012421114	9	4	43	0.0	0.0	4.00	1.75		0.2683	
2030121301	9	4	43	2.5	2.5	7.840e-3	1.0			
2030221302	9	4	43	2.5	2.5	2.943e-2	1.0			
2030321303	9	4	43	2.5	2.5	2.703e-2	1.0			
2030421304	9	4	43	2.5	2.5	4.712e-2	1.0			
2030621306	9	4	43	2.5	2.5	6.521e-1	1.0			
2000121001	9	4	43	2.5	2.5	9.539e-2	1.0			
2000221002	9	4	43	2.5	2.5	1.435e-1	1.0			
2000321003	9	4	43	2.5	2.5	2.365e-1	1.0			
2000421004	9	4	43	2.5	2.5	2.759e-1	1.0			
2010121101	9	4	43	2.5	2.5	1.308e+0	1.0			
2010221102	9	4	43	2.5	2.5	3.734e+0	1.0			
2010321103	9	4	43	2.5	2.5	1.011e+0	1.0			
5108 5118	0	0	00	0.0	0.0	3.45	1.0	0.02701		

5108	5128	0	0	00	0.0	0.0	3.45	1.0	0.03232
5108	2108	0	0	00	0.0	0.0	3.45	1.0	0.06099
5108	2118	0	0	00	0.0	0.0	3.45	1.0	0.03667
5108	2128	0	0	00	0.0	0.0	3.45	1.0	0.05283
5108	4108	0	0	00	0.0	0.0	3.45	1.0	0.32735
5108	4118	0	0	00	0.0	0.0	3.45	1.0	0.11778
5118	5128	0	0	00	0.0	0.0	2.55	1.0	0.04971
5118	2108	0	0	00	0.0	0.0	2.55	1.0	0.04962
5118	2118	0	0	00	0.0	0.0	2.55	1.0	0.04236
5118	2128	0	0	00	0.0	0.0	2.55	1.0	0.06777
5118	4108	0	0	00	0.0	0.0	2.55	1.0	0.19575
5118	4118	0	0	00	0.0	0.0	2.55	1.0	0.22923
5128	2108	0	0	00	0.0	0.0	5.10	1.0	0.03575
5128	2118	0	0	00	0.0	0.0	5.10	1.0	0.03386
5128	2128	0	0	00	0.0	0.0	5.10	1.0	0.07998
5128	4108	0	0	00	0.0	0.0	5.10	1.0	0.09265
5128	4118	0	0	00	0.0	0.0	5.10	1.0	0.35417
2108	2118	0	0	00	0.0	0.0	3.45	1.0	0.02701
2108	2128	0	0	00	0.0	0.0	3.45	1.0	0.03232
2108	4108	0	0	00	0.0	0.0	3.45	1.0	0.32735
2108	4118	0	0	00	0.0	0.0	3.45	1.0	0.11778
2118	2128	0	0	00	0.0	0.0	2.55	1.0	0.04971
2118	4108	0	0	00	0.0	0.0	2.55	1.0	0.19575
2118	4118	0	0	00	0.0	0.0	2.55	1.0	0.22923
2128	4108	0	0	00	0.0	0.0	5.10	1.0	0.09265
2128	4118	0	0	00	0.0	0.0	5.10	1.0	0.35417
4108	4118	0	0	00	0.0	0.0	12.65	1.0	0.13163
5110	5108	0	0	00	2.58	0.0	2.25	1.0	
5111	5108	0	0	00	2.58	0.0	1.20	1.0	
5111	5118	0	0	00	2.58	0.0	1.05	1.0	
5112	5118	0	0	00	2.58	0.0	1.50	1.0	
5111	5128	0	0	00	2.58	0.0	0.175	1.0	
5112	5128	0	0	00	2.58	0.0	0.250	1.0	
5103	5128	0	0	00	1.5	0.0	0.789	1.0	
5102	5128	0	0	00	1.5	0.0	1.136	1.0	
5113	5128	0	0	00	2.58	0.0	1.250	1.0	
4104	4108	0	0	00	0.215	0.0	1.50	3.0	
4105	4108	0	0	00	0.215	0.0	0.808	3.0	
4105	4118	0	0	00	0.694	0.0	0.25	3.0	
4103	4118	0	0	00	0.0	0.0	0.632	3.0	
4102	4118	0	0	00	0.0	0.0	2.118	3.0	
3104	4108	0	0	00	0.215	0.0	1.50	3.0	
3105	4108	0	0	00	0.215	0.0	0.808	3.0	
3105	4118	0	0	00	0.604	0.0	0.25	3.0	
3103	4118	0	0	00	0.0	0.0	0.652	3.0	
3102	4118	0	0	00	0.0	0.0	2.118	3.0	
5306	4306	0	0	00	1.50	1.50	0.6521	1.0	
5101	4101	0	0	00	1.50	1.5	1.308	1.0	
5102	4102	0	0	00	1.50	1.5	2.599	1.0	
5103	4103	0	0	00	1.50	1.5	.2241	1.0	
5110	4104	0	0	00	2.815	1.5	0.375	1.0	
5111	4105	0	0	00	2.946	1.5	0.202	1.0	
4306	3306	0	0	00	1.5	1.5	0.6521	1.0	
4101	3101	0	0	00	1.5	1.5	1.308	1.0	
4102	3102	0	0	00	1.5	1.5	2.599	1.0	
4103	3103	0	0	00	1.5	1.5	.2241	1.0	
4104	3104	0	0	00	1.5	1.5	0.375	1.0	
4105	3105	0	0	00	1.5	1.5	0.202	1.0	
3306	2306	0	0	00	1.5	4.750	0.6521	1.0	
3102	2101	0	0	00	1.5	4.750	1.903	1.0	3.47
3103	2102	0	0	00	1.5	4.750	0.2241	1.0	3.47
3104	2101	0	0	00	1.5	4.750	0.307	1.0	3.47
3104	2102	0	0	00	1.5	4.750	0.068	1.0	3.47
3105	2102	0	0	00	1.5	4.750	0.208	1.0	3.47
2108	2103	0	0	00	0.0	4.75	1.350	1.0	
2108	2104	0	0	00	0.0	4.75	2.145	1.0	

2118	2105	0	0	00	0.0	5.000	2.505	1.0		
2128	2106	0	0	00	0.0	5.000	1.515	1.0		
2128	2107	0	0	00	0.0	5.000	3.495	1.0		
2306	1306	0	0	00	4.750	5.000	0.652	1.0		
2101	1101	0	0	00	4.750	5.0	0.694	1.0		
2102	1104	0	0	00	4.750	5.0	0.406	1.0		
2103	1105	0	0	00	4.75	5.0	1.222	1.0		
2104	1106	0	0	00	4.75	5.0	2.145	1.0		
2105	1107	0	0	00	5.0	5.0	2.505	1.0		
2106	1108	0	0	00	5.0	5.0	1.515	1.0		
2107	1101	0	0	00	5.0	5.0	0.115	1.0		
2107	1109	0	0	00	5.0	5.0	2.223	1.0		
4305	4306	0	0	00	0.0	0.139375	2.121	3.0		
4306	4307	0	0	00	0.139375	0.0	2.558	3.0		
4307	41005	0	0	00	0.0	0.0	2.5584	3.0		.5738
	0.1650	80.6			0.1717	116.6	0.1782	152.6	0.1847	188.6
	0.1912	224.6			0.1976	260.6	0.2107	332.6	0.2252	404.6
	0.2400	476.6			0.2565	548.6	0.2719	620.6	0.2906	710.6
	0.3060	800.6			0.3214	890.6	0.3380	980.6	0.3688	1160.6
	0.3996	1340.6			0.4282	1520.6	0.4579	1700.6	0.5163	2060.6
	0.5735	2420.6			0.6275	2780.6	0.7089	3320.6	0.8135	4040.6
	0.9368	4940.6								
4100	4101	0	0	00	0.0	0.400	2.627	3.0		
4101	4102	0	0	00	0.375	0.961	3.318	3.0		
4102	4103	0	0	00	0.793	0.215	1.030	3.0		
4102	4104	0	0	00	0.321	0.215	1.500	3.0		
4103	4105	0	0	00	0.000	0.215	0.808	3.0		
4104	4105	0	0	00	1.290	0.694	0.250	3.0		
3305	3306	0	0	00	0.0	0.139375	2.121	3.0		
3306	3307	0	0	00	0.139375	0.0	2.558	3.0		
3307	31005	0	0	00	0.0	0.0	2.5584	3.0		.5738
	0.1650	80.6			0.1717	116.6	0.1782	152.6	0.1847	188.6
	0.1912	224.6			0.1976	260.6	0.2107	332.6	0.2252	404.6
	0.2400	476.6			0.2565	548.6	0.2719	620.6	0.2906	710.6
	0.3060	800.6			0.3214	890.6	0.3380	980.6	0.3688	1160.6
	0.3996	1340.6			0.4282	1520.6	0.4579	1700.6	0.5163	2060.6
	0.5735	2420.6			0.6275	2780.6	0.7089	3320.6	0.8135	4040.6
	0.9368	4940.6								
3100	3101	0	0	00	0.0	0.400	2.627	3.0		
3101	3102	0	0	00	0.375	0.961	3.318	3.0		
3102	3103	0	0	00	0.793	0.215	1.030	3.0		
3102	3104	0	0	00	0.321	0.215	1.500	3.0		
3103	3105	0	0	00	0.000	0.215	0.808	3.0		
3104	3105	0	0	00	1.290	0.694	0.250	3.0		
2305	2306	0	0	00	0.0	0.139	2.121	9.5		
2306	2307	0	0	00	0.139	0.0	2.558	9.5		
2307	21005	0	0	00	0.0	0.0	2.558	9.5		0.648
	0.0103	80.6			0.0107	116.6	0.0111	152.6	0.0115	188.6
	0.0119	224.6			0.0123	260.6	0.0131	332.6	0.0141	404.6
	0.0150	476.6			0.0160	548.6	0.0170	620.6	0.0181	710.6
	0.0191	800.6			0.0201	890.6	0.0211	980.6	0.0230	1160.6
	0.0249	1340.6			0.0267	1520.6	0.0286	1700.6	0.0322	2060.6
	0.0358	2420.6			0.0391	2780.6	0.0442	3320.6	0.0507	4040.6
	0.0584	4940.6								
2100	2101	0	0	00	0.0	0.690	3.660	9.5		
2101	2102	0	0	00	0.690	0.358	1.715	9.5		
2101	2103	0	0	00	0.537	1.290	0.900	9.5		
2101	2107	0	0	00	0.640	0.387	2.093	9.5		
2102	2104	0	0	00	0.0	1.290	1.430	9.5		
2102	2106	0	0	00	0.0	1.436	0.907	9.5		
2103	2104	0	0	00	0.774	1.230	1.500	9.5		
2104	2105	0	0	00	1.230	1.436	1.500	9.5		
2105	2106	0	0	00	1.290	0.780	1.670	10.0		
2106	2107	0	0	00	0.780	1.800	1.670	10.0		
1305	1306	0	0	00	0.0	0.139	2.121	10.0		
1306	1307	0	0	00	0.139	0.0	2.5584	10.0		

25

25

25

1307	11005	0	0	00	0.0	0.0	2.5584	10.0	0.611	25
0.0511	80.6	0.0532	116.6	0.0552	152.6	0.0572	188.6			
0.0592	224.6	0.0612	260.6	0.0653	332.6	0.0698	404.6			
0.0743	476.6	0.0794	548.6	0.0842	620.6	0.0900	710.6			
0.0948	800.6	0.0996	890.6	0.1047	980.6	0.1142	1160.6			
0.1237	1340.6	0.1326	1520.6	0.1418	1700.6	0.1599	2060.6			
0.1776	2420.6	0.1943	2780.6	0.2196	3320.6	0.2520	4040.6			
0.2902	4940.6									
1100	1101	0	0	00	0.0	0.628	2.7803	10.0		
1101	1102	0	0	00	0.628	0.0	3.9466	10.0		
1102	11035	0	0	00	0.0	0.0	3.9446	10.0	0.566	25
0.0107	80.6	0.0112	116.6	0.0116	152.6	0.0120	188.6			
0.0124	224.6	0.0129	260.6	0.0137	332.6	0.0147	404.6			
0.0156	476.6	0.0167	548.6	0.0177	620.6	0.0189	710.6			
0.0199	800.6	0.0209	890.6	0.0220	980.6	0.0240	1160.6			
0.0260	1340.6	0.0279	1520.6	0.0298	1700.6	0.0336	2060.6			
0.0373	2420.6	0.0408	2780.6	0.0461	3320.6	0.0529	4040.6			
0.0609	4940.6									
1103	1104	0	0	00	0.0	0.344	1.523	10.0		
1103	1105	0	0	00	0.0	1.046	1.091	10.0		
1103	1109	0	0	00	0.0	0.803	2.389	10.0		
1104	1106	0	0	00	0.0	1.290	1.260	10.0		
1104	1108	0	0	00	0.0	1.436	0.829	10.0		
1105	1106	0	0	00	0.774	1.230	1.445	10.0		
1106	1107	0	0	00	1.23	1.436	1.500	10.0		
1107	1108	0	0	00	1.290	0.780	1.670	10.0		
1108	1109	0	0	00	0.780	1.233	1.599	10.0		
5301	50010	0	0	00	.01	.0875	.408	3.0	694.4	
5001	5002	0	0	00	.0875	.0875	.683	3.0		
5002	53020	0	0	00	.0875	.015	.957	3.0	694.4	
5303	50030	0	0	00	.01	.07925	1.367	3.0	694.4	
5003	5004	0	0	00	.07925	.07925	1.616	3.0		
5004	53040	0	0	00	.07925	.0125	1.865	3.0	694.4	
5308	5301	0	0	00	0.0	.01	.376	3.0		
5308	54015	0	0	00	0.0	0.0	.376	3.0	1.e-12	-4
1.e-12	0.0	1.e-12	.220	.583	.222	.583		10.0		
5309	5302	0	0	00	0.0	.015	1.005	3.0		
5309	54025	0	0	00	0.0	0.0	1.005	3.0	1.e-12	-4
1.e-12	0.0	1.e-12	.220	.497	.222	.497		10.0		
5310	5303	0	0	00	0.0	.010	1.336	3.0		
5310	54025	0	0	00	0.0	0.0	1.336	3.0	1.e-12	-4
1.e-12	0.0	1.e-12	.220	.497	.222	.497		10.0		
5311	5304	0	0	00	.125	1.905	3.0			
5311	54035	0	0	00	0.0	0.0	1.905	3.0	1.e-12	-4
1.e-12	0.0	1.e-12	.220	.408	.222	.408		10.0		
5305	54035	0	0	00	0.0	0.0	2.121	3.0	1.e-12	-4
1.e-12	0.0	1.e-12	.220	.408	.222	.408		10.0		
5305	5306	0	0	00	0.0	.139375	2.121	3.0		
5306	5307	0	0	00	.139375	0.0	2.5584	3.0		
5307	51005	0	0	00	0.0	0.0	2.5584	3.0	.5738	25
0.1650	80.6	0.1717	116.6	0.1782	152.6	0.1847	188.6			
0.1912	224.6	0.1976	260.6	0.2107	332.6	0.2252	404.6			
0.2400	476.6	0.2565	548.6	0.2719	620.6	0.2906	710.6			
0.3060	800.6	0.3214	890.6	0.3380	980.6	0.3688	1160.6			
0.3996	1340.6	0.4282	1520.6	0.4579	1700.6	0.5163	2060.6			
0.5735	2420.6	0.6275	2780.6	0.7089	3320.6	0.8135	4040.6			
0.9368	4940.6									
5301	6301	0	0	00	1.5	1.5	7.840e-3	1.0		
5302	6302	0	0	00	1.5	1.5	2.943e-2	1.0		
5303	6303	0	0	00	1.5	1.5	2.703e-2	1.0		
5304	6304	0	0	00	1.5	1.5	4.712e-2	1.0		
5306	6306	0	0	00	1.5	1.5	6.521e-1	1.0		
5001	6001	0	0	00	1.5	1.5	9.539e-2	1.0		
5002	6002	0	0	00	1.5	1.5	1.435e-1	1.0		
5003	6003	0	0	00	1.5	1.5	2.365e-1	1.0		
5004	6004	0	0	00	1.5	1.5	2.759e-1	1.0		

5101	6101	0	0	00	1.5	1.5	1.308e+0	1.0		
5102	6102	0	0	00	1.5	1.5	3.734e+0	1.0		
5103	6103	0	0	00	1.5	1.5	1.011e+0	1.0		
5110	6110	0	0	00	2.58	2.58	1.75	1.50		
5111	6111	0	0	00	2.58	2.58	1.75	1.50		
5112	6112	0	0	00	2.58	2.58	1.75	1.00		
5113	6113	0	0	00	2.58	2.58	1.25	1.00		
5100	5101	0	0	00	0.	3.77e-1	2.63	3.0		
5101	5102	0	0	00	3.77e-1	9.133e-1	3.318	3.0		
5102	5103	0	0	00	8.08e-1	6.17e-1	2.442	3.0		
5102	5110	0	0	00	4.30e-1	1.51e+0	.563	8.0	3.47e+0	
5103	5111	0	0	00	8.07e-1	1.56e+0	.563	8.0	3.47e+0	
5103	5113	0	0	00	6.45e-1	0.531	.469	8.0	5.0e-1	
5110	5111	0	0	00	0.75e+0	0.75e+0	.656	8.0		
5111	5112	0	0	00	0.75e+0	0.5e+0	.656	8.0		
5112	5113	0	0	00	1.51e+0	1.08e+0	.375	8.0		

Block 6 external thermal connectors

5305	1000	0	0	0	-4	2.121	3.0			
.174		0.			.174	.220	0.	.222	0.	10.
5311	1000	0	0	0	-4	1.905	3.0			
.174		0.			.174	.220	0.	.222	0.	10.
5310	1000	0	0	0	-4	1.336	3.0			
.139		0.			.139	.220	0.	.222	0.	10.
5309	1000	0	0	0	-4	1.005	3.0			
.139		0.			.139	.220	0.	.222	0.	10.
5308	1000	0	0	0	-4	.376	3.0			
.172		0.			.172	.220	0.	.222	0.	10.
6305	1000	51	1000	0	-4	2.121	4.0			
.174		0.			.174	.220	0.	.222	0.	10.
6311	1000	51	1000	0	-4	1.905	4.0			
.174		0.			.174	.220	0.	.222	0.	10.
6310	1000	51	1000	0	-4	1.336	4.0			
.139		0.			.139	.220	0.	.222	0.	10.
6309	1000	51	1000	0	-4	1.005	4.0			
.139		0.			.139	.220	0.	.222	0.	10.
6308	1000	51	1000	0	-4	.376	4.0			
.172		0.			.172	.220	0.	.222	0.	10.
401	3000	0				0.1802	1.0	1.e+12		
402	3000	0				0.9877	1.0	1.e+12		
403	3000	0				1.1069	1.0	1.e+12		

Block 7 external temps

2000	150.
1000	468.7
3000	324.9

Block 9 power generation rates

1	2	-1	20	3	1900.	1	4
173.2400	.0000	.0279	0.0100000	0.0341500	0.0239000	0.0297900	0.0794000
0.0473500	0.0	0.0402700	0.01906000	0.0241100	0.2461000	0.0214600	0.3850000
0.0273200	0.1350000	0.0255200	0.0134000	1.6350000	0.0121900	2.1906000	
0.0195800	0.5239000	0.0154100	4.1350	0.0091690	5.5239	0.0073920	11.0794
0.0113600	2.7461	0.0100100	22.1906	0.0053240	27.7460	0.0045120	41.6350
0.0064240	16.6350	0.0057920	2069.99	2.5	2070.0	2.5	5000.0
2.50	1900.0	2.50					
0	1.384		30	0.0			
0.00	0.0	1.0	26.20	0.0	1.0		
32.50	0.3975	1.0	40.50	0.5393	1.0		
48.50	0.7058	1.0	56.50	0.7398	1.0		
64.50	0.8895	1.0	72.50	1.0358	1.0		
80.50	0.9075	1.0	88.50	1.0036	1.0		
96.50	1.0674	1.0	104.50	1.1398	1.0		
112.50	1.2026	1.0	120.50	1.2558	1.0		
128.50	1.2996	1.0	136.50	1.3341	1.0		

144.50	1.3596	1.0	152.50	1.3766	1.0
160.50	1.3702	1.0	168.50	1.3779	1.0
176.50	1.3836	1.0	184.50	1.3854	1.0
192.50	1.3810	1.0	200.50	1.3691	1.0
208.50	1.3490	1.0	216.50	1.3195	1.0
224.50	1.2773	1.0	232.50	1.2109	1.0
240.50	1.2070	1.0	248.50	1.2648	1.0
4108	0	0	0	0.0	450.
4118	0	0	0	0.0	450.
4402	0	0	0	0.0	450.
4401	0	0	0	0.0	450.
4305	0	0	0	0.0	450.
4306	0	0	0	0.0	450.
4307	0	0	0	0.0	450.
4100	0	0	0	0.0	450.
4101	0	0	0	0.0	450.
4102	0	0	0	0.0	450.
4103	0	0	0	0.0	450.
4104	0	0	0	0.0	450.
4105	0	0	0	0.0	450.
4403	0	0	0	0.0	450.
3403	0	0	0	0.0	450.
3402	0	0	0	0.0	450.
3401	0	0	0	0.0	450.
3305	0	0	0	0.0	450.
3306	0	0	0	0.0	450.
3307	0	0	0	0.0	450.
3100	0	0	0	0.0	450.
3101	0	0	0	0.0	450.
3102	0	0	0	0.0	450.
3103	0	0	0	0.0	450.
3104	0	0	0	0.0	450.
3105	0	0	0	0.0	450.
2128	0	0	0	0.0	450.
2118	0	0	0	0.0	450.
2108	0	0	0	0.0	450.
2403	0	0	0	0.0	450.
2402	0	0	0	0.0	450.
2401	0	0	0	0.0	450.
2305	0	0	0	0.0	450.
2306	0	0	0	0.0	450.
2307	0	0	0	0.0	450.
2100	0	0	0	0.0	450.
2101	0	0	0	0.0	450.
2102	0	0	0	0.0	450.
2103	0	0	0	0.0	450.
2104	0	0	0	0.0	450.
2105	0	0	0	0.0	450.
2106	0	0	0	0.0	450.
2107	0	0	0	0.0	450.
1401	0	0	0	0.0	450.
1403	0	0	0	0.0	450.
1402	0	0	0	0.0	450.
1305	0	0	0	0.0	450.
1306	0	0	0	0.0	450.
1307	0	0	0	0.0	450.
1100	0	0	0	0.0	450.
1101	0	0	0	0.0	450.
1102	0	0	0	0.0	450.
1103	0	0	0	0.0	450.
1104	0	0	0	0.0	450.
1105	0	0	0	0.0	450.
1106	0	0	0	0.0	450.
1107	0	0	0	0.0	450.
1108	0	0	0	0.0	450.
1109	0	0	0	0.0	450.

19129	9	4000	0	.0000	200.
19128	9	4000	0	.0000	200.
19127	9	4000	0	.0000	200.
19126	9	4000	0	.0000	200.
20129	9	4000	0	.0000	200.
20128	9	4000	0	.0000	200.
20127	9	4000	0	.0000	200.
20126	9	4000	0	.0000	200.
5001	52	1000	0	.8411	700.
5002	52	1000	0	.8411	700.
5003	52	1000	0	1.0429	700.
5004	52	1000	0	1.0429	700.
5301	52	1000	0	.01960	700.
5302	52	1000	0	.01570	700.
5303	52	1000	0	.01710	700.
5304	52	1000	0	.01310	700.
5306	52	1000	0	.01010	520.
5308	52	1000	0	.00000	700.
5309	52	1000	0	.00000	700.
5310	52	1000	0	.00000	700.
5311	52	1000	0	.00000	700.
5100	52	1000	0	0.002561	650.
5101	52	1000	0	0.002561	750.
5102	52	1000	0	0.002561	850.
5103	52	1000	0	0.002561	900.
5110	13	1000	0	0.001668	1000.
5111	13	1000	0	0.001668	1050.
5112	13	1000	0	0.001668	1100.
5113	13	1000	0	0.001668	1020.
21110	9	4000	0	0.001668	1000.
21111	9	4000	0	0.001668	1050.
21112	9	4000	0	0.001668	1100.
21113	9	4000	0	0.001668	1020.
22110	8	4000	0	0.001668	1000.
22111	8	4000	0	0.001668	1050.
22112	8	4000	0	0.001668	1100.
22113	8	4000	0	0.001668	1020.
19120	9	4000	0	0.001668	600.
19121	9	4000	0	0.001668	800.
19122	9	4000	0	0.001668	900.
19123	9	4000	0	0.001668	920.
20120	9	4000	0	0.001668	600.
20121	9	4000	0	0.001668	800.
20122	9	4000	0	0.001668	900.
20123	9	4000	0	0.001668	920.

block10 mass flow connectors

1	3				
-1	0				
888	888				
-1	20.43		.045		
401	1401	56 1000 1000	1.0	0.0	1.0
888	888				
-1	88.47		.247		
402	1402	56 1000 1000	1.0	0.0	1.0
888	888				
-1	70.38		.277		
403	1403	56 1000 1000	1.0	0.0	1.0
888	888				
0	-1	5500. 0	9.621e-2		
40419404	9	0 4000	1.0	1.0	1.0
888	888				
0	-1	5500. 0	9.621e-2		
40420404	9	0 4000	1.0	1.0	1.0

ended-1

1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119

1	3
-1 0	
888	888
	-1
401	1401
888	888
	-1
402	1402
888	888
	-1
403	1403
888	888
0	-1
404	1404
888	888
0	-1

401	1401	56	1000	1000	1.0	0.0	1.0
888	888						
402	1402	56	1000	1000	1.0	0.0	1.0
888	888						
403	1403	56	1000	1000	1.0	0.0	1.0
888	888						
404	1404	9	4000	4000	1.0	1.0	1.0
888	888						

card
no.

1120
1121
1122

[illegible]

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data block 1	problem controls, limits and constants
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```
iprint      num kdata kspec      mcpu      msec npunch ndot      irite      itape      timep      scale
      0          0      -1          0          0          0      1          0          0          0 0.33333E-01 0.10000E+01
```

B.78

kd	kt	delto	small	tvary	tau	timax	tmin	tmax
1	3	1.00000E+12	1.00000E-12	5.00000E+00	0.00000E+00	8.01667E-01	7.99999E+01	6.50000E+03

kd	ksym	geom	sigma	tbase
1	1	1.00000E+00	1.18958E-11	4.60000E+02

tone	alone	gone	fone	hone	rone	pone
4.5000E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

idiag	nchans	fuel	rad
5	5	9.89200E-01	

data block 2

material properties

name	matl	index	ltabc	ltabk	ltabp	density	capacity	conductivity	tmelt	hmelt
u-mtl	1	1	15	4	3	6.8300E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

capacity	slope	energy	slope	tvarc
3.130000E-02	0.000000E+00	1.565000E+00	3.130000E-02	1.000000E+02
3.130000E-02	0.000000E+00	3.730960E+01	3.130000E-02	1.242000E+03
3.130000E-02	0.000000E+00	3.731273E+01	3.130000E-02	1.242100E+03
3.140000E-02	2.500000E-04	3.732527E+01	3.130000E-02	1.242500E+03
3.900000E-02	8.000000E-04	3.765967E+01	3.520000E-02	1.252000E+03
3.900000E-02	0.000000E+00	3.766357E+01	3.900000E-02	1.252100E+03
3.900000E-02	0.000000E+00	4.421167E+01	3.900000E-02	1.420000E+03
3.350000E-02	-5.500000E-02	4.421529E+01	3.625000E-02	1.420100E+03
3.350000E-02	0.000000E+00	4.454694E+01	3.350000E-02	1.430000E+03
3.350000E-02	0.000000E+00	4.455029E+01	3.350000E-02	1.430100E+03
3.350000E-02	0.000000E+00	6.344094E+01	3.350000E-02	1.994000E+03
4.800000E-02	1.450000E-01	6.344502E+01	4.075000E-02	1.994100E+03
4.800000E-02	0.000000E+00	6.468822E+01	4.800000E-02	2.020000E+03
4.800000E-02	0.000000E+00	6.469302E+01	4.800000E-02	2.020100E+03
4.800000E-02	0.000000E+00	2.077282E+02	4.800000E-02	5.000000E+03
conductivity	slope	tvarc		
1.317000E+00	3.525000E-04	2.000000E+02		
1.458000E+00	3.525000E-04	6.000000E+02		
1.688000E+00	5.750000E-04	1.000000E+03		
1.833000E+00	3.625000E-04	1.400000E+03		

hmelt	tmelt
4.906000E+00	1.247000E+03
8.278000E+00	1.425000E+03
2.286100E+00	2.007000E+03

name	matl	index	ltabc	ltabk	ltabp	density	capacity	conductivity	tmelt	hmelt
graph	2	2	5	0	0	6.1400E-02	0.0000E+00	1.7120E+00	0.0000E+00	0.0000E+00

capacity	slope	energy	slope	tvarc
2.200000E-01	5.555556E-04	8.833000E+00	2.700000E-01	8.030000E+01
3.200000E-01	5.555556E-04	5.743300E+01	2.700000E-01	2.603000E+02
3.700000E-01	7.443799E-05	2.891695E+02	3.450000E-01	9.320000E+02
4.200000E-01	8.802817E-05	5.135295E+02	3.950000E-01	1.500000E+03
5.040000E-01	9.882353E-06	4.440529E+03	4.620000E-01	1.000000E+04

name	matl	index	ltabc	ltabk	ltabp	density	capacity	conductivity	tmelt	hmelt
zz-cl	100	3	8	13	0	2.3737E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

capacity	slope	energy	slope	tvarc
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6.700000E-02	2.777778E-05	2.713500E+00	6.950000E-02	8.100000E+01
7.200000E-02	2.777778E-05	1.522350E+01	6.950000E-02	2.610000E+02
7.900000E-02	1.620370E-05	4.783950E+01	7.550000E-02	6.930000E+02
9.000000E-02	1.358025E-05	1.162845E+02	8.450000E-02	1.503000E+03
8.500000E-02	-1.760563E-05	1.411345E+02	8.750000E-02	1.787000E+03
8.500000E-02	0.000000E+00	2.442395E+02	8.500000E-02	3.000000E+03
8.600000E-02	1.000000E-06	3.297395E+02	8.550000E-02	4.000000E+03
8.700000E-02	1.000000E-06	4.162395E+02	8.650000E-02	5.000000E+03

conductivity	slope	tvark
6.250000E-01	2.990046E-04	2.610000E+02
7.541700E-01	2.990046E-04	6.930000E+02
1.022500E+00	3.312716E-04	1.503000E+03
1.039200E+00	4.073171E-04	1.544000E+03
1.055000E+00	4.388889E-04	1.580000E+03
1.070800E+00	4.388889E-04	1.616000E+03
1.103300E+00	4.513889E-04	1.688000E+03
1.120800E+00	4.861111E-04	1.724000E+03
1.138300E+00	4.861111E-04	1.760000E+03
1.152500E+00	5.259259E-04	1.787000E+03
2.087500E+00	9.230010E-04	2.800000E+03
4.185600E+00	1.748417E-03	4.000000E+03
5.934000E+00	1.748400E-03	5.000000E+03

name	matl	index	ltabc	ltabk	ltabp	density	capacity	conductivity	tmelt	hmelt
steam	10	4	14	14	0	6.9400E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

p= 200.0 psia

steam viscosity and density table

temp	viscosity	temp	density
3.800000E+02	3.850000E-02	3.800000E+02	4.37200E-01
6.000000E+02	5.050000E-02	6.000000E+02	3.27000E-01
1.000000E+03	7.240000E-02	8.000000E+02	2.32100E-01
1.600000E+03	1.05200E-01	1.000000E+03	1.63000E-01
2.000000E+03	1.27100E-01	1.200000E+03	1.36500E-01
2.400000E+03	1.49000E-01	1.400000E+03	1.17400E-01
2.600000E+03	1.59900E-01	1.600000E+03	1.09700E-01
2.800000E+03	1.70800E-01	2.000000E+03	1.03000E-01
3.000000E+03	1.81800E-01	2.400000E+03	9.71000E-02
3.200000E+03	1.92700E-01	3.000000E+03	9.18000E-02
3.400000E+03	2.03700E-01	3.400000E+03	8.70000E-02
3.600000E+03	2.14600E-01	3.600000E+03	8.27000E-02
4.000000E+03	2.15000E-02	4.000000E+03	6.91000E-02
5.000000E+03	2.93000E-02	5.000000E+03	6.15000E-02

capacity	slope	energy	slope	tvark
6.620000E-01	-6.454545E-04	1.257800E+02	5.910000E-01	3.800000E+02
5.200000E-01	-6.454545E-04	2.558000E+02	5.910000E-01	6.000000E+02
5.200000E-01	0.000000E+00	4.638000E+02	5.200000E-01	1.000000E+03
5.750000E-01	9.166667E-05	7.923000E+02	5.475000E-01	1.600000E+03
6.060000E-01	7.750000E-05	1.028500E+03	5.905000E-01	2.000000E+03
6.500000E-01	1.100000E-04	1.279700E+03	6.280000E-01	2.400000E+03
6.700000E-01	1.000000E-04	1.411700E+03	6.600000E-01	2.600000E+03
6.900000E-01	1.000000E-04	1.547700E+03	6.800000E-01	2.800000E+03
7.050000E-01	7.500000E-05	1.687200E+03	6.975000E-01	3.000000E+03
7.250000E-01	1.000000E-04	1.830200E+03	7.150000E-01	3.200000E+03
7.450000E-01	1.000000E-04	1.977200E+03	7.350000E-01	3.400000E+03
7.600000E-01	7.500000E-05	2.127700E+03	7.525000E-01	3.600000E+03
8.124000E-01	6.550000E-05	2.756660E+03	7.862000E-01	4.400000E+03
8.640000E-01	8.600000E-05	3.259580E+03	8.382000E-01	5.000000E+03

conductivity	slope	tvark
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1.600000E-03	2.727273E-06	3.800000E+02
2.200000E-03	2.727273E-06	6.000000E+02
3.500000E-03	3.250000E-06	1.000000E+03
5.700000E-03	1.100000E-05	1.200000E+03
7.100000E-03	1.750000E-06	2.000000E+03
8.300000E-03	3.000000E-06	2.400000E+03
8.800000E-03	2.500000E-06	2.600000E+03
9.200000E-03	2.000000E-06	2.800000E+03
9.400000E-03	1.000000E-06	3.000000E+03
9.600000E-03	1.000000E-06	3.200000E+03
9.500000E-03	-5.000000E-07	3.400000E+03
9.300000E-03	-1.000000E-06	3.600000E+03
6.200000E-03	-3.875000E-06	4.400000E+03
1.200000E-03	-8.333333E-06	5.000000E+03

data block 4 node descriptors

variable axial length model option

level	length (in)
1	10.0000
2	9.5000
3	3.0000
4	3.0000
5	3.0000
6	4.0000
7	4.0000
8	4.0000
9	4.0000
10	4.0000
11	4.0000
12	4.0000
13	4.0000
14	4.0000
15	4.0000
16	4.0000
17	4.0000
18	4.0000
19	4.0000
20	4.0000
21	4.0000
22	4.0000
23	4.0000
24	4.0000
25	4.0000
26	4.0000
27	4.0000
28	4.0000
29	4.0000
30	4.0000
31	4.0000
32	4.0000
33	4.0000
34	4.0000
35	4.0000
36	4.0000
37	4.0000
38	4.0000
39	4.0000
40	4.0000
41	4.0000
42	4.0000

43 4.0000
44 4.0000
45 4.0000
46 4.0000
47 4.0000
48 4.0000
49 4.0000
50 4.0000
51 4.0000
52 4.0000
53 4.0000
54 4.0000
55 4.0000
56 4.0000
57 4.0000

this simulation is performed using a 57 axial level model with a lower boundary of 0.000 in.
the bundle height is 236.50 in.

the overall model length is 236.50 in.

node	index	matl	ntype	dlong	dwide	drad	volume	oxarea	zrthik	pin	flow	rga
6001	1	1	0	9.54000E-02	1.00000E+00	4.00000E+00	3.81600E-01	3.70000E-02	1.75000E-01	1	1	
8001	2	1	0	9.54000E-02	1.00000E+00	4.00000E+00	3.81600E-01	3.70000E-02	1.75000E-01	1	1	
10001	3	1	0	9.54000E-02	1.00000E+00	4.00000E+00	3.81600E-01	3.70000E-02	1.75000E-01	1	1	
12001	4	1	0	9.54000E-02	1.00000E+00	4.00000E+00	3.81600E-01	3.70000E-02	1.75000E-01	1	1	
14001	5	1	0	9.54000E-02	1.00000E+00	4.00000E+00	3.81600E-01	3.70000E-02	1.75000E-01	1	1	
16001	6	1	0	9.54000E-02	1.00000E+00	4.00000E+00	3.81600E-01	3.70000E-02	1.75000E-01	1	1	
18001	7	1	0	9.54000E-02	1.00000E+00	4.00000E+00	3.81600E-01	3.70000E-02	1.75000E-01	1	1	
6002	8	1	0	1.43000E-01	1.00000E+00	4.00000E+00	5.72000E-01	1.00000E-01	1.75000E-01	1	2	
8002	9	1	0	1.43000E-01	1.00000E+00	4.00000E+00	5.72000E-01	1.00000E-01	1.75000E-01	1	2	
10002	10	1	0	1.43000E-01	1.00000E+00	4.00000E+00	5.72000E-01	1.00000E-01	1.75000E-01	1	2	
12002	11	1	0	1.43000E-01	1.00000E+00	4.00000E+00	5.72000E-01	1.00000E-01	1.75000E-01	1	2	
14002	12	1	0	1.43000E-01	1.00000E+00	4.00000E+00	5.72000E-01	1.00000E-01	1.75000E-01	1	2	
16002	13	1	0	1.43000E-01	1.00000E+00	4.00000E+00	5.72000E-01	1.00000E-01	1.75000E-01	1	2	
18002	14	1	0	1.43000E-01	1.00000E+00	4.00000E+00	5.72000E-01	1.00000E-01	1.75000E-01	1	2	
6003	15	1	0	2.36000E-01	1.00000E+00	4.00000E+00	9.44000E-01	1.34000E-01	1.58500E-01	2	2	
8003	16	1	0	2.36000E-01	1.00000E+00	4.00000E+00	9.44000E-01	1.34000E-01	1.58500E-01	2	2	
10003	17	1	0	2.36000E-01	1.00000E+00	4.00000E+00	9.44000E-01	1.34000E-01	1.58500E-01	2	2	
12003	18	1	0	2.36000E-01	1.00000E+00	4.00000E+00	9.44000E-01	1.34000E-01	1.58500E-01	2	2	
14003	19	1	0	2.36000E-01	1.00000E+00	4.00000E+00	9.44000E-01	1.34000E-01	1.58500E-01	2	2	
16003	20	1	0	2.36000E-01	1.00000E+00	4.00000E+00	9.44000E-01	1.34000E-01	1.58500E-01	2	2	
18003	21	1	0	2.36000E-01	1.00000E+00	4.00000E+00	9.44000E-01	1.34000E-01	1.58500E-01	2	2	
6004	22	1	0	2.76000E-01	1.00000E+00	4.00000E+00	1.10400E+00	1.91000E-01	1.58500E-01	2	3	
8004	23	1	0	2.76000E-01	1.00000E+00	4.00000E+00	1.10400E+00	1.91000E-01	1.58500E-01	2	3	
10004	24	1	0	2.76000E-01	1.00000E+00	4.00000E+00	1.10400E+00	1.91000E-01	1.58500E-01	2	3	
12004	25	1	0	2.76000E-01	1.00000E+00	4.00000E+00	1.10400E+00	1.91000E-01	1.58500E-01	2	3	
14004	26	1	0	2.76000E-01	1.00000E+00	4.00000E+00	1.10400E+00	1.91000E-01	1.58500E-01	2	3	
16004	27	1	0	2.76000E-01	1.00000E+00	4.00000E+00	1.10400E+00	1.91000E-01	1.58500E-01	2	3	
18004	28	1	0	2.76000E-01	1.00000E+00	4.00000E+00	1.10400E+00	1.91000E-01	1.58500E-01	2	3	
6301	29	100	0	7.84000E-03	1.00000E+00	4.00000E+00	3.13600E-02	3.76000E-01	2.00000E-02	0	1	
8301	30	100	0	7.84000E-03	1.00000E+00	4.00000E+00	3.13600E-02	3.76000E-01	2.00000E-02	0	1	
10301	31	100	0	7.84000E-03	1.00000E+00	4.00000E+00	3.13600E-02	3.76000E-01	2.00000E-02	0	1	
12301	32	100	0	7.84000E-03	1.00000E+00	4.00000E+00	3.13600E-02	3.76000E-01	2.00000E-02	0	1	
14301	33	100	0	7.84000E-03	1.00000E+00	4.00000E+00	3.13600E-02	3.76000E-01	2.00000E-02	0	1	
16301	34	100	0	7.84000E-03	1.00000E+00	4.00000E+00	3.13600E-02	3.76000E-01	2.00000E-02	0	1	
18301	35	100	0	7.84000E-03	1.00000E+00	4.00000E+00	3.13600E-02	3.76000E-01	2.00000E-02	0	1	
6302	36	100	0	2.94300E-02	1.00000E+00	4.00000E+00	1.17720E-01	1.00500E+00	3.00000E-02	0	2	
8302	37	100	0	2.94300E-02	1.00000E+00	4.00000E+00	1.17720E-01	1.00500E+00	3.00000E-02	0	2	
10302	38	100	0	2.94300E-02	1.00000E+00	4.00000E+00	1.17720E-01	1.00500E+00	3.00000E-02	0	2	
12302	39	100	0	2.94300E-02	1.00000E+00	4.00000E+00	1.17720E-01	1.00500E+00	3.00000E-02	0	2	
14302	40	100	0	2.94300E-02	1.00000E+00	4.00000E+00	1.17720E-01	1.00500E+00	3.00000E-02	0	2	
16302	41	100	0	2.94300E-02	1.00000E+00	4.00000E+00	1.17720E-01	1.00500E+00	3.00000E-02	0	2	

data block 5

nod1	nod2	index	del1	del2	dlong	drad	hint	rint	area	ihtrcor
6301	6001	1	1.0000E-02	8.7500E-02	4.0800E-01	4.0000E+00	6.9440E+02	0.0000E+00	1.6320E+00	0
8301	8001	2	1.0000E-02	8.7500E-02	4.0800E-01	4.0000E+00	6.9440E+02	0.0000E+00	1.6320E+00	0
10301	10001	3	1.0000E-02	8.7500E-02	4.0800E-01	4.0000E+00	6.9440E+02	0.0000E+00	1.6320E+00	0
12301	12001	4	1.0000E-02	8.7500E-02	4.0800E-01	4.0000E+00	6.9440E+02	0.0000E+00	1.6320E+00	0
14301	14001	5	1.0000E-02	8.7500E-02	4.0800E-01	4.0000E+00	6.9440E+02	0.0000E+00	1.6320E+00	0
16301	16001	6	1.0000E-02	8.7500E-02	4.0800E-01	4.0000E+00	6.9440E+02	0.0000E+00	1.6320E+00	0
18301	18001	7	1.0000E-02	8.7500E-02	4.0800E-01	4.0000E+00	6.9440E+02	0.0000E+00	1.6320E+00	0
6001	6002	8	8.7500E-02	8.7500E-02	6.8300E-01	4.0000E+00	1.0000E+12	0.0000E+00	2.7320E+00	0
8001	8002	9	8.7500E-02	8.7500E-02	6.8300E-01	4.0000E+00	1.0000E+12	0.0000E+00	2.7320E+00	0
10001	10002	10	8.7500E-02	8.7500E-02	6.8300E-01	4.0000E+00	1.0000E+12	0.0000E+00	2.7320E+00	0
12001	12002	11	8.7500E-02	8.7500E-02	6.8300E-01	4.0000E+00	1.0000E+12	0.0000E+00	2.7320E+00	0
14001	14002	12	8.7500E-02	8.7500E-02	6.8300E-01	4.0000E+00	1.0000E+12	0.0000E+00	2.7320E+00	0
16001	16002	13	8.7500E-02	8.7500E-02	6.8300E-01	4.0000E+00	1.0000E+12	0.0000E+00	2.7320E+00	0
18001	18002	14	8.7500E-02	8.7500E-02	6.8300E-01	4.0000E+00	1.0000E+12	0.0000E+00	2.7320E+00	0
6002	6302	15	8.7500E-02	1.5000E-02	9.5700E-01	4.0000E+00	6.9440E+02	0.0000E+00	3.8280E+00	0
8002	8302	16	8.7500E-02	1.5000E-02	9.5700E-01	4.0000E+00	6.9440E+02	0.0000E+00	3.8280E+00	0
10002	10302	17	8.7500E-02	1.5000E-02	9.5700E-01	4.0000E+00	6.9440E+02	0.0000E+00	3.8280E+00	0
12002	12302	18	8.7500E-02	1.5000E-02	9.5700E-01	4.0000E+00	6.9440E+02	0.0000E+00	3.8280E+00	0
14002	14302	19	8.7500E-02	1.5000E-02	9.5700E-01	4.0000E+00	6.9440E+02	0.0000E+00	3.8280E+00	0
16002	16302	20	8.7500E-02	1.5000E-02	9.5700E-01	4.0000E+00	6.9440E+02	0.0000E+00	3.8280E+00	0
18002	18302	21	8.7500E-02	1.5000E-02	9.5700E-01	4.0000E+00	6.9440E+02	0.0000E+00	3.8280E+00	0
6303	6003	22	1.0000E-02	7.9250E-02	1.3670E+00	4.0000E+00	6.9440E+02	0.0000E+00	5.4680E+00	0
8303	8003	23	1.0000E-02	7.9250E-02	1.3670E+00	4.0000E+00	6.9440E+02	0.0000E+00	5.4680E+00	0
10303	10003	24	1.0000E-02	7.9250E-02	1.3670E+00	4.0000E+00	6.9440E+02	0.0000E+00	5.4680E+00	0
12303	12003	25	1.0000E-02	7.9250E-02	1.3670E+00	4.0000E+00	6.9440E+02	0.0000E+00	5.4680E+00	0
14303	14003	26	1.0000E-02	7.9250E-02	1.3670E+00	4.0000E+00	6.9440E+02	0.0000E+00	5.4680E+00	0
16303	16003	27	1.0000E-02	7.9250E-02	1.3670E+00	4.0000E+00	6.9440E+02	0.0000E+00	5.4680E+00	0
18303	18003	28	1.0000E-02	7.9250E-02	1.3670E+00	4.0000E+00	6.9440E+02	0.0000E+00	5.4680E+00	0
6003	6004	29	7.9250E-02	7.9250E-02	1.6160E+00	4.0000E+00	1.0000E+12	0.0000E+00	6.4640E+00	0
8003	8004	30	7.9250E-02	7.9250E-02	1.6160E+00	4.0000E+00	1.0000E+12	0.0000E+00	6.4640E+00	0
10003	10004	31	7.9250E-02	7.9250E-02	1.6160E+00	4.0000E+00	1.0000E+12	0.0000E+00	6.4640E+00	0
12003	12004	32	7.9250E-02	7.9250E-02	1.6160E+00	4.0000E+00	1.0000E+12	0.0000E+00	6.4640E+00	0
14003	14004	33	7.9250E-02	7.9250E-02	1.6160E+00	4.0000E+00	1.0000E+12	0.0000E+00	6.4640E+00	0
16003	16004	34	7.9250E-02	7.9250E-02	1.6160E+00	4.0000E+00	1.0000E+12	0.0000E+00	6.4640E+00	0
18003	18004	35	7.9250E-02	7.9250E-02	1.6160E+00	4.0000E+00	1.0000E+12	0.0000E+00	6.4640E+00	0
6004	6304	36	7.9250E-02	1.2500E-02	1.8650E+00	4.0000E+00	6.9440E+02	0.0000E+00	7.4600E+00	0
8004	8304	37	7.9250E-02	1.2500E-02	1.8650E+00	4.0000E+00	6.9440E+02	0.0000E+00	7.4600E+00	0
10004	10304	38	7.9250E-02	1.2500E-02	1.8650E+00	4.0000E+00	6.9440E+02	0.0000E+00	7.4600E+00	0
12004	12304	39	7.9250E-02	1.2500E-02	1.8650E+00	4.0000E+00	6.9440E+02	0.0000E+00	7.4600E+00	0
14004	14304	40	7.9250E-02	1.2500E-02	1.8650E+00	4.0000E+00	6.9440E+02	0.0000E+00	7.4600E+00	0
16004	16304	41	7.9250E-02	1.2500E-02	1.8650E+00	4.0000E+00	6.9440E+02	0.0000E+00	7.4600E+00	0
18004	18304	42	7.9250E-02	1.2500E-02	1.8650E+00	4.0000E+00	6.9440E+02	0.0000E+00	7.4600E+00	0
6308	6301	43	0.0000E+00	1.0000E-02	3.7600E-01	4.0000E+00	1.0000E+12	0.0000E+00	1.5040E+00	0
8308	8301	44	0.0000E+00	1.0000E-02	3.7600E-01	4.0000E+00	1.0000E+12	0.0000E+00	1.5040E+00	0
10308	10301	45	0.0000E+00	1.0000E-02	3.7600E-01	4.0000E+00	1.0000E+12	0.0000E+00	1.5040E+00	0
12308	12301	46	0.0000E+00	1.0000E-02	3.7600E-01	4.0000E+00	1.0000E+12	0.0000E+00	1.5040E+00	0
14308	14301	47	0.0000E+00	1.0000E-02	3.7600E-01	4.0000E+00	1.0000E+12	0.0000E+00	1.5040E+00	0
16308	16301	48	0.0000E+00	1.0000E-02	3.7600E-01	4.0000E+00	1.0000E+12	0.0000E+00	1.5040E+00	0
18308	18301	49	0.0000E+00	1.0000E-02	3.7600E-01	4.0000E+00	1.0000E+12	0.0000E+00	1.5040E+00	0
6308	6401	50	0.0000E+00	0.0000E+00	3.7600E-01	4.0000E+00	1.0000E-12	0.0000E+00	1.5040E+00	5
8308	8401	51	0.0000E+00	0.0000E+00	3.7600E-01	4.0000E+00	1.0000E-12	0.0000E+00	1.5040E+00	5
10308	10401	52	0.0000E+00	0.0000E+00	3.7600E-01	4.0000E+00	1.0000E-12	0.0000E+00	1.5040E+00	5
12308	12401	53	0.0000E+00	0.0000E+00	3.7600E-01	4.0000E+00	1.0000E-12	0.0000E+00	1.5040E+00	5
14308	14401	54	0.0000E+00	0.0000E+00	3.7600E-01	4.0000E+00	1.0000E-12	0.0000E+00	1.5040E+00	5
16308	16401	55	0.0000E+00	0.0000E+00	3.7600E-01	4.0000E+00	1.0000E-12	0.0000E+00	1.5040E+00	5
18308	18401	56	0.0000E+00	0.0000E+00	3.7600E-01	4.0000E+00	1.0000E-12	0.0000E+00	1.5040E+00	5
6309	6302	57	0.0000E+00	1.5000E-02	1.0050E+00	4.0000E+00	1.0000E+12	0.0000E+00	4.0200E+00	0
nod1	nod2	index	del1	del2	dlong	drad	hint	rint	area	ihtrcor
8309	8302	58	0.0000E+00	1.5000E-02	1.0050E+00	4.0000E+00	1.0000E+12	0.0000E+00	4.0200E+00	0

1100	1101	2756	0.0000E+00	6.2800E-01	2.7803E+00	1.0000E+01	1.0000E+12	0.0000E+00	2.7803E+01	0
1101	1102	2757	6.2800E-01	0.0000E+00	3.9466E+00	1.0000E+01	1.0000E+12	0.0000E+00	3.9466E+01	0
1102	1103	2758	0.0000E+00	0.0000E+00	3.9446E+00	1.0000E+01	1.0000E+12	5.6600E-01	3.9446E+01	5
1103	1104	2759	0.0000E+00	3.4400E-01	1.5230E+00	1.0000E+01	1.0000E+12	0.0000E+00	1.5230E+01	0
1103	1105	2760	0.0000E+00	1.0460E+00	1.0910E+00	1.0000E+01	1.0000E+12	0.0000E+00	1.0910E+01	0
1103	1109	2761	0.0000E+00	8.0300E-01	2.3890E+00	1.0000E+01	1.0000E+12	0.0000E+00	2.3890E+01	0
1104	1106	2762	0.0000E+00	1.2900E+00	1.2600E+00	1.0000E+01	1.0000E+12	0.0000E+00	1.2600E+01	0
1104	1108	2763	0.0000E+00	1.4360E+00	8.2900E-01	1.0000E+01	1.0000E+12	0.0000E+00	8.2900E+00	0
1105	1106	2764	7.7400E-01	1.2300E+00	1.4450E+00	1.0000E+01	1.0000E+12	0.0000E+00	1.4450E+01	0
1106	1107	2765	1.2300E+00	1.4360E+00	1.5000E+00	1.0000E+01	1.0000E+12	0.0000E+00	1.5000E+01	0
1107	1108	2766	1.2900E+00	7.8000E-01	1.6700E+00	1.0000E+01	1.0000E+12	0.0000E+00	1.6700E+01	0
1108	1109	2767	7.8000E-01	1.2330E+00	1.5990E+00	1.0000E+01	1.0000E+12	0.0000E+00	1.5990E+01	0
5301	5001	2768	1.0000E-02	8.7500E-02	4.0800E-01	3.0000E+00	6.9440E+02	0.0000E+00	1.2240E+00	0
5001	5002	2769	8.7500E-02	8.7500E-02	6.8300E-01	3.0000E+00	1.0000E+12	0.0000E+00	2.0490E+00	0
5002	5302	2770	8.7500E-02	1.5000E-02	9.5700E-01	3.0000E+00	6.9440E+02	0.0000E+00	2.8710E+00	0
5303	5003	2771	1.0000E-02	7.9250E-02	1.3670E+00	3.0000E+00	6.9440E+02	0.0000E+00	4.1010E+00	0
5003	5004	2772	7.9250E-02	7.9250E-02	1.6160E+00	3.0000E+00	1.0000E+12	0.0000E+00	4.8480E+00	0
5004	5304	2773	7.9250E-02	1.2500E-02	1.8650E+00	3.0000E+00	6.9440E+02	0.0000E+00	5.5950E+00	0
5308	5301	2774	0.0000E+00	1.0000E-02	3.7600E-01	3.0000E+00	1.0000E+12	0.0000E+00	1.1280E+00	0
5308	5401	2775	0.0000E+00	0.0000E+00	3.7600E-01	3.0000E+00	1.0000E-12	0.0000E+00	1.1280E+00	5
5309	5302	2776	0.0000E+00	1.5000E-02	1.0050E+00	3.0000E+00	1.0000E+12	0.0000E+00	3.0150E+00	0
5309	5402	2777	0.0000E+00	0.0000E+00	1.0050E+00	3.0000E+00	1.0000E-12	0.0000E+00	3.0150E+00	5
5310	5303	2778	0.0000E+00	1.0000E-02	1.3360E+00	3.0000E+00	1.0000E+12	0.0000E+00	4.0080E+00	0
5310	5402	2779	0.0000E+00	0.0000E+00	1.3360E+00	3.0000E+00	1.0000E-12	0.0000E+00	4.0080E+00	5
5311	5304	2780	0.0000E+00	1.2500E-01	1.9050E+00	3.0000E+00	1.0000E+12	0.0000E+00	5.7150E+00	0
5311	5403	2781	0.0000E+00	0.0000E+00	1.9050E+00	3.0000E+00	1.0000E-12	0.0000E+00	5.7150E+00	5
5305	5403	2782	0.0000E+00	0.0000E+00	2.1210E+00	3.0000E+00	1.0000E-12	0.0000E+00	6.3630E+00	5
5305	5306	2783	0.0000E+00	1.3938E-01	2.1210E+00	3.0000E+00	1.0000E+12	0.0000E+00	6.3630E+00	0
5306	5307	2784	1.3938E-01	0.0000E+00	2.5584E+00	3.0000E+00	1.0000E+12	0.0000E+00	7.6752E+00	0
5307	5100	2785	0.0000E+00	0.0000E+00	2.5584E+00	3.0000E+00	1.0000E-24	5.7380E-01	7.6752E+00	5
5301	6301	2786	1.5000E+00	1.5000E+00	7.8400E-03	1.0000E+00	1.0000E+12	0.0000E+00	7.8400E-03	0
5302	6302	2787	1.5000E+00	1.5000E+00	2.9430E-02	1.0000E+00	1.0000E+12	0.0000E+00	2.9430E-02	0
5303	6303	2788	1.5000E+00	1.5000E+00	2.7030E-02	1.0000E+00	1.0000E+12	0.0000E+00	2.7030E-02	0
5304	6304	2789	1.5000E+00	1.5000E+00	4.7120E-02	1.0000E+00	1.0000E+12	0.0000E+00	4.7120E-02	0
5306	6306	2790	1.5000E+00	1.5000E+00	6.5210E-01	1.0000E+00	1.0000E+12	0.0000E+00	6.5210E-01	0
5001	6001	2791	1.5000E+00	1.5000E+00	9.5390E-02	1.0000E+00	1.0000E+12	0.0000E+00	9.5390E-02	0
5002	6002	2792	1.5000E+00	1.5000E+00	1.4350E-01	1.0000E+00	1.0000E+12	0.0000E+00	1.4350E-01	0
5003	6003	2793	1.5000E+00	1.5000E+00	2.3650E-01	1.0000E+00	1.0000E+12	0.0000E+00	2.3650E-01	0

nod1	nod2	index	dell	del2	dlong	drad	hint	rint	area	ihlcor
5004	6004	2794	1.5000E+00	1.5000E+00	2.7590E-01	1.0000E+00	1.0000E+12	0.0000E+00	2.7590E-01	0
5101	6101	2795	1.5000E+00	1.5000E+00	1.3080E+00	1.0000E+00	1.0000E+12	0.0000E+00	1.3080E+00	0
5102	6102	2796	1.5000E+00	1.5000E+00	3.7340E+00	1.0000E+00	1.0000E+12	0.0000E+00	3.7340E+00	0
5103	6103	2797	1.5000E+00	1.5000E+00	1.0110E+00	1.0000E+00	1.0000E+12	0.0000E+00	1.0110E+00	0
5110	6110	2798	2.5800E+00	2.5800E+00	1.7500E+00	1.5000E+00	1.0000E+12	0.0000E+00	2.6250E+00	0
5111	6111	2799	2.5800E+00	2.5800E+00	1.7500E+00	1.5000E+00	1.0000E+12	0.0000E+00	2.6250E+00	0
5112	6112	2800	2.5800E+00	2.5800E+00	1.7500E+00	1.5000E+00	1.0000E+12	0.0000E+00	1.7500E+00	0
5113	6113	2801	2.5800E+00	2.5800E+00	1.2500E+00	1.0000E+00	1.0000E+12	0.0000E+00	1.2500E+00	0
5100	5101	2802	0.0000E+00	3.7700E-01	2.6300E+00	3.0000E+00	1.0000E+12	0.0000E+00	7.8900E+00	0
5101	5102	2803	3.7700E-01	9.1330E-01	3.3180E+00	3.0000E+00	1.0000E+12	0.0000E+00	9.9540E+00	0
5102	5103	2804	8.8800E-01	6.1700E-01	2.4420E+00	3.0000E+00	1.0000E+12	0.0000E+00	7.3260E+00	0
5102	5110	2805	4.3000E-01	1.5100E+00	5.6300E-01	8.0000E+00	3.4700E+00	0.0000E+00	4.5040E+00	0
5103	5111	2806	8.0700E-01	1.5600E+00	5.6300E-01	8.0000E+00	3.4700E+00	0.0000E+00	4.5040E+00	0
5103	5113	2807	6.4500E-01	5.3100E-01	4.6900E-01	8.0000E+00	5.0000E-01	0.0000E+00	3.7520E+00	0
5110	5111	2808	7.5000E-01	7.5000E-01	6.5600E-01	8.0000E+00	1.0000E+12	0.0000E+00	5.2480E+00	0
5111	5112	2809	7.5000E-01	5.0000E-01	6.5600E-01	8.0000E+00	1.0000E+12	0.0000E+00	5.2480E+00	0
5112	5113	2810	1.5100E+00	1.0800E+00	3.7500E-01	8.0000E+00	1.0000E+12	0.0000E+00	3.0000E+00	0

variable internal thermal connections

nod1	nod2	neon	ij	ihlcor	type	hint	area	bridge temp
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6308	6401	50	1	5	user specified thermal conn. data	0.00000E+00	0.00000E+00	0.0
					hint (btu/hr-in**2-f) time (hr)			
					1.00000E-12 0.0000			
					1.00000E-12 0.2200			
					5.83000E-01 0.2220			
					5.83000E-01 10.0000			
8308	8401	51	2	5	user specified thermal conn. data	0.00000E+00	0.00000E+00	0.0
					hint (btu/hr-in**2-f) time (hr)			
					1.00000E-12 0.0000			
					1.00000E-12 0.2200			
					5.83000E-01 0.2220			
					5.83000E-01 10.0000			
10308	10401	52	3	5	user specified thermal conn. data	0.00000E+00	0.00000E+00	0.0
					hint (btu/hr-in**2-f) time (hr)			
					1.00000E-12 0.0000			
					1.00000E-12 0.2200			
					5.83000E-01 0.2220			
					5.83000E-01 10.0000			
12308	12401	53	4	5	user specified thermal conn. data	0.00000E+00	0.00000E+00	0.0
					hint (btu/hr-in**2-f) time (hr)			
					1.00000E-12 0.0000			
					1.00000E-12 0.2200			
					5.83000E-01 0.2220			
					5.83000E-01 10.0000			
14308	14401	54	5	5	user specified thermal conn. data	0.00000E+00	0.00000E+00	0.0
					hint (btu/hr-in**2-f) time (hr)			
					1.00000E-12 0.0000			
					1.00000E-12 0.2200			
					5.83000E-01 0.2220			
					5.83000E-01 10.0000			
16308	16401	55	6	5	user specified thermal conn. data	0.00000E+00	0.00000E+00	0.0
					hint (btu/hr-in**2-f) time (hr)			
					1.00000E-12 0.0000			
					1.00000E-12 0.2200			
					5.83000E-01 0.2220			
					5.83000E-01 10.0000			
18308	18401	56	7	5	user specified thermal conn. data	0.00000E+00	0.00000E+00	0.0
					hint (btu/hr-in**2-f) time (hr)			
					1.00000E-12 0.0000			
					1.00000E-12 0.2200			
					5.83000E-01 0.2220			
					5.83000E-01 10.0000			
6309	6402	64	8	5	user specified thermal conn. data	0.00000E+00	0.00000E+00	0.0

7.08900E-01 3320.6
8.13500E-01 4040.6
9.36800E-01 4940.6

data block 6

external thermal connectors

nods	nodsb	index	ltabh	power	dlong	drad	hsure	rsure	areas
5305	1000	1	-4	0.0000E+00	2.1210E+00	3.0000E+00	0.0000E+00	0.0000E+00	6.3630E+00
	hsurt	slope	tvarh						
	0.174000E+00	0.000000E+00	0.000000E+00						
	1.740000E-01	0.000000E+00	2.200000E-01						
	0.000000E+00	-8.700000E+01	2.220000E-01						
	0.000000E+00	0.000000E+00	1.000000E+01						
5311	1000	2	-4	0.0000E+00	1.9050E+00	3.0000E+00	0.0000E+00	0.0000E+00	5.7150E+00
	hsurt	slope	tvarh						
	0.174000E+00	0.000000E+00	0.000000E+00						
	1.740000E-01	0.000000E+00	2.200000E-01						
	0.000000E+00	-8.700000E+01	2.220000E-01						
	0.000000E+00	0.000000E+00	1.000000E+01						
5310	1000	3	-4	0.0000E+00	1.3360E+00	3.0000E+00	0.0000E+00	0.0000E+00	4.0080E+00
	hsurt	slope	tvarh						
	0.139000E+00	0.000000E+00	0.000000E+00						
	1.390000E-01	0.000000E+00	2.200000E-01						
	0.000000E+00	-6.950000E+01	2.220000E-01						
	0.000000E+00	0.000000E+00	1.000000E+01						
5309	1000	4	-4	0.0000E+00	1.0050E+00	3.0000E+00	0.0000E+00	0.0000E+00	3.0150E+00
	hsurt	slope	tvarh						
	0.139000E+00	0.000000E+00	0.000000E+00						
	1.390000E-01	0.000000E+00	2.200000E-01						
	0.000000E+00	-6.950000E+01	2.220000E-01						
	0.000000E+00	0.000000E+00	1.000000E+01						
5308	1000	5	-4	0.0000E+00	3.7600E-01	3.0000E+00	0.0000E+00	0.0000E+00	1.1280E+00
	hsurt	slope	tvarh						
	0.172000E+00	0.000000E+00	0.000000E+00						
	1.720000E-01	0.000000E+00	2.200000E-01						
	0.000000E+00	-8.600000E+01	2.220000E-01						
	0.000000E+00	0.000000E+00	1.000000E+01						
6305	1000	6	-4	0.0000E+00	2.1210E+00	4.0000E+00	0.0000E+00	0.0000E+00	8.4840E+00
	hsurt	slope	tvarh						
	0.174000E+00	0.000000E+00	0.000000E+00						
	1.740000E-01	0.000000E+00	2.200000E-01						
	0.000000E+00	-8.700000E+01	2.220000E-01						
	0.000000E+00	0.000000E+00	1.000000E+01						
7305	1000	7	-4	0.0000E+00	2.1210E+00	4.0000E+00	0.0000E+00	0.0000E+00	8.4840E+00
	hsurt	slope	tvarh						

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56308 1000 264 -4 0.0000E+00 3.7600E-01 4.0000E+00 0.0000E+00 0.0000E+00 1.5040E+00

      hsurf      slope      tvarh
0.172000E+00 0.000000E+00 0.000000E+00
1.720000E-01 0.000000E+00 2.200000E-01
0.000000E+00 -8.600000E+01 2.220000E-01
0.000000E+00 0.000000E+00 1.000000E+01

      noda noda index ltabh      power      dlong      drad      hsure      rsure      areas
57308 1000 265 -4 0.0000E+00 3.7600E-01 4.0000E+00 0.0000E+00 0.0000E+00 1.5040E+00

      hsurf      slope      tvarh
0.172000E+00 0.000000E+00 0.000000E+00
1.720000E-01 0.000000E+00 2.200000E-01
0.000000E+00 -8.600000E+01 2.220000E-01
0.000000E+00 0.000000E+00 1.000000E+01

      noda noda index ltabh      power      dlong      drad      hsure      rsure      areas
401 3000 266 0 0.0000E+00 1.8020E-01 1.0000E+00 1.0000E+12 0.0000E+00 1.8020E-01
402 3000 267 0 0.0000E+00 9.8770E-01 1.0000E+00 1.0000E+12 0.0000E+00 9.8770E-01
403 3000 268 0 0.0000E+00 1.1069E+00 1.0000E+00 1.0000E+12 0.0000E+00 1.1069E+00
=====

```

data block 7 external temps

```

      noda index ltabt      tempb      slope      timeb
2000 1 0 1.500000E+02 0.000000E+00 0.000000E+00
1000 2 0 4.687000E+02 0.000000E+00 0.000000E+00
3000 3 0 3.249000E+02 0.000000E+00 0.000000E+00
=====

```

data block 9 power generation rates

```

baker metal-water reaction model used
tfail = 1.900E+03

```

power - time table

```

      pmult      time (hrs)
4.73500E-02 0.00000E+00
4.02700E-02 1.00000E-02
3.41500E-02 2.39000E-02
2.97900E-02 7.94000E-02
2.73200E-02 1.35000E-01
2.55200E-02 1.90600E-01
2.41100E-02 2.46100E-01
2.14600E-02 3.85000E-01
1.95800E-02 5.23900E-01
1.54100E-02 1.07940E+00
1.34000E-02 1.63500E+00
1.21900E-02 2.19060E+00
1.13600E-02 2.74610E+00
1.00100E-02 4.13500E+00
9.16900E-03 5.52390E+00
7.39200E-03 1.10794E+01
6.42400E-03 1.66350E+01
5.79200E-03 2.21906E+01
5.32400E-03 2.77460E+01
4.51200E-03 4.16350E+01

```

axial power factor and power integral table

elevation (in)	paxial	pintegral (in)
0.000	0.0000	1.0
26.200	0.0000	1.0
32.500	0.3975	1.0
40.500	0.5393	1.0
48.500	0.7058	1.0
56.500	0.7398	1.0
64.500	0.8895	1.0
72.500	1.0358	1.0
80.500	0.9075	1.0
88.500	1.0036	1.0
96.500	1.0674	1.0
104.500	1.1398	1.0
112.500	1.2026	1.0
120.500	1.2558	1.0
128.500	1.2996	1.0
136.500	1.3341	1.0
144.500	1.3596	1.0
152.500	1.3766	1.0
160.500	1.3702	1.0
168.500	1.3779	1.0
176.500	1.3836	1.0
184.500	1.3854	1.0
192.500	1.3810	1.0
200.500	1.3691	1.0
208.500	1.3490	1.0
216.500	1.3195	1.0
224.500	1.2773	1.0
232.500	1.2109	1.0
240.500	1.2070	1.0
248.500	1.2648	1.0
236.500	1.2648	236.5

uranium oxide area variation table

oxmult	oxtemp (f)
2.50000E+00	1.90000E+03
2.50000E+00	2.06999E+03
2.50000E+00	2.07000E+03
2.00000E+00	5.50000E+04

*** power generation summary ***

rod average power (fission and gamma heat) 173.240 kw/ft
the average gamma contribution is 0.000 percent of the rod average power
the average fission heat generation rate is 1.60235E+04 btu/hr-in**3
the power ratio is *****

note	index	paxial	pradial	pfact1	plocal	tt	gg	h/z	aa	npc
4108	1	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	4.50000E+02	0.00000E+00	0.101	0.000	0
4118	2	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	4.50000E+02	0.00000E+00	0.101	0.000	0
4402	3	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	4.50000E+02	0.00000E+00	0.101	0.000	0

note	index	psdial	pradial	pfacta	plscal	ll	yy	h/z	aa	npc
39122	1198	1.37212E+00	1.66800E-03	2.20870E-03	2.37707E+02	9.00000E+02	3.66731E+01	0.687	0.000	0
43122	1199	1.38405E+00	1.66800E-03	2.30860E-03	2.39773E+02	9.00000E+02	3.69918E+01	0.755	0.000	0
47122	1200	1.37803E+00	1.66800E-03	2.29855E-03	2.38729E+02	9.00000E+02	3.68308E+01	0.822	0.000	0
51122	1201	1.34163E+00	1.66800E-03	2.23783E-03	2.32423E+02	9.00000E+02	3.58579E+01	0.890	0.000	0
55122	1202	1.26070E+00	1.66800E-03	2.10285E-03	2.18404E+02	9.00000E+02	3.36950E+01	0.958	0.000	0
19123	1203	9.31525E-01	1.66800E-03	1.55378E-03	1.61377E+02	9.20000E+02	2.48971E+01	0.349	0.000	0
23123	1204	1.08550E+00	1.66800E-03	1.10106E-03	1.08052E+02	9.20000E+02	2.90124E+01	0.416	0.000	0
27123	1205	1.21590E+00	1.66800E-03	2.02012E-03	2.10643E+02	9.20000E+02	3.24976E+01	0.484	0.000	0
31123	1206	1.30822E+00	1.66800E-03	2.18212E-03	2.26637E+02	9.20000E+02	3.49652E+01	0.552	0.000	0
35123	1207	1.36385E+00	1.66800E-03	2.27490E-03	2.36273E+02	9.20000E+02	3.64519E+01	0.619	0.000	0
39123	1208	1.37212E+00	1.66800E-03	2.28870E-03	2.37707E+02	9.20000E+02	3.66731E+01	0.687	0.000	0
43123	1209	1.38405E+00	1.66800E-03	2.30860E-03	2.39773E+02	9.20000E+02	3.69918E+01	0.755	0.000	0
47123	1210	1.37803E+00	1.66800E-03	2.29855E-03	2.38729E+02	9.20000E+02	3.68308E+01	0.822	0.000	0
51123	1211	1.34163E+00	1.66800E-03	2.23783E-03	2.32423E+02	9.20000E+02	3.58579E+01	0.890	0.000	0
55123	1212	1.26070E+00	1.66800E-03	2.10285E-03	2.18404E+02	9.20000E+02	3.36950E+01	0.958	0.000	0
20120	1213	9.79575E-01	1.66800E-03	1.63393E-03	1.69702E+02	6.00000E+02	2.61813E+01	0.366	0.000	0
24120	1214	1.12170E+00	1.66800E-03	1.87100E-03	1.94323E+02	6.00000E+02	2.99799E+01	0.433	0.000	0
28120	1215	1.24250E+00	1.66800E-03	2.07249E-03	2.15251E+02	6.00000E+02	3.32086E+01	0.501	0.000	0
32120	1216	1.32547E+00	1.66800E-03	2.21089E-03	2.29625E+02	6.00000E+02	3.54263E+01	0.569	0.000	0
36120	1217	1.37235E+00	1.66800E-03	2.28908E-03	2.37746E+02	6.00000E+02	3.66791E+01	0.636	0.000	0
40120	1218	1.37597E+00	1.66800E-03	2.29513E-03	2.38374E+02	6.00000E+02	3.67760E+01	0.704	0.000	0
44120	1219	1.38495E+00	1.66800E-03	2.31010E-03	2.39929E+02	6.00000E+02	3.70159E+01	0.772	0.000	0
48120	1220	1.37208E+00	1.66800E-03	2.28862E-03	2.37698E+02	6.00000E+02	3.66718E+01	0.839	0.000	0
52120	1221	1.32688E+00	1.66800E-03	2.21323E-03	2.29868E+02	6.00000E+02	3.54637E+01	0.907	0.000	0
56120	1222	1.22750E+00	1.66800E-03	2.04747E-03	2.12652E+02	6.00000E+02	3.28077E+01	0.975	0.000	0
20121	1223	9.79575E-01	1.66800E-03	1.63393E-03	1.69702E+02	8.00000E+02	2.61813E+01	0.366	0.000	0
24121	1224	1.12170E+00	1.66800E-03	1.87100E-03	1.94323E+02	8.00000E+02	2.99799E+01	0.433	0.000	0
28121	1225	1.24250E+00	1.66800E-03	2.07249E-03	2.15251E+02	8.00000E+02	3.32086E+01	0.501	0.000	0
32121	1226	1.32547E+00	1.66800E-03	2.21089E-03	2.29625E+02	8.00000E+02	3.54263E+01	0.569	0.000	0
36121	1227	1.37235E+00	1.66800E-03	2.28908E-03	2.37746E+02	8.00000E+02	3.66791E+01	0.636	0.000	0
40121	1228	1.37597E+00	1.66800E-03	2.29513E-03	2.38374E+02	8.00000E+02	3.67760E+01	0.704	0.000	0
44121	1229	1.38495E+00	1.66800E-03	2.31010E-03	2.39929E+02	8.00000E+02	3.70159E+01	0.772	0.000	0
48121	1230	1.37208E+00	1.66800E-03	2.28862E-03	2.37698E+02	8.00000E+02	3.66718E+01	0.839	0.000	0
52121	1231	1.32688E+00	1.66800E-03	2.21323E-03	2.29868E+02	8.00000E+02	3.54637E+01	0.907	0.000	0
56121	1232	1.22750E+00	1.66800E-03	2.04747E-03	2.12652E+02	8.00000E+02	3.28077E+01	0.975	0.000	0
20122	1233	9.79575E-01	1.66800E-03	1.63393E-03	1.69702E+02	9.00000E+02	2.61813E+01	0.366	0.000	0
24122	1234	1.12170E+00	1.66800E-03	1.87100E-03	1.94323E+02	9.00000E+02	2.99799E+01	0.433	0.000	0
28122	1235	1.24250E+00	1.66800E-03	2.07249E-03	2.15251E+02	9.00000E+02	3.32086E+01	0.501	0.000	0
32122	1236	1.32547E+00	1.66800E-03	2.21089E-03	2.29625E+02	9.00000E+02	3.54263E+01	0.569	0.000	0
36122	1237	1.37235E+00	1.66800E-03	2.28908E-03	2.37746E+02	9.00000E+02	3.66791E+01	0.636	0.000	0
40122	1238	1.37597E+00	1.66800E-03	2.29513E-03	2.38374E+02	9.00000E+02	3.67760E+01	0.704	0.000	0
44122	1239	1.38495E+00	1.66800E-03	2.31010E-03	2.39929E+02	9.00000E+02	3.70159E+01	0.772	0.000	0
48122	1240	1.37208E+00	1.66800E-03	2.28862E-03	2.37698E+02	9.00000E+02	3.66718E+01	0.839	0.000	0
52122	1241	1.32688E+00	1.66800E-03	2.21323E-03	2.29868E+02	9.00000E+02	3.54637E+01	0.907	0.000	0
56122	1242	1.22750E+00	1.66800E-03	2.04747E-03	2.12652E+02	9.00000E+02	3.28077E+01	0.975	0.000	0
20123	1243	9.79575E-01	1.66800E-03	1.63393E-03	1.69702E+02	9.20000E+02	2.61813E+01	0.366	0.000	0
24123	1244	1.12170E+00	1.66800E-03	1.87100E-03	1.94323E+02	9.20000E+02	2.99799E+01	0.433	0.000	0
28123	1245	1.24250E+00	1.66800E-03	2.07249E-03	2.15251E+02	9.20000E+02	3.32086E+01	0.501	0.000	0
32123	1246	1.32547E+00	1.66800E-03	2.21089E-03	2.29625E+02	9.20000E+02	3.54263E+01	0.569	0.000	0
36123	1247	1.37235E+00	1.66800E-03	2.28908E-03	2.37746E+02	9.20000E+02	3.66791E+01	0.636	0.000	0
40123	1248	1.37597E+00	1.66800E-03	2.29513E-03	2.38374E+02	9.20000E+02	3.67760E+01	0.704	0.000	0
44123	1249	1.38495E+00	1.66800E-03	2.31010E-03	2.39929E+02	9.20000E+02	3.70159E+01	0.772	0.000	0
48123	1250	1.37208E+00	1.66800E-03	2.28862E-03	2.37698E+02	9.20000E+02	3.66718E+01	0.839	0.000	0
52123	1251	1.32688E+00	1.66800E-03	2.21323E-03	2.29868E+02	9.20000E+02	3.54637E+01	0.907	0.000	0
56123	1252	1.22750E+00	1.66800E-03	2.04747E-03	2.12652E+02	9.20000E+02	3.28077E+01	0.975	0.000	0

data block 10

mass flow connectors

the steam limiting model was not used for this simulation

an initial flow rate of 2.043000E+01 lbm/hr was user prescribed for flow region 1

flow region hydraulic diameter = 0.00000E+00 in; flow region cross-sectional area= 4.50000E-02 in**2

nodf1	nodf2	index	ltabf1	flowt	slof1	tvarf1	delf1	delf2	fregion
401	1401	1	0	2.043000E+01			0.000000E+00	1.000000E+00	1
1401	2401	2	0	2.043000E+01			0.000000E+00	1.000000E+00	1
2401	3401	3	0	2.043000E+01			0.000000E+00	1.000000E+00	1
3401	4401	4	0	2.043000E+01			0.000000E+00	1.000000E+00	1
4401	5401	5	0	2.043000E+01			0.000000E+00	1.000000E+00	1
5401	6401	6	0	2.043000E+01			0.000000E+00	1.000000E+00	1
6401	7401	7	0	2.043000E+01			0.000000E+00	1.000000E+00	1
7401	8401	8	0	2.043000E+01			0.000000E+00	1.000000E+00	1
8401	9401	9	0	2.043000E+01			0.000000E+00	1.000000E+00	1
9401	10401	10	0	2.043000E+01			0.000000E+00	1.000000E+00	1
10401	11401	11	0	2.043000E+01			0.000000E+00	1.000000E+00	1
11401	12401	12	0	2.043000E+01			0.000000E+00	1.000000E+00	1
12401	13401	13	0	2.043000E+01			0.000000E+00	1.000000E+00	1
13401	14401	14	0	2.043000E+01			0.000000E+00	1.000000E+00	1
14401	15401	15	0	2.043000E+01			0.000000E+00	1.000000E+00	1
15401	16401	16	0	2.043000E+01			0.000000E+00	1.000000E+00	1
16401	17401	17	0	2.043000E+01			0.000000E+00	1.000000E+00	1
17401	18401	18	0	2.043000E+01			0.000000E+00	1.000000E+00	1
18401	19401	19	0	2.043000E+01			0.000000E+00	1.000000E+00	1
19401	20401	20	0	2.043000E+01			0.000000E+00	1.000000E+00	1
20401	21401	21	0	2.043000E+01			0.000000E+00	1.000000E+00	1
21401	22401	22	0	2.043000E+01			0.000000E+00	1.000000E+00	1
22401	23401	23	0	2.043000E+01			0.000000E+00	1.000000E+00	1
23401	24401	24	0	2.043000E+01			0.000000E+00	1.000000E+00	1
24401	25401	25	0	2.043000E+01			0.000000E+00	1.000000E+00	1
25401	26401	26	0	2.043000E+01			0.000000E+00	1.000000E+00	1
26401	27401	27	0	2.043000E+01			0.000000E+00	1.000000E+00	1
27401	28401	28	0	2.043000E+01			0.000000E+00	1.000000E+00	1
28401	29401	29	0	2.043000E+01			0.000000E+00	1.000000E+00	1
29401	30401	30	0	2.043000E+01			0.000000E+00	1.000000E+00	1
30401	31401	31	0	2.043000E+01			0.000000E+00	1.000000E+00	1
31401	32401	32	0	2.043000E+01			0.000000E+00	1.000000E+00	1
32401	33401	33	0	2.043000E+01			0.000000E+00	1.000000E+00	1
33401	34401	34	0	2.043000E+01			0.000000E+00	1.000000E+00	1
34401	35401	35	0	2.043000E+01			0.000000E+00	1.000000E+00	1
35401	36401	36	0	2.043000E+01			0.000000E+00	1.000000E+00	1
36401	37401	37	0	2.043000E+01			0.000000E+00	1.000000E+00	1
37401	38401	38	0	2.043000E+01			0.000000E+00	1.000000E+00	1
38401	39401	39	0	2.043000E+01			0.000000E+00	1.000000E+00	1
39401	40401	40	0	2.043000E+01			0.000000E+00	1.000000E+00	1
40401	41401	41	0	2.043000E+01			0.000000E+00	1.000000E+00	1
41401	42401	42	0	2.043000E+01			0.000000E+00	1.000000E+00	1
42401	43401	43	0	2.043000E+01			0.000000E+00	1.000000E+00	1
43401	44401	44	0	2.043000E+01			0.000000E+00	1.000000E+00	1
44401	45401	45	0	2.043000E+01			0.000000E+00	1.000000E+00	1
45401	46401	46	0	2.043000E+01			0.000000E+00	1.000000E+00	1
46401	47401	47	0	2.043000E+01			0.000000E+00	1.000000E+00	1
47401	48401	48	0	2.043000E+01			0.000000E+00	1.000000E+00	1
48401	49401	49	0	2.043000E+01			0.000000E+00	1.000000E+00	1
49401	50401	50	0	2.043000E+01			0.000000E+00	1.000000E+00	1
50401	51401	51	0	2.043000E+01			0.000000E+00	1.000000E+00	1
51401	52401	52	0	2.043000E+01			0.000000E+00	1.000000E+00	1
52401	53401	53	0	2.043000E+01			0.000000E+00	1.000000E+00	1
53401	54401	54	0	2.043000E+01			0.000000E+00	1.000000E+00	1
54401	55401	55	0	2.043000E+01			0.000000E+00	1.000000E+00	1
55401	56401	56	0	2.043000E+01			0.000000E+00	1.000000E+00	1
56401	57401	57	0	2.043000E+01			0.000000E+00	1.000000E+00	1

flow region hydraulic diameter = 0.00000E+00 in; flow region cross-sectional area= 9.62100E-02 in**2

nodf1	nodf2	index	ltabfl	flowt	alofl	tvarfl	delf1	delf2	fregion
404	19404	172	0	5.500000E+03			1.000000E+00	1.000000E+00	4
404	23404	173	0	5.500000E+03			1.000000E+00	1.000000E+00	4
404	27404	174	0	5.500000E+03			1.000000E+00	1.000000E+00	4
404	31404	175	0	5.500000E+03			1.000000E+00	1.000000E+00	4
404	35404	176	0	5.500000E+03			1.000000E+00	1.000000E+00	4
404	39404	177	0	5.500000E+03			1.000000E+00	1.000000E+00	4
404	43404	178	0	5.500000E+03			1.000000E+00	1.000000E+00	4
404	47404	179	0	5.500000E+03			1.000000E+00	1.000000E+00	4
404	51404	180	0	5.500000E+03			1.000000E+00	1.000000E+00	4
404	55404	181	0	5.500000E+03			1.000000E+00	1.000000E+00	4

an initial flow rate of 5.500000E+03 lbm/hr was user prescribed for flow region 5

flow region hydraulic diameter = 0.00000E+00 in; flow region cross-sectional area= 9.62100E-02 in**2

nodf1	nodf2	index	ltabfl	flowt	alofl	tvarfl	delf1	delf2	fregion
404	20404	182	0	5.500000E+03			1.000000E+00	1.000000E+00	5
404	24404	183	0	5.500000E+03			1.000000E+00	1.000000E+00	5
404	28404	184	0	5.500000E+03			1.000000E+00	1.000000E+00	5
404	32404	185	0	5.500000E+03			1.000000E+00	1.000000E+00	5
404	36404	186	0	5.500000E+03			1.000000E+00	1.000000E+00	5
404	40404	187	0	5.500000E+03			1.000000E+00	1.000000E+00	5
404	44404	188	0	5.500000E+03			1.000000E+00	1.000000E+00	5
404	48404	189	0	5.500000E+03			1.000000E+00	1.000000E+00	5
404	52404	190	0	5.500000E+03			1.000000E+00	1.000000E+00	5
404	56404	191	0	5.500000E+03			1.000000E+00	1.000000E+00	5

data ended -1

machine time () = 5 seconds. cpu,i/o,sys percents = unknown

*** trump input parameter list***

```

(m1 = 1)
(m2 = 10)
(m3 = 1)
(m4 = 1801)
(m5 = 4201)
(m6 = 300)
(m7 = 8)
(m8 = 200)
(m9 = 501)
(ma = 251)
(mb = 10)
(mc = 60)
(md = 700)
(me = 501)
(mg = 120)
(mi0 = 251)
(m11 = 10)
(m12 = 60)
(m13 = 700)
(m14 = 501)
(m15 = 120)

```

```

summary of input data
block number      2      4      5      6      7      8      9     10     12
times read in    1 1001 1001 2001 1 1000 1001 1001 1000
item name        mat node nod1 nodes nodb nodg note nodfl nodpl
maximum size     10 1801 4201 300  8  200 501 251 12
unmodified size  0  0  0  0  0  0  0  0  0
final size       4 1668 2810 268  3  0 1252 191  0

```

```

tables          nvarc  nvarh  nvarh  nvarh  nvarh  nvarfl  total
                4      3      265    0      0      0      272

```

maximum allowed table length is 501.

```

other totals    nospec nogen norad norads nmelt nreact
                561  901  262    0    0    0

```

material summary

name	matl	nodes	density	capacity	tot vol	tot mass	tot cap	tot heat
u-mtl	1	212	6.83000E-01	3.13000E-02	1.58334E+02	1.08142E+02	3.38486E+00	2.36940E+03
graph	2	586	6.14000E-02	2.20000E-01	2.86889E+03	1.76150E+02	3.87529E+01	3.31489E+04
zr-cl	100	675	2.37370E-01	6.70000E-02	1.78860E+02	4.24559E+01	2.84454E+00	1.52213E+03
steam	10	195	6.94000E-04	6.62000E-01	1.49866E+02	1.04007E-01	6.88526E-02	3.09837E+01

```

system total 1668          3.35595E+03  3.26852E+02  4.50512E+01  3.70714E+04
trump-bd version 2.18 output data

```

*ver2.17 trump bd full power spiked hot channel reflood station blackout (hygen.

```

-----
printout cycle  mf  mas  kwit  deltmx  small  tvary  dtemp  dtmaxs  nuts
              1   0   0   1   0  0.10000E-09  0.10000E-11  0.50000E+01  0.30975E-06  0.00000E+00  0

total time      time step      heat flow      temp from flux      flux rate      temp rate
1.00000E-12    1.00000E-12    -3.85797E-08    -5.43846E-10    -3.85797E+04    -5.43846E+02

sys pres       sat temp       heat content      gen rate      pigral      ffactor
2.00000E+02    0.00000E+00    4.99095E+04    1.38233E+05    0.00000E+00    1.00000E+00

boil level     x interface      lower bound      rodave      gfactor      bundle flow
1              0.00000E+00    0.00000E+00    1.73240E+02    4.73500E-02    0.00000E+00
-----

```

cladm= 7.00000E+02 fuelmx= 7.00000E+02 at 3.60000E-09 seconds

peak fuel temperature level:pin no.: (44: 2) peak clad temperature level:pin no.: (45: 0)

material data

name matl,	tot cap	tot heat	avg temp
u-mtl 1	3.38486E+00	2.20016E+03	7.00000E+02

hmelt	tmelt
4.906000E+00	1.247000E+03
8.278000E+00	1.425000E+03
2.286100E+00	2.007000E+03

name matl,	tot cap	tot heat	avg temp
graph 2	6.42446E+01	4.61798E+04	8.61618E+02

name	matl,	tot cap	tot heat	avg temp
zr-cl	100	3.24510E+00	1.51183E+03	5.36207E+02

name	matl,	tot cap	tot heat	avg temp
steam	10	6.41534E-02	1.77372E+01	4.50000E+02

boundary node data

nodeb	tempb	heat flow	avg rate
2000	1.5000E+02	0.0000E+00	0.0000E+00
1000	4.6870E+02	-3.8581E-08	-3.8581E+04
3000	3.2490E+02	1.3642E-12	1.3642E+00

system total	-3.8580E-08	-3.8580E+04
--------------	-------------	-------------

external connection data

nodea	nodeb	areaa	hsura	power	rsura	trans	heat flow	avg rate
5305	1000	6.3630E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.1072E+00	-5.4902E-11	-5.4902E+01
5311	1000	5.7150E+00	1.7400E-01	0.0000E+00	0.0000E+00	9.9441E-01	-2.2358E-10	-2.2358E+02
5310	1000	4.0080E+00	1.3900E-01	0.0000E+00	0.0000E+00	5.5711E-01	-1.2862E-10	-1.2862E+02
5309	1000	3.0150E+00	1.3900E-01	0.0000E+00	0.0000E+00	4.1909E-01	-9.6668E-11	-9.6668E+01
5308	1000	1.1280E+00	1.7200E-01	0.0000E+00	0.0000E+00	1.9402E-01	-4.4774E-11	-4.4774E+01
6305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
7305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
8305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
9305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
10305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
11305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
12305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
13305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
14305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
15305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
16305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
17305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
18305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
19305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
20305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
21305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
22305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
23305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
24305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
25305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
26305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
27305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
28305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
29305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
30305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
31305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
32305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
33305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
34305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
35305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
36305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
37305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
38305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
39305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
40305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
41305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
42305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
43305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
44305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
45305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01
46305	1000	8.4840E+00	1.7400E-01	0.0000E+00	0.0000E+00	1.4762E+00	-7.3203E-11	-7.3203E+01

```

29308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
30308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
31308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
32308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
33308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
34308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
35308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
36308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
37308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
38308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
39308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
40308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
41308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
42308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
43308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
44308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
45308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
46308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
47308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
48308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
49308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
50308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
51308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
52308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
53308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
54308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
55308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
56308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
57308 1000 1.5040E+00 1.7200E-01 0.0000E+00 0.0000E+00 2.5869E-01 -5.9699E-11 -5.9699E+01
401 3000 1.8020E-01 1.0000E+12 0.0000E+00 0.0000E+00 1.8020E+11 0.0000E+00 0.0000E+00
402 3000 9.8770E-01 1.0000E+12 0.0000E+00 0.0000E+00 9.8770E+11 4.5475E-13 4.5475E-01
403 3000 1.1069E+00 1.0000E+12 0.0000E+00 0.0000E+00 1.1069E+12 9.0949E-13 9.0949E-01

```

```

=====
keyc = 0, iterations... total = 0, average = 0, maximum = 0. for = 0.570
trump-bd version 2.18 output data data deck 1

```

```

*ver2.17 trump bd full power spiked hot channel reflood station blackout (hygen).

```

```

=====
printout cycle mf mss kwit deltmx small tvary dtmp dtmaxs nuta
2 1 1 0 0.64740E-07 0.64740E-09 0.50000E+01 0.33347E+02 0.00000E+00 0

total time time step heat flow temp from flux flux rate temp rate
1.01000E-10 1.00000E-10 -3.89669E-06 -5.49304E-08 -3.85811E+04 -5.43865E+02

sys pres sat temp heat content gen rate pigral ffactor
2.00000E+02 0.00000E+00 4.99095E+04 1.38233E+05 0.00000E+00 1.00000E+00

boil level x interface lower bound rodave gfactor bundle flow
1 0.00000E+00 0.00000E+00 1.73240E+02 4.73500E-02 0.00000E+00

```

```

=====
cladm= 7.00000E+02 fuelmx= 7.00000E+02 at 3.63600E-07 seconds

```

```

peak fuel temperature level:pin no.: ( 44: 2 ) peak clad temperature level:pin no.: ( 44: 0 )

```

```

material data

```

```

name matl, tot cap tot heat avg temp
u-mtl 1 3.38486E+00 2.20016E+03 7.00000E+02

hmelt tmelt

```

4.906000E+00 1.247000E+03
8.278000E+00 1.425000E+03
2.286100E+00 2.007000E+03

name matl, tot cap tot heat avg temp
graph 2 6.42446E+01 4.61797E+04 8.61618E+02

name matl, tot cap tot heat avg temp
zz-cl 100 3.24510E+00 1.51183E+03 5.36207E+02

name matl, tot cap tot heat avg temp
steam 10 6.41534E-02 1.77372E+01 4.50000E+02

boundary node data

node temp heat flow avg rate
2000 1.5000E+02 0.0000E+00 0.0000E+00
1000 4.6870E+02 -3.8967E-06 -3.8581E+04
3000 3.2490E+02 1.3642E-12 1.3507E-02

system total -3.8967E-06 -3.8581E+04

kcyc = 1, iterations... total = 0, average = 0, maximum = 0, for = 0.570
special temps 5001 615.9 10001 792.2 14001 847.7 18001 874.4 22001 906.3 30001 975.8 38001 1090.3
special phchg 5001 1.000#1 10001 1.000#1 14001 1.000#1 18001 1.000#1 22001 1.000#1 30001 1.000#1 38001 1.000#1
special cladmx= 1.06453E+03 at 61.04 seconds
special temps 44001 1004.1 46001 1003.3 54001 975.8 5003 607.0 10003 817.2 14003 883.3 18003 915.2
special phchg 44001 1.000#1 46001 1.000#1 54001 1.000#1 5003 1.000#1 10003 1.000#1 14003 1.000#1 18003 1.000#1
special cladmx= 1.06453E+03 at 61.04 seconds
special temps 22003 953.2 30003 1035.9 38003 1065.0 44003 1069.6 46003 1068.6 54003 1035.8 5306 639.4
special phchg 22003 1.000#1 30003 1.000#1 38003 1.000#1 44003 1.000#1 46003 1.000#1 54003 1.000#1 5306 1.000#1
special cladmx= 1.06453E+03 at 61.04 seconds
special temps 10306 658.6 14306 659.3 18306 659.3 22306 659.6 30306 660.4 38306 660.7 44306 655.7
special phchg 10306 1.000#1 14306 1.000#1 18306 1.000#1 22306 1.000#1 30306 1.000#1 38306 1.000#1 44306 1.000#1
special cladmx= 1.06453E+03 at 61.04 seconds
special temps 46306 660.8 54306 660.4 5101 785.1 10101 816.0 53003 1042.9 57001 953.1 57003 1008.8
special cladmx= 1.06453E+03 at 61.04 seconds
special temps 53001 981.7 50001 995.1 50003 1058.8 42001 1003.3 42003 1068.6
special cladmx= 1.06453E+03 at 61.04 seconds

1 trump-bd version 2.18 output data data deck 1

*var2.17 trump bd full power spiked hot channel reflood station blackout (hygen.)

printout cycle mf mss kwit deltmx small tvary dtemp dtmaxa nuts
3 344 4 15 0 0.11230E-02 0.30071E-05 0.50000E+01 0.34126E+01 0.27500E+01 22

total time time step heat flow temp from flux flux rate temp rate
3.3333E-02 9.05732E-04 -2.72150E+03 -3.83941E+01 -8.16450E+04 -1.15182E+03

sys pres sat temp heat content gen rate pigral ffactor
2.00000E+02 0.00000E+00 5.08628E+04 9.76228E+04 0.00000E+00 1.00000E+00

boil level x interface lower bound rodave gfactor bundle flow
1 0.00000E+00 0.00000E+00 1.73240E+02 3.34395E-02 0.00000E+00

cladmx= 1.16609E+03 fuelmx= 1.17161E+03 at 1.20000E+02 seconds

peak fuel temperature level:pin no.: { 44: 2 } peak clad temperature level:pin no.: { 44: 0 }

*ver2.17 trump bd full power spiked hot channel reflood station blackout (hygen).

```

-----
printout cycle  mf  msa  kwit  deltmx  small  tvary  dtemp  dtmaxs  nuts
      33  1610   51   22    1  0.10108E-01  0.30071E-05  0.50000E+01  0.78913E-01  0.80948E-01  .0

total time      time step      heat flow      temp from flux      flux rate      temp rate
8.01667E-01     2.32274E-04    -2.14050E+04    -3.08321E+02    -2.67006E+04    -3.84600E+02

sys pres      sat temp      heat content      gen rate      pigrat      ffactor
2.00000E+02   0.00000E+00    4.29642E+04     5.10764E+04     0.00000E+00    1.00000E+00

boil level      x interface      lower bound      rodave      gfactor      bundle flow
1               0.00000E+00     0.00000E+00     1.73240E+02    1.74956E-02    0.00000E+00
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cladm= 1.06231E+03 fuelmx= 1.06514E+03 at 2.88600E+03 seconds

peak fuel temperature level: pin no.: { 57: 2 } peak clad temperature level: pin no.: { 57: 0 }
 final heat = 4.29642E+04 final flow = -2.14050E+04

node	temp	node	temp	node	temp	node	temp	node	temp
6001	3.49456E+02	8001	3.75756E+02	10001	3.98081E+02	12001	4.14707E+02	14001	4.37180E+02
16001	4.64305E+02	18001	4.75465E+02	6002	3.49222E+02	8002	3.75365E+02	10002	3.97631E+02
12002	4.14299E+02	14002	4.36780E+02	16002	4.63907E+02	18002	4.75255E+02	6003	3.61500E+02
8003	4.01060E+02	10003	4.34704E+02	12003	4.59932E+02	14003	4.92088E+02	16003	5.29336E+02
18003	5.44370E+02	6004	3.61728E+02	8004	4.01573E+02	10004	4.35486E+02	12004	4.60951E+02
14004	4.93326E+02	16004	5.30769E+02	18004	5.45948E+02	6301	3.48511E+02	8301	3.73943E+02
10301	3.95642E+02	12301	4.11931E+02	14301	4.33895E+02	16301	4.60416E+02	18301	4.71624E+02
6302	3.48271E+02	8302	3.73615E+02	10302	3.95371E+02	12302	4.11856E+02	14302	4.33991E+02
16302	4.60700E+02	18302	4.72313E+02	6303	3.60320E+02	8303	3.98794E+02	10303	4.31662E+02
12303	4.56470E+02	14303	4.88049E+02	16303	5.24658E+02	18303	5.39789E+02	6304	3.60955E+02
8304	4.00186E+02	10304	4.33743E+02	12304	4.59129E+02	14304	4.91262E+02	16304	5.28376E+02
18304	5.43824E+02	6305	4.08093E+02	8305	4.46161E+02	10305	4.71607E+02	12305	4.93105E+02
14305	5.14551E+02	16305	5.36242E+02	18305	5.54210E+02	6311	3.59105E+02	8311	3.96880E+02
10311	4.29607E+02	12311	4.54821E+02	14311	4.86404E+02	16311	5.22773E+02	18311	5.38857E+02
6310	3.60072E+02	8310	3.98320E+02	10310	4.31029E+02	12310	4.55752E+02	14310	4.87215E+02
16310	5.23697E+02	18310	5.38850E+02	6309	3.48035E+02	8309	3.73180E+02	10309	3.94811E+02
12309	4.11252E+02	14309	4.33305E+02	16309	4.59914E+02	18309	4.71592E+02	6308	3.48316E+02
8308	3.73569E+02	10308	3.95140E+02	12308	4.11362E+02	14308	4.33224E+02	16308	4.59625E+02
18308	4.70844E+02	6306	4.14258E+02	8306	4.53865E+02	10306	4.79586E+02	12306	5.00947E+02
14306	5.22173E+02	16306	5.43529E+02	18306	5.60931E+02	6307	4.19219E+02	8307	4.60048E+02
10307	4.85966E+02	12307	5.07199E+02	14307	5.28221E+02	16307	5.49279E+02	18307	5.66222E+02
6401	3.26482E+02	8401	3.31303E+02	10401	3.37945E+02	12401	3.45958E+02	14401	3.55330E+02
16401	3.66710E+02	18401	3.78773E+02	6402	3.27380E+02	8402	3.34776E+02	10402	3.44907E+02
12402	3.57009E+02	14402	3.70984E+02	16402	3.87677E+02	18402	4.05043E+02	6403	3.35354E+02
8403	3.53668E+02	10403	3.74732E+02	12403	3.97017E+02	14403	4.20309E+02	16403	4.45329E+02
18403	4.69749E+02	6100	5.11288E+02	8100	5.70471E+02	10100	5.97824E+02	12100	6.15556E+02
14100	6.31989E+02	16100	6.47008E+02	18100	6.55638E+02	6101	5.16402E+02	8101	5.76959E+02
10101	6.04593E+02	12101	6.22250E+02	14101	6.38525E+02	16101	6.53279E+02	18101	6.61450E+02
6102	5.28724E+02	8102	5.92868E+02	10102	6.21166E+02	12102	6.38609E+02	14102	6.54480E+02
16102	6.68598E+02	18102	6.75637E+02	6103	5.34433E+02	8103	6.00825E+02	10103	6.29423E+02
12103	6.46717E+02	14103	6.62366E+02	16103	6.76217E+02	18103	6.82686E+02	6110	5.43828E+02
8110	6.16647E+02	10110	6.45973E+02	12110	6.62899E+02	14110	6.78069E+02	16110	6.91566E+02
18110	6.96989E+02	6111	5.46259E+02	8111	6.20234E+02	10111	6.49672E+02	12111	6.66512E+02
14111	6.81574E+02	16111	6.94968E+02	18111	7.00140E+02	6112	5.48417E+02	8112	6.23693E+02
10112	6.53252E+02	12112	6.70005E+02	14112	6.84961E+02	16112	6.98270E+02	18112	7.03210E+02
6113	5.46647E+02	8113	6.21310E+02	10113	6.50830E+02	12113	6.67648E+02	14113	6.82682E+02
16113	6.96086E+02	18113	7.01210E+02	6114	5.47339E+02	8114	6.19956E+02	10114	6.48976E+02
12114	6.65768E+02	14114	6.80820E+02	16114	6.94000E+02	18114	6.99043E+02	6104	5.31799E+02
8104	5.96884E+02	10104	6.25282E+02	12104	6.42655E+02	14104	6.58425E+02	16104	6.72377E+02
18104	6.79098E+02	22001	5.18244E+02	26001	5.69630E+02	30001	6.24546E+02	34001	6.82119E+02
38001	7.39680E+02	42001	7.97416E+02	46001	8.54189E+02	50001	9.07399E+02	54001	9.54897E+02
22002	5.18201E+02	26002	5.69749E+02	30002	6.24864E+02	34002	6.82656E+02	38002	7.40406E+02
42002	7.98213E+02	46002	8.55014E+02	50002	9.08241E+02	54002	9.55749E+02	22003	5.99130E+02

26003	6.62004E+02	30003	7.25963E+02	34003	7.88406E+02	38003	8.46372E+02	42003	9.01738E+02
46003	9.54436E+02	50003	1.00172E+03	54003	1.04129E+03	58003	6.00937E+02	62003	6.63953E+02
30004	7.27977E+02	34004	7.90356E+02	38004	8.48167E+02	42004	9.03350E+02	46004	9.55845E+02
50004	1.00291E+03	54004	1.04226E+03	58004	1.08241E+03	62004	6.64507E+02	66004	7.16972E+02
34301	6.76062E+02	38301	7.33460E+02	42301	7.91190E+02	46301	8.48037E+02	50301	9.01429E+02
54301	9.49237E+02	22302	5.15047E+02	26302	5.63119E+02	30302	6.21296E+02	34302	6.79088E+02
38302	7.36957E+02	42302	7.94848E+02	46302	8.51737E+02	50302	9.05109E+02	54302	9.52845E+02
22303	5.94038E+02	26303	6.56422E+02	30303	7.20084E+02	34303	7.82458E+02	38303	8.40572E+02
42303	8.96129E+02	46303	9.49060E+02	50303	9.96660E+02	54303	1.03664E+03	22304	5.98641E+02
26304	6.61397E+02	30304	7.25236E+02	34304	7.87475E+02	38304	8.45222E+02	42304	9.00347E+02
46304	9.52794E+02	50304	9.99870E+02	54304	1.03930E+03	58304	5.92781E+02	62304	6.37568E+02
30305	6.84117E+02	34305	7.29528E+02	38305	7.72954E+02	42305	8.13961E+02	46305	8.52799E+02
50305	8.88938E+02	54305	9.21106E+02	22311	5.93311E+02	26311	6.55472E+02	30311	7.18896E+02
34311	7.80830E+02	38311	8.38450E+02	42311	8.93458E+02	46311	9.45813E+02	50311	9.92929E+02
54311	1.03259E+03	22310	5.93003E+02	26310	6.55288E+02	30310	7.18892E+02	34310	7.81257E+02
38310	8.39404E+02	42310	8.95003E+02	46310	9.47982E+02	50310	9.95648E+02	54310	1.03571E+03
22309	5.14279E+02	26309	5.65489E+02	30309	6.20436E+02	34309	6.78229E+02	38309	7.36128E+02
42309	7.94041E+02	46309	8.50952E+02	50309	9.04361E+02	54309	9.52153E+02	22308	5.12907E+02
26308	5.63480E+02	30308	6.17741E+02	34308	6.74856E+02	38308	7.32224E+02	42308	7.89957E+02
46308	8.46822E+02	50308	9.00253E+02	54308	9.48124E+02	22306	5.98683E+02	26306	6.42847E+02
30306	6.88673E+02	34306	7.33310E+02	38306	7.75963E+02	42306	8.16225E+02	46306	8.54349E+02
50306	8.89806E+02	54306	9.21305E+02	22307	6.03282E+02	26307	6.46916E+02	30307	6.92137E+02
34307	7.36138E+02	38307	7.78161E+02	42307	8.17821E+02	46307	8.55367E+02	50307	8.90279E+02
54307	9.21249E+02	22401	4.05215E+02	26401	4.37478E+02	30401	4.75720E+02	34401	5.19850E+02
38401	5.69523E+02	42401	6.23550E+02	46401	6.78948E+02	50401	7.34175E+02	54401	7.79838E+02
22402	4.42041E+02	26402	4.85737E+02	30402	5.35906E+02	34402	5.91759E+02	38402	6.50615E+02
42402	7.08747E+02	46402	7.66078E+02	50402	8.21649E+02	54402	8.74126E+02	22403	5.17439E+02
26403	5.68939E+02	30403	6.23803E+02	34403	6.78484E+02	38403	7.31600E+02	42403	7.82296E+02
46403	8.30785E+02	50403	8.76435E+02	54403	9.18193E+02	22100	6.79867E+02	26100	7.13350E+02
30100	7.47781E+02	34100	7.81347E+02	38100	8.13144E+02	42100	8.43087E+02	46100	8.71414E+02
50100	8.97423E+02	54100	9.20400E+02	22101	6.84999E+02	26101	7.17972E+02	30101	7.51790E+02
34101	7.84683E+02	38101	8.15785E+02	42101	8.45036E+02	46101	8.72678E+02	50101	8.98019E+02
54101	9.20328E+02	22102	6.97458E+02	26102	7.29151E+02	30102	7.61441E+02	34102	7.92669E+02
38102	8.22057E+02	42102	8.49603E+02	46102	8.75558E+02	50102	8.99255E+02	54102	9.19928E+02
22103	7.03540E+02	26103	7.34555E+02	30103	7.66052E+02	34103	7.96429E+02	38103	8.24948E+02
42103	8.51629E+02	46103	8.76733E+02	50103	8.99605E+02	54103	9.19473E+02	22110	7.15540E+02
26110	7.45082E+02	30110	7.74901E+02	34110	8.03513E+02	38110	8.30253E+02	42110	8.55165E+02
46110	8.78552E+02	50110	8.99778E+02	54110	9.18080E+02	22111	7.18222E+02	26111	7.47445E+02
30111	7.76896E+02	34111	8.05117E+02	38111	8.31463E+02	42111	8.55982E+02	46111	8.78986E+02
50111	8.99842E+02	54111	9.17789E+02	22112	7.20810E+02	26112	7.49717E+02	30112	7.78806E+02
34112	8.06647E+02	38112	8.32607E+02	42112	8.56743E+02	46112	8.79374E+02	50112	8.99872E+02
54112	9.17476E+02	22113	7.19093E+02	26113	7.48210E+02	30113	7.77540E+02	34113	8.05631E+02
38113	8.31844E+02	42113	8.56225E+02	46113	8.79094E+02	50113	8.99821E+02	54113	9.17647E+02
22114	7.17563E+02	26114	7.46906E+02	30114	7.76471E+02	34114	8.04817E+02	38114	8.31287E+02
42114	8.55958E+02	46114	8.79106E+02	50114	9.00088E+02	54114	9.18129E+02	22104	7.00515E+02
26104	7.31899E+02	30104	7.63812E+02	34104	7.94626E+02	38104	8.23583E+02	42104	8.50696E+02
46104	8.76217E+02	50104	8.99483E+02	54104	9.19725E+02	7001	3.66349E+02	9001	3.86740E+02
11001	4.07850E+02	13001	4.24828E+02	15001	4.50983E+02	17001	4.72921E+02	7002	3.65988E+02
9002	3.86316E+02	11002	4.07403E+02	13002	4.24431E+02	15002	4.50577E+02	17002	4.72587E+02
7003	3.86449E+02	9003	4.17881E+02	11003	4.49439E+02	13003	4.74742E+02	15003	5.11269E+02
17003	5.40994E+02	7004	3.86828E+02	9004	4.18533E+02	11004	4.50346E+02	13004	4.75874E+02
15004	5.12611E+02	17004	5.42507E+02	7301	3.64809E+02	9301	3.84611E+02	11301	4.05181E+02
13301	4.21832E+02	15301	4.47377E+02	17301	4.68942E+02	7302	3.64465E+02	9302	3.84304E+02
11302	4.04986E+02	13302	4.21849E+02	15302	4.47557E+02	17302	4.69396E+02	7303	3.84539E+02
9303	4.15214E+02	11303	4.46113E+02	13303	4.71022E+02	15303	5.06882E+02	17303	5.36239E+02
7304	3.85589E+02	9304	4.16962E+02	11304	4.48504E+02	13304	4.73962E+02	15304	5.10363E+02
17304	5.40145E+02	7305	4.33405E+02	9305	4.61472E+02	11305	4.83788E+02	13305	5.04857E+02
15305	5.26579E+02	17305	5.46270E+02	7311	3.82630E+02	9311	4.13223E+02	11311	4.44143E+02
13311	4.69449E+02	15311	5.05085E+02	17311	5.34622E+02	7310	3.84138E+02	9310	4.14658E+02
11310	4.45422E+02	13310	4.70251E+02	15310	5.05979E+02	17310	5.35264E+02	7309	3.64086E+02
9309	3.83805E+02	11309	4.04388E+02	13309	4.21211E+02	15309	4.46815E+02	17309	4.68614E+02
7308	3.64491E+02	9308	3.84173E+02	11308	4.04633E+02	13308	4.21219E+02	15308	4.46642E+02
17308	4.68133E+02	7306	4.40878E+02	9306	4.69537E+02	11306	4.91809E+02	13306	5.12682E+02
15306	5.34135E+02	17306	5.53324E+02	7307	4.46887E+02	9307	4.75993E+02	11307	4.98202E+02
13307	5.18898E+02	15307	5.40104E+02	17307	5.58868E+02	7401	3.28691E+02	9401	3.34389E+02
11401	3.41862E+02	13401	3.50410E+02	15401	3.60780E+02	17401	3.72828E+02	7402	3.30769E+02

9402	3.39499E+02	11402	3.50838E+02	13402	3.63677E+02	15402	3.79016E+02	17402	3.96532E+02
7403	3.44199E+02	9403	3.63984E+02	11403	3.85896E+02	13403	4.08499E+02	15403	4.32678E+02
17403	4.57893E+02	7100	5.55303E+02	9100	5.89817E+02	11100	6.09451E+02	13100	6.25949E+02
15100	6.41884E+02	17100	6.52746E+02	7101	5.61572E+02	9101	5.96638E+02	11101	6.16271E+02
13101	6.32639E+02	15101	6.48367E+02	17101	6.58816E+02	7102	5.77309E+02	9102	6.13477E+02
11102	6.33016E+02	13102	6.49035E+02	15102	6.64237E+02	17102	6.73629E+02	7103	5.85959E+02
9103	6.22193E+02	11103	6.41515E+02	13103	6.57312E+02	15103	6.72231E+02	17103	6.81011E+02
7110	6.06219E+02	9110	6.40992E+02	11110	6.59345E+02	13110	6.74561E+02	15110	6.88841E+02
17110	6.96107E+02	7111	6.10341E+02	9111	6.44981E+02	11111	6.63181E+02	13111	6.78281E+02
15111	6.92427E+02	17111	6.99390E+02	7112	6.14547E+02	9112	6.48944E+02	11112	6.66958E+02
13112	6.81937E+02	15112	6.95950E+02	17112	7.02598E+02	7113	6.11933E+02	9113	6.46402E+02
11113	6.64510E+02	13113	6.79573E+02	15113	6.93682E+02	17113	7.00510E+02	7104	5.81152E+02
9104	6.17562E+02	11104	6.37073E+02	13104	6.53003E+02	15104	6.68081E+02	17104	6.77222E+02
7114	6.07382E+02	9114	6.42938E+02	11114	6.61475E+02	13114	6.76625E+02	15114	6.90805E+02
17114	6.98081E+02	21001	5.06922E+02	25001	5.56809E+02	29001	6.11016E+02	33001	6.68003E+02
37001	7.26317E+02	41001	7.83426E+02	45001	8.40753E+02	49001	8.95006E+02	53001	9.44154E+02
57001	9.85273E+02	21002	5.06836E+02	25002	5.56808E+02	29002	6.11278E+02	33002	6.68480E+02
37002	7.26998E+02	41002	7.84209E+02	45002	8.41569E+02	49002	8.95840E+02	53002	9.45000E+02
57002	9.86130E+02	21003	5.84930E+02	25003	6.46630E+02	29003	7.10636E+02	33003	7.73579E+02
37003	8.33417E+02	41003	8.88528E+02	45003	9.42191E+02	49003	9.90959E+02	53003	1.03268E+03
57003	1.06434E+03	21004	5.86687E+02	25004	6.48550E+02	29004	7.12645E+02	33004	7.75580E+02
37004	8.35254E+02	41004	8.90189E+02	45004	9.43654E+02	49004	9.92206E+02	53004	1.03371E+03
57004	1.06514E+03	21301	5.02634E+02	25301	5.51833E+02	29301	6.05447E+02	33301	6.62011E+02
37301	7.20087E+02	41301	7.77179E+02	45301	8.34559E+02	49301	8.88966E+02	53301	9.38390E+02
57301	9.79939E+02	21302	5.03736E+02	25302	5.53495E+02	29302	6.07713E+02	33302	6.64885E+02
37302	7.23486E+02	41302	7.80811E+02	45302	8.38249E+02	49302	8.92651E+02	53302	9.42016E+02
57302	9.83461E+02	21303	5.79961E+02	25303	6.41139E+02	29303	7.04794E+02	33303	7.67613E+02
37303	8.27542E+02	41303	8.82858E+02	45303	9.36738E+02	49303	9.85802E+02	53303	1.02791E+03
57303	1.06008E+03	21304	5.84439E+02	25304	6.46041E+02	29304	7.09932E+02	33304	7.72697E+02
37304	8.32296E+02	41304	8.87192E+02	45304	9.40600E+02	49304	9.89147E+02	53304	1.03071E+03
57304	1.06231E+03	21305	5.83215E+02	25305	6.27252E+02	29305	6.73677E+02	33305	7.19562E+02
37305	7.63611E+02	41305	8.05096E+02	45305	8.44420E+02	49305	8.81057E+02	53305	9.14164E+02
57305	9.41343E+02	21311	5.79210E+02	25311	6.40218E+02	29311	7.03647E+02	33311	7.66090E+02
37311	8.25486E+02	41311	8.80310E+02	45311	9.33606E+02	49311	9.82159E+02	53311	1.02390E+03
57311	1.05591E+03	21310	5.78948E+02	25310	6.40023E+02	29310	7.03608E+02	33310	7.66407E+02
37310	8.26358E+02	41310	8.81719E+02	45310	9.35644E+02	49310	9.84770E+02	53310	1.02696E+03
57310	1.05923E+03	21309	5.02979E+02	25309	5.52673E+02	29309	6.06853E+02	33309	6.64018E+02
37309	7.22641E+02	41309	7.79995E+02	45309	8.37454E+02	49309	8.91889E+02	53309	9.41304E+02
57309	9.82826E+02	21308	5.01767E+02	25308	5.50834E+02	29308	6.04336E+02	33308	6.60817E+02
37308	7.18848E+02	41308	7.75941E+02	45308	8.33334E+02	49308	8.87775E+02	53308	9.37256E+02
57308	9.78892E+02	21306	5.89348E+02	25306	6.32778E+02	29306	6.78504E+02	33306	7.23624E+02
37306	7.66898E+02	41306	8.07625E+02	45306	8.46221E+02	49306	8.82150E+02	53306	9.14574E+02
57306	9.41034E+02	21307	5.94131E+02	25307	6.37040E+02	29307	6.82179E+02	33307	7.26670E+02
37307	7.69311E+02	41307	8.09426E+02	45307	8.47433E+02	49307	8.82794E+02	53307	9.14675E+02
57307	9.40579E+02	21401	3.98082E+02	25401	4.28862E+02	29401	4.65619E+02	33401	5.08289E+02
37401	5.56681E+02	41401	6.09814E+02	45401	6.65090E+02	49401	7.20466E+02	53401	7.74763E+02
57401	8.26378E+02	21402	4.32181E+02	25402	4.74202E+02	29402	5.22817E+02	33402	5.77338E+02
37402	6.36000E+02	41402	6.94288E+02	45402	7.51887E+02	49402	8.08008E+02	53402	8.61405E+02
57402	9.10304E+02	21403	5.05213E+02	25403	5.55715E+02	29403	6.10019E+02	33403	6.64961E+02
37403	7.18611E+02	41403	7.69856E+02	45403	8.18930E+02	49403	8.65355E+02	53403	9.08199E+02
57403	9.45889E+02	21100	6.74049E+02	25100	7.06903E+02	29100	7.41248E+02	33100	7.74943E+02
37100	8.07077E+02	41100	8.37272E+02	45100	8.65959E+02	49100	8.92531E+02	53100	9.16187E+02
57100	9.33813E+02	21101	6.79365E+02	25101	7.11725E+02	29101	7.45484E+02	33101	7.78521E+02
37101	8.09965E+02	41101	8.39464E+02	45101	8.67459E+02	49101	8.93340E+02	53101	9.16316E+02
57101	9.33248E+02	21102	6.92324E+02	25102	7.23449E+02	29102	7.55735E+02	33102	7.87133E+02
37102	8.16865E+02	41102	8.44644E+02	45102	8.70928E+02	49102	8.95108E+02	53102	9.16413E+02
57102	9.31643E+02	21103	6.98801E+02	25103	7.29286E+02	29103	7.60793E+02	33103	7.91337E+02
37103	8.20183E+02	41103	8.47079E+02	45103	8.72489E+02	49103	8.95805E+02	53103	9.16265E+02
57103	9.30680E+02	21104	6.95408E+02	25104	7.26211E+02	29104	7.58118E+02	33104	7.89099E+02
37104	8.18397E+02	41104	8.45736E+02	45104	8.71581E+02	49104	8.95325E+02	53104	9.16205E+02
57104	9.31056E+02	21110	7.12278E+02	25110	7.41447E+02	29110	7.71274E+02	33110	7.99996E+02
37110	8.26967E+02	41110	8.52014E+02	45110	8.75611E+02	49110	8.97143E+02	53110	9.15867E+02
57110	9.28627E+02	21111	7.15169E+02	25111	7.44041E+02	29111	7.73503E+02	33111	8.01830E+02
37111	8.28394E+02	41111	8.53039E+02	45111	8.76239E+02	49111	8.97382E+02	53111	9.15726E+02
57111	9.28137E+02	21112	7.18017E+02	25112	7.46602E+02	29112	7.75703E+02	33112	8.03642E+02
37112	8.29805E+02	41112	8.54054E+02	45112	8.76865E+02	49112	8.97625E+02	53112	9.15597E+02

57112	9.27663E+02	21113	7.16225E+02	25113	7.45025E+02	29113	7.74376E+02	33113	8.02576E+02
37113	8.29002E+02	41113	8.53507E+02	45113	8.76566E+02	49113	8.97563E+02	53113	9.15760E+02
57113	9.28015E+02	21114	7.13605E+02	25114	7.42422E+02	29114	7.71946E+02	31114	8.00307E+02
37114	8.27094E+02	41114	8.51897E+02	45114	8.75272E+02	49114	8.96619E+02	53114	9.15197E+02
57114	9.27993E+02	19001	4.82838E+02	23001	5.30905E+02	27001	5.83536E+02	31001	6.39194E+02
35001	6.97357E+02	39001	7.54348E+02	43001	8.12334E+02	47001	8.68391E+02	51001	9.20371E+02
55001	9.65655E+02	19002	4.82697E+02	23002	5.30896E+02	27002	5.83697E+02	31002	6.39561E+02
35002	6.97944E+02	39002	7.55099E+02	43002	8.13136E+02	47002	8.69218E+02	51002	9.21211E+02
55002	9.66508E+02	19003	5.53976E+02	23003	6.14918E+02	27003	6.78584E+02	31003	7.42352E+02
35003	8.04231E+02	39003	8.60620E+02	43003	9.15811E+02	47003	9.67321E+02	51003	1.01287E+03
55003	1.04955E+03	19004	5.55617E+02	23004	6.16767E+02	27004	6.80558E+02	31004	7.44362E+02
35004	8.06146E+02	39004	8.62372E+02	43004	9.17375E+02	47004	9.68677E+02	51004	1.01400E+03
55004	1.05046E+03	19301	4.78952E+02	23301	5.26278E+02	27301	5.78242E+02	31301	6.33394E+02
35301	6.91212E+02	39301	7.48107E+02	43301	8.06103E+02	47301	8.62260E+02	51301	9.14452E+02
55301	9.60093E+02	19302	4.79810E+02	23302	5.27657E+02	27302	5.80202E+02	31302	6.35966E+02
35302	6.94376E+02	39302	7.51667E+02	43302	8.09774E+02	47302	8.65955E+02	51302	9.18113E+02
55302	9.63675E+02	19303	5.49374E+02	23303	6.09679E+02	27303	6.72892E+02	31303	7.36419E+02
35303	7.98285E+02	39303	8.54861E+02	43303	9.10242E+02	47303	9.62004E+02	51303	1.00789E+03
55303	1.04503E+03	19304	5.53552E+02	23304	6.14394E+02	27304	6.77936E+02	31304	7.41571E+02
35304	8.03223E+02	39304	8.59410E+02	43304	9.14345E+02	47304	9.65613E+02	51304	1.01097E+03
55304	1.04755E+03	19305	5.62336E+02	23305	6.03895E+02	27305	6.49416E+02	31305	6.95935E+02
35305	7.41022E+02	39305	7.83764E+02	43305	8.24212E+02	47305	8.62280E+02	51305	8.97272E+02
55305	9.28076E+02	19311	5.48729E+02	23311	6.08885E+02	27311	6.71855E+02	31311	7.35115E+02
35311	7.96484E+02	39311	8.52598E+02	43311	9.07398E+02	47311	9.58603E+02	51311	1.00404E+03
55311	1.04093E+03	19310	5.48432E+02	23310	6.08614E+02	27310	6.71736E+02	31310	7.35217E+02
35310	7.97085E+02	39310	8.53701E+02	43310	9.09123E+02	47310	9.60939E+02	51310	1.00689E+03
55310	1.04413E+03	19309	4.79103E+02	23309	5.26868E+02	27309	5.79357E+02	31309	6.35100E+02
35309	6.93516E+02	39309	7.50842E+02	43309	8.08967E+02	47309	8.65174E+02	51309	9.17373E+02
55309	9.63000E+02	19308	4.78164E+02	23308	5.25345E+02	27308	5.77184E+02	31308	6.32238E+02
35308	6.89988E+02	39308	7.46867E+02	43308	8.04870E+02	47308	8.61049E+02	51308	9.13286E+02
55308	9.59000E+02	19306	5.68759E+02	23306	6.09661E+02	27306	6.54542E+02	31306	7.00319E+02
35306	7.44637E+02	39306	7.86608E+02	43306	8.26316E+02	47306	8.63667E+02	51306	8.97962E+02
55306	9.28093E+02	19307	5.73793E+02	23307	6.14131E+02	27307	6.58469E+02	31307	7.03629E+02
35307	7.47316E+02	39307	7.88663E+02	43307	8.27773E+02	47307	8.64545E+02	51307	8.98284E+02
55307	9.27883E+02	19401	3.84834E+02	23401	4.12728E+02	27401	4.46496E+02	31401	4.86221E+02
35401	5.31806E+02	39401	5.82685E+02	43401	6.37376E+02	47401	6.92834E+02	51401	7.47834E+02
55401	8.01025E+02	19402	4.13635E+02	23402	4.52345E+02	27402	4.97719E+02	31402	5.49397E+02
35402	6.06500E+02	39402	6.65217E+02	43402	7.23207E+02	47402	7.80205E+02	51402	8.35139E+02
55402	8.86547E+02	19403	4.81344E+02	23403	5.29953E+02	27403	5.82459E+02	31403	6.37604E+02
35403	6.91998E+02	39403	7.44498E+02	43403	7.94667E+02	47403	8.42517E+02	51403	8.87297E+02
55403	9.27826E+02	19100	6.58692E+02	23100	6.88211E+02	27100	7.22252E+02	31100	7.56478E+02
35100	7.89543E+02	39100	8.20648E+02	43100	8.50175E+02	47100	8.77902E+02	51100	9.03123E+02
55100	9.24756E+02	19101	6.64240E+02	23101	6.93222E+02	27101	7.26733E+02	31101	7.60327E+02
35101	7.92719E+02	39101	8.23128E+02	43101	8.51962E+02	47101	8.78996E+02	51101	9.03530E+02
55101	9.24488E+02	19102	6.77706E+02	23102	7.05377E+02	27102	7.37559E+02	31102	7.69574E+02
35102	8.00295E+02	39102	8.28979E+02	43102	8.56102E+02	47102	8.81427E+02	51102	9.04265E+02
55102	9.23572E+02	19103	6.83834E+02	23103	7.10937E+02	27103	7.42468E+02	31103	7.73720E+02
35103	8.03638E+02	39103	8.31498E+02	43103	8.57808E+02	47103	8.82325E+02	51103	9.04361E+02
55103	9.22902E+02	19104	6.80823E+02	23104	7.08160E+02	27104	7.40013E+02	31104	7.71644E+02
35104	8.01958E+02	39104	8.30221E+02	43104	8.56922E+02	47104	8.81825E+02	51104	9.04246E+02
55104	9.23159E+02	19120	6.99958E+02	23120	7.26091E+02	27120	7.55859E+02	31120	7.84998E+02
35120	8.12677E+02	39120	8.38289E+02	43120	8.62395E+02	47120	8.84702E+02	51120	9.04507E+02
55120	9.20915E+02	19121	6.97784E+02	23121	7.23901E+02	27121	7.53869E+02	31121	7.83272E+02
35121	8.11258E+02	39121	8.37145E+02	43121	8.61535E+02	47121	8.84139E+02	51121	9.04261E+02
55121	9.20983E+02	19122	6.97784E+02	23122	7.23595E+02	27122	7.53497E+02	31122	7.82870E+02
35122	8.10844E+02	39122	8.36730E+02	43122	8.61115E+02	47122	8.83732E+02	51122	9.03903E+02
55122	9.20725E+02	19123	6.97906E+02	23123	7.23949E+02	27123	7.53902E+02	31123	7.83294E+02
35123	8.11270E+02	39123	8.37141E+02	43123	8.61516E+02	47123	8.84103E+02	51123	9.04229E+02
55123	9.20945E+02	19124	6.97559E+02	23124	7.23246E+02	27124	7.53140E+02	31124	7.82529E+02
35124	8.10531E+02	39124	8.36459E+02	43124	8.60884E+02	47124	8.83553E+02	51124	9.03789E+02
55124	9.20693E+02	19125	7.00209E+02	23125	7.26314E+02	27125	7.56050E+02	31125	7.85147E+02
35125	8.12712E+02	39125	8.38352E+02	43125	8.62413E+02	47125	8.84698E+02	51125	9.04502E+02
55125	9.20844E+02	19126	7.01106E+02	23126	7.27101E+02	27126	7.56713E+02	31126	7.85659E+02
35126	8.12832E+02	39126	8.38565E+02	43126	8.62475E+02	47126	8.84688E+02	51126	9.04484E+02
55126	9.20624E+02	19127	7.01111E+02	23127	7.27106E+02	27127	7.56717E+02	31127	7.85662E+02
35127	8.12833E+02	39127	8.38567E+02	43127	8.62475E+02	47127	8.84688E+02	51127	9.04484E+02

55127	9.20623E+02	19128	7.01110E+02	23128	7.27112E+02	27128	7.56723E+02	31128	7.85667E+02
35128	8.12834E+02	39128	8.38569E+02	43128	8.62476E+02	47128	8.84687E+02	51128	9.04484E+02
55128	9.20621E+02	19129	7.01120E+02	23129	7.27114E+02	27129	7.56724E+02	31129	7.85668E+02
35129	8.12834E+02	39129	8.38569E+02	43129	8.62476E+02	47129	8.84687E+02	51129	9.04484E+02
55129	9.20621E+02	19404	4.50000E+02	23404	4.50000E+02	27404	4.50000E+02	31404	4.50000E+02
35404	4.50000E+02	39404	4.50000E+02	43404	4.50000E+02	47404	4.50000E+02	51404	4.50000E+02
55404	4.50000E+02	401	3.24900E+02	402	3.24900E+02	403	3.24900E+02	404	4.50000E+02
20001	4.94549E+02	24001	5.43319E+02	28001	5.96725E+02	32001	6.53030E+02	36001	7.11536E+02
40001	7.68366E+02	44001	8.26119E+02	48001	8.81356E+02	52001	9.32058E+02	56001	9.74868E+02
20002	4.94435E+02	24002	5.43353E+02	28002	5.96939E+02	32002	6.53456E+02	36002	7.12176E+02
40002	7.69140E+02	44002	8.26933E+02	48002	8.82191E+02	52002	9.32905E+02	56002	9.75731E+02
20003	5.69062E+02	24003	6.30126E+02	28003	6.93992E+02	32003	7.57407E+02	36003	8.18600E+02
40003	8.74062E+02	44003	9.28593E+02	48003	9.78839E+02	52003	1.02265E+03	56003	1.05620E+03
20004	5.70761E+02	24004	6.32010E+02	28004	6.95984E+02	32004	7.59404E+02	36004	8.20475E+02
40004	8.75767E+02	44004	9.30104E+02	48004	9.80139E+02	52004	1.02373E+03	56004	1.05705E+03
20301	4.90465E+02	24301	5.38529E+02	28301	5.91301E+02	32301	6.47146E+02	36301	7.05352E+02
40301	7.62134E+02	44301	8.19918E+02	48301	8.75281E+02	52301	9.26224E+02	56301	9.69442E+02
20302	4.91443E+02	24302	5.40050E+02	28302	5.93419E+02	32302	6.49874E+02	36302	7.08646E+02
40302	7.65743E+02	44302	8.23606E+02	48302	8.78977E+02	52302	9.29874E+02	56302	9.73005E+02
20303	5.64279E+02	24303	6.24771E+02	28303	6.88234E+02	32303	7.51467E+02	36303	8.12695E+02
40303	8.68361E+02	44303	9.23092E+02	48303	9.73611E+02	52303	1.01778E+03	56303	1.05183E+03
20304	5.68608E+02	24304	6.29578E+02	28304	6.93326E+02	32304	7.56588E+02	36304	8.17538E+02
40304	8.72798E+02	44304	9.27071E+02	48304	9.77084E+02	52304	1.02072E+03	56304	1.05420E+03
20305	5.71054E+02	24305	6.13820E+02	28305	6.59862E+02	32305	7.06182E+02	36305	7.50871E+02
40305	7.93031E+02	44305	8.32999E+02	48305	8.70461E+02	52305	9.04658E+02	56305	9.34184E+02
20311	5.63592E+02	24311	6.23936E+02	28311	6.87165E+02	32311	7.50083E+02	36311	8.10775E+02
40311	8.65977E+02	44311	9.20121E+02	48311	9.70101E+02	52311	1.01386E+03	56311	1.04773E+03
20310	5.63303E+02	24310	6.23683E+02	28310	6.87066E+02	32310	7.50265E+02	36310	8.11504E+02
40310	8.67214E+02	44310	9.21988E+02	48310	9.72564E+02	52310	1.01681E+03	56310	1.05096E+03
20309	4.90712E+02	24309	5.39248E+02	28309	5.92570E+02	32309	6.49011E+02	36309	7.07796E+02
40309	7.64927E+02	44309	8.22809E+02	48309	8.78209E+02	52309	9.29150E+02	56309	9.72355E+02
20308	4.89639E+02	24308	5.37565E+02	28308	5.90219E+02	32308	6.45973E+02	36308	7.04121E+02
40308	7.60897E+02	44308	8.18692E+02	48308	8.74083E+02	52308	9.25076E+02	56308	9.68376E+02
20306	5.77217E+02	24306	6.19352E+02	28306	6.64727E+02	32306	7.10296E+02	36306	7.54219E+02
40306	7.95621E+02	44306	8.34861E+02	48306	8.71616E+02	52306	9.05130E+02	56306	9.33994E+02
20307	5.82043E+02	24307	6.23637E+02	28307	6.68449E+02	32307	7.13397E+02	36307	7.56693E+02
40307	7.97481E+02	44307	8.36131E+02	48307	8.72318E+02	52307	9.05288E+02	56307	9.33629E+02
20401	3.91263E+02	24401	4.20593E+02	28401	4.55857E+02	32401	4.97056E+02	36401	5.44072E+02
40401	5.96111E+02	44401	6.51202E+02	48401	7.06654E+02	52401	7.61349E+02	56401	8.13787E+02
20402	4.22670E+02	24402	4.63040E+02	28402	5.10052E+02	32402	5.63179E+02	36402	6.21245E+02
40402	6.79742E+02	44402	7.37560E+02	48402	7.94158E+02	52402	8.48374E+02	56402	8.98554E+02
20403	4.93069E+02	24403	5.42598E+02	28403	5.96053E+02	32403	6.51205E+02	36403	7.05274E+02
40403	7.57139E+02	44403	8.06777E+02	48403	8.53947E+02	52403	8.97805E+02	56403	9.36972E+02
20100	6.63198E+02	24100	6.94382E+02	28100	7.28680E+02	32100	7.62788E+02	36100	7.95591E+02
40100	8.26360E+02	44100	8.55625E+02	48100	8.82969E+02	52100	9.07651E+02	56100	9.28205E+02
20101	6.68535E+02	24101	6.99204E+02	28101	7.32945E+02	32101	7.66409E+02	36101	7.98536E+02
40101	8.28613E+02	44101	8.57189E+02	48101	8.83846E+02	52101	9.07851E+02	56101	9.27737E+02
20102	6.81457E+02	24102	7.10834E+02	28102	7.43184E+02	32102	7.75052E+02	36102	8.05507E+02
40102	8.33876E+02	44102	8.60756E+02	48102	8.85725E+02	52102	9.08066E+02	56102	9.26338E+02
20103	6.87251E+02	24103	7.15995E+02	28103	7.47672E+02	32103	7.78780E+02	36103	8.08446E+02
40103	8.36012E+02	44103	8.62098E+02	48103	8.86280E+02	52103	9.07850E+02	56103	9.25408E+02
20104	6.84509E+02	24104	7.13600E+02	28104	7.45625E+02	32104	7.77114E+02	36104	8.07167E+02
40104	8.35122E+02	44104	8.61586E+02	48104	8.86134E+02	52104	9.08054E+02	56104	9.25903E+02
20120	7.01116E+02	24120	7.27840E+02	28120	7.57650E+02	32120	7.86722E+02	36120	8.14329E+02
40120	8.39827E+02	44120	8.63869E+02	48120	8.86058E+02	52120	9.05696E+02	56120	9.21758E+02
20121	6.99697E+02	24121	7.26788E+02	28121	7.56830E+02	32121	7.86150E+02	36121	8.13994E+02
40121	8.39713E+02	44121	8.63979E+02	48121	8.86391E+02	52121	9.06238E+02	56121	9.22388E+02
20122	7.00452E+02	24122	7.27699E+02	28122	7.57723E+02	32122	7.86995E+02	36122	8.14780E+02
40122	8.40442E+02	44122	8.64661E+02	48122	8.87009E+02	52122	9.06786E+02	56122	9.22760E+02
20123	7.00049E+02	24123	7.27186E+02	28123	7.57216E+02	32123	7.86509E+02	36123	8.14321E+02
40123	8.40002E+02	44123	8.64235E+02	48123	8.86604E+02	52123	9.06422E+02	56123	9.22500E+02
20124	7.00464E+02	24124	7.27771E+02	28124	7.57823E+02	32124	7.87123E+02	36124	8.14934E+02
40124	8.40628E+02	44124	8.64882E+02	48124	8.87262E+02	52124	9.07064E+02	56124	9.22994E+02
20125	7.01366E+02	24125	7.28062E+02	28125	7.57839E+02	32125	7.86818E+02	36125	8.14364E+02
40125	8.39848E+02	44125	8.63886E+02	48125	8.86055E+02	52125	9.05691E+02	56125	9.21686E+02
20126	7.02257E+02	24126	7.28844E+02	28126	7.58496E+02	32126	7.87147E+02	36126	8.14482E+02

40126	8.39919E+02	44126	8.63942E+02	48126	8.86044E+02	52126	9.05674E+02	56126	9.21463E+02
20127	7.02262E+02	24127	7.28848E+02	28127	7.58500E+02	32127	7.87149E+02	36127	8.14483E+02
40127	8.39920E+02	44127	8.63942E+02	48127	8.86044E+02	52127	9.05673E+02	56127	9.21462E+02
20128	7.02269E+02	24128	7.28855E+02	28128	7.58506E+02	32128	7.87152E+02	36128	8.14484E+02
40128	8.39920E+02	44128	8.63942E+02	48128	8.86044E+02	52128	9.05673E+02	56128	9.21460E+02
20129	7.02271E+02	24129	7.28856E+02	28129	7.58507E+02	32129	7.87152E+02	36129	8.14484E+02
40129	8.39920E+02	44129	8.63943E+02	48129	8.86044E+02	52129	9.05673E+02	56129	9.21459E+02
20404	4.50000E+02	24404	4.50000E+02	28404	4.50000E+02	32404	4.50000E+02	36404	4.50000E+02
40404	4.50000E+02	44404	4.50000E+02	48404	4.50000E+02	52404	4.50000E+02	56404	4.50000E+02
5108	5.22912E+02	5118	5.26990E+02	5128	5.12688E+02	5108	4.54512E+02	5118	4.54672E+02
2128	4.54527E+02	4108	4.50367E+02	4118	4.49941E+02	5001	3.30562E+02	5002	3.30506E+02
5003	3.34427E+02	5004	3.34518E+02	5301	3.30339E+02	5302	3.30282E+02	5303	3.34112E+02
5304	3.34349E+02	5305	3.35259E+02	5308	3.30293E+02	5311	3.33935E+02	5310	3.34045E+02
5309	3.30225E+02	5306	4.00936E+02	5307	4.05324E+02	5401	3.25138E+02	5402	3.25302E+02
5403	3.28677E+02	5100	4.87890E+02	5101	4.92386E+02	5102	5.04515E+02	5103	5.13475E+02
5110	5.24211E+02	5111	5.27995E+02	5112	5.31003E+02	5113	5.27623E+02	4402	3.24900E+02
4401	3.24900E+02	4305	4.48277E+02	4306	4.48277E+02	4307	4.48443E+02	4100	4.51604E+02
4101	4.51788E+02	4102	4.49941E+02	4103	4.49941E+02	4104	4.50461E+02	4105	4.50296E+02
4403	3.24900E+02	3403	3.24900E+02	3402	3.24900E+02	3401	3.24900E+02	3305	4.50061E+02
3306	4.50061E+02	3307	4.50060E+02	3100	4.50049E+02	3101	4.50049E+02	3102	4.49941E+02
3103	4.49941E+02	3104	4.50251E+02	3105	4.50150E+02	2403	3.24900E+02	2402	3.24900E+02
2401	3.24900E+02	2305	4.53251E+02	2306	4.53251E+02	2307	4.53254E+02	2100	4.53548E+02
2101	4.53551E+02	2102	4.53569E+02	2103	4.53595E+02	2104	4.53601E+02	2105	4.53630E+02
2106	4.53607E+02	2107	4.53589E+02	1401	3.24900E+02	1403	3.24900E+02	1402	3.24900E+02
1305	4.51013E+02	1306	4.51013E+02	1307	4.51014E+02	1100	4.51050E+02	1101	4.51052E+02
1102	4.51057E+02	1103	4.51451E+02	1104	4.51454E+02	1105	4.51458E+02	1106	4.51462E+02
1107	4.51468E+02	1108	4.51462E+02	1109	4.51455E+02				

*** oxidation summary ***

node	qzrh2o(kw)	qfison(kw)	qgen(kw)	zrlft(in)	steamf(kg/s)	h fraction	h2 rel(kg/s)
1306	0.00000E+00	0.00000E+00	0.00000E+00	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
2306	0.00000E+00	0.00000E+00	0.00000E+00	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
3306	0.00000E+00	0.00000E+00	0.00000E+00	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
4306	0.00000E+00	0.00000E+00	0.00000E+00	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
5001	0.00000E+00	9.98348E-04	9.98348E-04	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
5002	0.00000E+00	1.49648E-03	1.49648E-03	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
5003	0.00000E+00	3.06225E-03	3.06225E-03	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
5004	0.00000E+00	3.58128E-03	3.58128E-03	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
5301	0.00000E+00	1.91187E-06	1.91187E-06	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
5302	0.00000E+00	5.74878E-06	5.74878E-06	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
5303	0.00000E+00	5.74442E-06	5.74442E-06	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
5304	0.00000E+00	7.67676E-06	7.67676E-06	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
5306	0.00000E+00	8.19448E-05	8.19448E-05	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
6001	0.00000E+00	7.15483E-03	7.15483E-03	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
6002	0.00000E+00	1.07247E-02	1.07247E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
6003	0.00000E+00	2.19461E-02	2.19461E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
6004	0.00000E+00	2.56658E-02	2.56658E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
6301	0.00000E+00	1.37017E-05	1.37017E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
6302	0.00000E+00	4.11996E-05	4.11996E-05	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
6303	0.00000E+00	4.11683E-05	4.11683E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
6304	0.00000E+00	5.50168E-05	5.50168E-05	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
6306	0.00000E+00	5.87271E-04	5.87271E-04	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
7001	0.00000E+00	1.14175E-02	1.14175E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
7002	0.00000E+00	1.71143E-02	1.71143E-02	1.75000E-01	2.00000E+24	0.00000E+00	0.00000E+00
7003	0.00000E+00	3.50212E-02	3.50212E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
7004	0.00000E+00	4.09570E-02	4.09570E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
7301	0.00000E+00	2.18649E-05	2.18649E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
7302	0.00000E+00	6.57455E-05	6.57455E-05	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
7303	0.00000E+00	6.56955E-05	6.56955E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
7304	0.00000E+00	8.77947E-05	8.77947E-05	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
7306	0.00000E+00	9.37155E-04	9.37155E-04	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00

8001	0.00000E+00	1.32873E-02	1.32873E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
8002	0.00000E+00	1.99170E-02	1.99170E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
8003	0.00000E+00	4.07562E-02	4.07562E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
8004	0.00000E+00	4.76641E-02	4.76641E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
8301	0.00000E+00	2.54455E-05	2.54455E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
8302	0.00000E+00	7.65120E-05	7.65120E-05	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
8303	0.00000E+00	7.64538E-05	7.64538E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
8304	0.00000E+00	1.02172E-04	1.02172E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
8306	0.00000E+00	1.09062E-03	1.09062E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
9001	0.00000E+00	1.53198E-02	1.53198E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
9002	0.00000E+00	2.29637E-02	2.29637E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
9003	0.00000E+00	4.69908E-02	4.69908E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
9004	0.00000E+00	5.49554E-02	5.49554E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
9301	0.00000E+00	2.93380E-05	2.93380E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
9302	0.00000E+00	8.82162E-05	8.82162E-05	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
9303	0.00000E+00	8.81491E-05	8.81491E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
9304	0.00000E+00	1.17801E-04	1.17801E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
9306	0.00000E+00	1.25746E-03	1.25746E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
10001	0.00000E+00	1.75153E-02	1.75153E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
10002	0.00000E+00	2.62545E-02	2.62545E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
10003	0.00000E+00	5.37249E-02	5.37249E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
10004	0.00000E+00	6.28308E-02	6.28308E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
10301	0.00000E+00	3.35423E-05	3.35423E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
10302	0.00000E+00	1.00858E-04	1.00858E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
10303	0.00000E+00	1.00781E-04	1.00781E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
10304	0.00000E+00	1.34683E-04	1.34683E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
10306	0.00000E+00	1.43766E-03	1.43766E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
11001	0.00000E+00	1.88371E-02	1.88371E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
11002	0.00000E+00	2.82360E-02	2.82360E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
11003	0.00000E+00	5.77795E-02	5.77795E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
11004	0.00000E+00	6.75726E-02	6.75726E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
11301	0.00000E+00	3.60737E-05	3.60737E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
11302	0.00000E+00	1.08470E-04	1.08470E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
11303	0.00000E+00	1.08387E-04	1.08387E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
11304	0.00000E+00	1.44848E-04	1.44848E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
11306	0.00000E+00	1.54616E-03	1.54616E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
12001	0.00000E+00	1.92854E-02	1.92854E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
12002	0.00000E+00	2.89080E-02	2.89080E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
12003	0.00000E+00	5.91546E-02	5.91546E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
12004	0.00000E+00	6.91808E-02	6.91808E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
12301	0.00000E+00	3.69323E-05	3.69323E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
12302	0.00000E+00	1.11051E-04	1.11051E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
12303	0.00000E+00	1.10967E-04	1.10967E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
12304	0.00000E+00	1.48295E-04	1.48295E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
12306	0.00000E+00	1.58296E-03	1.58296E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
13001	0.00000E+00	2.04966E-02	2.04966E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
13002	0.00000E+00	3.07234E-02	3.07234E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
13003	0.00000E+00	6.28694E-02	6.28694E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
13004	0.00000E+00	7.35253E-02	7.35253E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
13301	0.00000E+00	3.92516E-05	3.92516E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
13302	0.00000E+00	1.18025E-04	1.18025E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
13303	0.00000E+00	1.17936E-04	1.17936E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
13304	0.00000E+00	1.57608E-04	1.57608E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
13306	0.00000E+00	1.68237E-03	1.68237E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
14001	0.00000E+00	2.24705E-02	2.24705E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
14002	0.00000E+00	3.36821E-02	3.36821E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
14003	0.00000E+00	6.89240E-02	6.89240E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
14004	0.00000E+00	8.06061E-02	8.06061E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
14301	0.00000E+00	4.30317E-05	4.30317E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
14302	0.00000E+00	1.29392E-04	1.29392E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
14303	0.00000E+00	1.29293E-04	1.29293E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
14304	0.00000E+00	1.72786E-04	1.72786E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
14306	0.00000E+00	1.84438E-03	1.84438E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
15001	0.00000E+00	2.44220E-02	2.44220E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
15002	0.00000E+00	3.66073E-02	3.66073E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
15003	0.00000E+00	7.49099E-02	7.49099E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00

15004	0.00000E+00	8.76065E-02	8.76065E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
15301	0.00000E+00	4.67688E-05	4.67688E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
15302	0.00000E+00	1.40629E-04	1.40629E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
15303	0.00000E+00	1.40522E-04	1.40522E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
15304	0.00000E+00	1.87792E-04	1.87792E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
15306	0.00000E+00	2.00456E-03	2.00456E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
16001	0.00000E+00	2.63510E-02	2.63510E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
16002	0.00000E+00	3.94989E-02	3.94989E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
16003	0.00000E+00	8.08269E-02	8.08269E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
16004	0.00000E+00	9.45264E-02	9.45264E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
16301	0.00000E+00	5.04631E-05	5.04631E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
16302	0.00000E+00	1.51737E-04	1.51737E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
16303	0.00000E+00	1.51622E-04	1.51622E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
16304	0.00000E+00	2.02625E-04	2.02625E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
16306	0.00000E+00	2.16290E-03	2.16290E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
17001	0.00000E+00	2.64697E-02	2.64697E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
17002	0.00000E+00	3.96768E-02	3.96768E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
17003	0.00000E+00	8.11909E-02	8.11909E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
17004	0.00000E+00	9.49521E-02	9.49521E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
17301	0.00000E+00	5.06903E-05	5.06903E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
17302	0.00000E+00	1.52420E-04	1.52420E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
17303	0.00000E+00	1.52305E-04	1.52305E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
17304	0.00000E+00	2.03538E-04	2.03538E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
17306	0.00000E+00	2.17264E-03	2.17264E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
18001	0.00000E+00	2.47780E-02	2.47780E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
18002	0.00000E+00	3.71410E-02	3.71410E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
18003	0.00000E+00	7.60019E-02	7.60019E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
18004	0.00000E+00	8.88835E-02	8.88835E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
18301	0.00000E+00	4.74506E-05	4.74506E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
18302	0.00000E+00	1.42679E-04	1.42679E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
18303	0.00000E+00	1.42570E-04	1.42570E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
18304	0.00000E+00	1.90529E-04	1.90529E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
18306	0.00000E+00	2.03379E-03	2.03379E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
19001	0.00000E+00	2.45657E-02	2.45657E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
19002	0.00000E+00	3.68228E-02	3.68228E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
19003	0.00000E+00	7.53507E-02	7.53507E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
19004	0.00000E+00	8.81220E-02	8.81220E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
19301	0.00000E+00	4.70441E-05	4.70441E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
19302	0.00000E+00	1.41456E-04	1.41456E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
19303	0.00000E+00	1.41349E-04	1.41349E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
19304	0.00000E+00	1.88897E-04	1.88897E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
19306	0.00000E+00	2.01636E-03	2.01636E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
19127	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
19128	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
20001	0.00000E+00	2.58328E-02	2.58328E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
20002	0.00000E+00	3.87222E-02	3.87222E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
20003	0.00000E+00	7.92375E-02	7.92375E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
20004	0.00000E+00	9.26675E-02	9.26675E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
20301	0.00000E+00	4.94707E-05	4.94707E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
20302	0.00000E+00	1.48753E-04	1.48753E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
20303	0.00000E+00	1.48640E-04	1.48640E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
20304	0.00000E+00	1.98641E-04	1.98641E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
20306	0.00000E+00	2.12037E-03	2.12037E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
20127	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
20128	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
21001	0.00000E+00	2.68870E-02	2.68870E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
21002	0.00000E+00	4.03024E-02	4.03024E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
21003	0.00000E+00	8.24710E-02	8.24710E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
21004	0.00000E+00	9.64492E-02	9.64492E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
21301	0.00000E+00	5.14895E-05	5.14895E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
21302	0.00000E+00	1.54823E-04	1.54823E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
21303	0.00000E+00	1.54706E-04	1.54706E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
21304	0.00000E+00	2.06747E-04	2.06747E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
21306	0.00000E+00	2.20690E-03	2.20690E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
22001	0.00000E+00	2.77283E-02	2.77283E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
22002	0.00000E+00	4.15633E-02	4.15633E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00

22003	0.00000E+00	8.50514E-02	8.50514E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
22004	0.00000E+00	9.94669E-02	9.94669E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
22301	0.00000E+00	5.31005E-05	5.31005E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
22302	0.00000E+00	1.59668E-04	1.59668E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
22303	0.00000E+00	1.59546E-04	1.59546E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
22304	0.00000E+00	2.13216E-04	2.13216E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
22306	0.00000E+00	2.27595E-03	2.27595E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
23001	0.00000E+00	2.86262E-02	2.86262E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
23002	0.00000E+00	4.29093E-02	4.29093E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
23003	0.00000E+00	8.78057E-02	8.78057E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
23004	0.00000E+00	1.02688E-01	1.02688E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
23301	0.00000E+00	5.48201E-05	5.48201E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
23302	0.00000E+00	1.64838E-04	1.64838E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
23303	0.00000E+00	1.64713E-04	1.64713E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
23304	0.00000E+00	2.20120E-04	2.20120E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
23306	0.00000E+00	2.34965E-03	2.34965E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
23127	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
23128	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
24001	0.00000E+00	2.95809E-02	2.95809E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
24002	0.00000E+00	4.43403E-02	4.43403E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
24003	0.00000E+00	9.07339E-02	9.07339E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
24004	0.00000E+00	1.06113E-01	1.06113E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
24301	0.00000E+00	5.66483E-05	5.66483E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
24302	0.00000E+00	1.70335E-04	1.70335E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
24303	0.00000E+00	1.70206E-04	1.70206E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
24304	0.00000E+00	2.27461E-04	2.27461E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
24306	0.00000E+00	2.42801E-03	2.42801E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
24127	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
24128	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
25001	0.00000E+00	3.04722E-02	3.04722E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
25002	0.00000E+00	4.56764E-02	4.56764E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
25003	0.00000E+00	9.34680E-02	9.34680E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
25004	0.00000E+00	1.09310E-01	1.09310E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
25301	0.00000E+00	5.83553E-05	5.83553E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
25302	0.00000E+00	1.75468E-04	1.75468E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
25303	0.00000E+00	1.75335E-04	1.75335E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
25304	0.00000E+00	2.34315E-04	2.34315E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
25306	0.00000E+00	2.50117E-03	2.50117E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
26001	0.00000E+00	3.13003E-02	3.13003E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
26002	0.00000E+00	4.69176E-02	4.69176E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
26003	0.00000E+00	9.60079E-02	9.60079E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
26004	0.00000E+00	1.12280E-01	1.12280E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
26301	0.00000E+00	5.99411E-05	5.99411E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
26302	0.00000E+00	1.80236E-04	1.80236E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
26303	0.00000E+00	1.80099E-04	1.80099E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
26304	0.00000E+00	2.40682E-04	2.40682E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
26306	0.00000E+00	2.56914E-03	2.56914E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
27001	0.00000E+00	3.20651E-02	3.20651E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
27002	0.00000E+00	4.80640E-02	4.80640E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
27003	0.00000E+00	9.83537E-02	9.83537E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
27004	0.00000E+00	1.15024E-01	1.15024E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
27301	0.00000E+00	6.14056E-05	6.14056E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
27302	0.00000E+00	1.84640E-04	1.84640E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
27303	0.00000E+00	1.84500E-04	1.84500E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
27304	0.00000E+00	2.46563E-04	2.46563E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
27306	0.00000E+00	2.63191E-03	2.63191E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
27127	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
27128	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
28001	0.00000E+00	3.27665E-02	3.27665E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
28002	0.00000E+00	4.91155E-02	4.91155E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
28003	0.00000E+00	1.00505E-01	1.00505E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
28004	0.00000E+00	1.17540E-01	1.17540E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
28301	0.00000E+00	6.27490E-05	6.27490E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
28302	0.00000E+00	1.88679E-04	1.88679E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
28303	0.00000E+00	1.88536E-04	1.88536E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
28304	0.00000E+00	2.51957E-04	2.51957E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00

35302	0.00000E+00	2.07107E-04	2.07107E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
35303	0.00000E+00	2.06950E-04	2.06950E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
35304	0.00000E+00	2.76565E-04	2.76565E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
35306	0.00000E+00	2.95216E-03	2.95216E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
35127	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
35128	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
36001	0.00000E+00	3.61909E-02	3.61909E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
36002	0.00000E+00	5.42484E-02	5.42484E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
36003	0.00000E+00	1.11009E-01	1.11009E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
36004	0.00000E+00	1.29824E-01	1.29824E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
36301	0.00000E+00	6.93067E-05	6.93067E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
36302	0.00000E+00	2.08398E-04	2.08398E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
36303	0.00000E+00	2.08239E-04	2.08239E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
36304	0.00000E+00	2.78289E-04	2.78289E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
36306	0.00000E+00	2.97056E-03	2.97056E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
36127	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
36128	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
37001	0.00000E+00	3.62608E-02	3.62608E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
37002	0.00000E+00	5.43531E-02	5.43531E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
37003	0.00000E+00	1.11223E-01	1.11223E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
37004	0.00000E+00	1.30075E-01	1.30075E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
37301	0.00000E+00	6.94405E-05	6.94405E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
37302	0.00000E+00	2.08800E-04	2.08800E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
37303	0.00000E+00	2.08642E-04	2.08642E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
37304	0.00000E+00	2.78826E-04	2.78826E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
37306	0.00000E+00	2.97630E-03	2.97630E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
38001	0.00000E+00	3.61764E-02	3.61764E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
38002	0.00000E+00	5.42266E-02	5.42266E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
38003	0.00000E+00	1.10964E-01	1.10964E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
38004	0.00000E+00	1.29772E-01	1.29772E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
38301	0.00000E+00	6.92789E-05	6.92789E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
38302	0.00000E+00	2.08314E-04	2.08314E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
38303	0.00000E+00	2.08156E-04	2.08156E-04				

48303	0.00000E+00	2.08198E-04	2.08198E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
48304	0.00000E+00	2.78233E-04	2.78233E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
48306	0.00000E+00	2.96997E-03	2.96997E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
48127	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
48128	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
49001	0.00000E+00	3.59726E-02	3.59726E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
49002	0.00000E+00	5.39213E-02	5.39213E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
49003	0.00000E+00	1.10340E-01	1.10340E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
49004	0.00000E+00	1.29041E-01	1.29041E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
49301	0.00000E+00	6.88888E-05	6.88888E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
49302	0.00000E+00	2.07141E-04	2.07141E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
49303	0.00000E+00	2.06984E-04	2.06984E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
49304	0.00000E+00	2.76610E-04	2.76610E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
49306	0.00000E+00	2.95265E-03	2.95265E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
50001	0.00000E+00	3.57076E-02	3.57076E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
50002	0.00000E+00	5.35240E-02	5.35240E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
50003	0.00000E+00	1.09527E-01	1.09527E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
50004	0.00000E+00	1.28090E-01	1.28090E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
50301	0.00000E+00	6.83812E-05	6.83812E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
50302	0.00000E+00	2.05615E-04	2.05615E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
50303	0.00000E+00	2.05459E-04	2.05459E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
50304	0.00000E+00	2.74573E-04	2.74573E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
50306	0.00000E+00	2.93090E-03	2.93090E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
51001	0.00000E+00	3.53806E-02	3.53806E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
51002	0.00000E+00	5.30338E-02	5.30338E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
51003	0.00000E+00	1.08524E-01	1.08524E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
51004	0.00000E+00	1.26917E-01	1.26917E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
51301	0.00000E+00	6.77550E-05	6.77550E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
51302	0.00000E+00	2.03732E-04	2.03732E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
51303	0.00000E+00	2.03577E-04	2.03577E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
51304	0.00000E+00	2.72058E-04	2.72058E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
51306	0.00000E+00	2.90406E-03	2.90406E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
51127	0.00000E+00	0.00000E+00	0.00000E+00				

55004	0.00000E+00	1.19262E-01	1.19262E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
55301	0.00000E+00	6.36681E-05	6.36681E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
55302	0.00000E+00	1.91443E-04	1.91443E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
55303	0.00000E+00	1.91298E-04	1.91298E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
55304	0.00000E+00	2.55648E-04	2.55648E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
55306	0.00000E+00	2.72889E-03	2.72889E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
55127	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
55128	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
56001	0.00000E+00	3.23710E-02	3.23710E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
56002	0.00000E+00	4.85225E-02	4.85225E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
56003	0.00000E+00	9.92920E-02	9.92920E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
56004	0.00000E+00	1.16121E-01	1.16121E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
56301	0.00000E+00	6.19915E-05	6.19915E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
56302	0.00000E+00	1.86402E-04	1.86402E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
56303	0.00000E+00	1.86260E-04	1.86260E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
56304	0.00000E+00	2.48915E-04	2.48915E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
56306	0.00000E+00	2.65702E-03	2.65702E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00
56127	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
56128	0.00000E+00	0.00000E+00	0.00000E+00	1.25000E-02	1.00000E+24	0.00000E+00	0.00000E+00
57001	0.00000E+00	3.19075E-02	3.19075E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
57002	0.00000E+00	4.78278E-02	4.78278E-02	1.75000E-01	1.00000E+24	0.00000E+00	0.00000E+00
57003	0.00000E+00	9.78704E-02	9.78704E-02	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
57004	0.00000E+00	1.14459E-01	1.14459E-01	1.58500E-01	1.00000E+24	0.00000E+00	0.00000E+00
57301	0.00000E+00	6.11039E-05	6.11039E-05	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
57302	0.00000E+00	1.83733E-04	1.83733E-04	3.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
57303	0.00000E+00	1.83593E-04	1.83593E-04	2.00000E-02	1.00000E+24	0.00000E+00	0.00000E+00
57304	0.00000E+00	2.45352E-04	2.45352E-04	2.50000E-02	1.00000E+24	0.00000E+00	0.00000E+00
57306	0.00000E+00	2.61898E-03	2.61898E-03	2.78750E-01	1.00000E+24	0.00000E+00	0.00000E+00

level	total qmwr (kw)	qfromzr (kw)	qfromu (kw)	ave zrthik (in)	ave uthik (in)
1	0.00000E+00	0.00000E+00	0.00000E+00	2.78750E-01	0.00000E+00
2	0.00000E+00	0.00000E+00	0.00000E+00	2.78750E-01	0.00000E+00
3	0.00000E+00	0.00000E+00	0.00000E+00	2.78750E-01	0.00000E+00
4	0.00000E+00	0.00000E+00	0.00000E+00	2.78750E-01	0.00000E+00
5	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
6	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
7	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
8	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
9	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
10	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
11	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
12	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
13	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
14	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
15	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
16	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
17	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
18	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
19	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
20	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
21	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
22	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
23	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
24	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
25	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
26	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
27	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
28	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
29	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
30	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
31	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
32	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
33	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
34	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01

35	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
36	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
37	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
38	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
39	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
40	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
41	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
42	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
43	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
44	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
45	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
46	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
47	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
48	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
49	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
50	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
51	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
52	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
53	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
54	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01
55	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
56	0.00000E+00	0.00000E+00	0.00000E+00	5.69643E-02	1.66750E-01
57	0.00000E+00	0.00000E+00	0.00000E+00	7.47500E-02	1.66750E-01

a hydrogen release rate of 0.00000E+00 kg/sec occurred in this timestep
a total of 0.00000E+00 kg of hydrogen have been released over the transient

*** pin heat generation and state summary ***

pin no.	power (kw)
1	3.90576E+00
2	1.04007E+01

the total power generated by the metal-water reaction during this timestep is 0.00000E+00 kw
the total power generated by nuclear heating during this timestep is 1.49696E+01 kw
the total power generated during this timestep is 1.49696E+01 kw

*** variable internal thermal connection and convection summary ***

convective losses - channel 401 = 1.70771E+00 kw
convective losses - channel 402 = 8.52678E+00 kw
convective losses - channel 403 = 7.16484E+00 kw
convective losses - channel 404 = 0.00000E+00 kw
convective losses - channel *** = 0.00000E+00 kw

nod1	nod2	hint	nod1	nod2	hint	nod1	nod2	hint
6308	6401	5.83000E-01	8308	8401	5.83000E-01	10308	10401	5.83000E-01
12308	12401	5.83000E-01	14308	14401	5.83000E-01	16308	16401	5.83000E-01
18308	18401	5.83000E-01	6309	6402	4.97000E-01	8309	8402	4.97000E-01
10309	10402	4.97000E-01	12309	12402	4.97000E-01	14309	14402	4.97000E-01
16309	16402	4.97000E-01	18309	18402	4.97000E-01	6310	6402	4.97000E-01
8310	8402	4.97000E-01	10310	10402	4.97000E-01	12310	12402	4.97000E-01
14310	14402	4.97000E-01	16310	16402	4.97000E-01	18310	18402	4.97000E-01
6311	6403	4.08000E-01	8311	8403	4.08000E-01	10311	10403	4.08000E-01
12311	12403	4.08000E-01	14311	14403	4.08000E-01	16311	16403	4.08000E-01
18311	18403	4.08000E-01	6305	6403	4.08000E-01	8305	8403	4.08000E-01

10305 10403	4.08000E-01	12305 12403	4.08000E-01	14305 14403	4.08000E-01
16305 16403	4.08000E-01	18305 18403	4.08000E-01	6307 6100	2.37671E-01
7307 7401	2.48664E-01	10307 10100	2.54968E-01	12307 12100	2.54971E-01
14307 14100	2.63243E-01	16307 16100	2.67101E-01	18307 18100	2.69836E-01
7308 7401	5.83000E-01	9308 9401	5.83000E-01	11308 11401	5.83000E-01
13308 13401	5.83000E-01	15308 15401	5.83000E-01	17308 17401	5.83000E-01
7309 7402	4.97000E-01	9309 9402	4.97000E-01	11309 11402	4.97000E-01
13309 13402	4.97000E-01	15309 15402	4.97000E-01	17309 17402	4.97000E-01
7310 7402	4.97000E-01	9310 9402	4.97000E-01	11310 11402	4.97000E-01
13310 13402	4.97000E-01	15310 15402	4.97000E-01	17310 17402	4.97000E-01
7311 7403	4.08000E-01	9311 9403	4.08000E-01	11311 11403	4.08000E-01
13311 13403	4.08000E-01	15311 15403	4.08000E-01	17311 17403	4.08000E-01
7305 7403	4.08000E-01	9305 9403	4.08000E-01	11305 11403	4.08000E-01
13305 13403	4.08000E-01	15305 15403	4.08000E-01	17305 17403	4.08000E-01
7307 7100	2.45618E-01	9307 9100	2.52908E-01	11307 11100	2.57622E-01
13307 13100	2.61600E-01	15307 15100	2.65572E-01	17307 17100	2.68740E-01
22308 22401	5.83000E-01	26308 26401	5.83000E-01	30308 30401	5.83000E-01
34308 34401	5.83000E-01	38308 38401	5.83000E-01	42308 42401	5.83000E-01
46308 46401	5.83000E-01	50308 50401	5.83000E-01	54308 54401	5.83000E-01
22309 22402	4.97000E-01	26309 26402	4.97000E-01	30309 30402	4.97000E-01
34309 34402	4.97000E-01	38309 38402	4.97000E-01	42309 42402	4.97000E-01
46309 46402	4.97000E-01	50309 50402	4.97000E-01	54309 54402	4.97000E-01
22310 22402	4.97000E-01	26310 26402	4.97000E-01	30310 30402	4.97000E-01
34310 34402	4.97000E-01	38310 38402	4.97000E-01	42310 42402	4.97000E-01
46310 46402	4.97000E-01	50310 50402	4.97000E-01	54310 54402	4.97000E-01
22311 22403	4.08000E-01	26311 26403	4.08000E-01	30311 30403	4.08000E-01
34311 34403	4.08000E-01	38311 38403	4.08000E-01	42311 42403	4.08000E-01
46311 46403	4.08000E-01	50311 50403	4.08000E-01	54311 54403	4.08000E-01
22305 22403	4.08000E-01	26305 26403	4.08000E-01	30305 30403	4.08000E-01
34305 34403	4.08000E-01	38305 38403	4.08000E-01	42305 42403	4.08000E-01
46305 46403	4.08000E-01	50305 50403	4.08000E-01	54305 54403	4.08000E-01
22307 22100	2.76262E-01	26307 26100	2.84273E-01	30307 30100	2.91449E-01
34307 34100	2.94962E-01	38307 38100	2.98306E-01	42307 42100	3.01458E-01
46307 46100	3.04442E-01	50307 50100	3.22001E-01	54307 54100	3.26976E-01
21308 21401	5.83000E-01	25308 25401	5.83000E-01	29308 29401	5.83000E-01
33308 33401	5.83000E-01	37308 37401	5.83000E-01	41308 41401	5.83000E-01
45308 45401	5.83000E-01	49308 49401	5.83000E-01	53308 53401	5.83000E-01
57308 57401	5.83000E-01	21309 21402	4.97000E-01	25309 25402	4.97000E-01
29309 29402	4.97000E-01	33309 33402	4.97000E-01	37309 37402	4.97000E-01
41309 41402	4.97000E-01	45309 45402	4.97000E-01	49309 49402	4.97000E-01
53309 53402	4.97000E-01	57309 57402	4.97000E-01	21310 21402	4.97000E-01
25310 25402	4.97000E-01	29310 29402	4.97000E-01	33310 33402	4.97000E-01
37310 37402	4.97000E-01	41310 41402	4.97000E-01	45310 45402	4.97000E-01
49310 49402	4.97000E-01	53310 53402	4.97000E-01	57310 57402	4.97000E-01
21311 21403	4.08000E-01	25311 25403	4.08000E-01	29311 29403	4.08000E-01
33311 33403	4.08000E-01	37311 37403	4.08000E-01	41311 41403	4.08000E-01
45311 45403	4.08000E-01	49311 49403	4.08000E-01	53311 53403	4.08000E-01
57311 57403	4.08000E-01	21305 21403	4.08000E-01	25305 25403	4.08000E-01
29305 29403	4.08000E-01	33305 33403	4.08000E-01	37305 37403	4.08000E-01
41305 41403	4.08000E-01	45305 45403	4.08000E-01	49305 49403	4.08000E-01
53305 53403	4.08000E-01	57305 57403	4.08000E-01	21307 21100	2.74707E-01
25307 25100	2.82577E-01	29307 29100	2.90793E-01	33307 33100	2.97482E-01
37307 37100	3.03879E-01	41307 41100	3.09894E-01	45307 45100	3.15600E-01
49307 49100	3.20899E-01	53307 53100	3.25981E-01	57307 57100	3.29997E-01
19308 19401	5.83000E-01	23308 23401	5.83000E-01	27308 27401	5.83000E-01
31308 31401	5.83000E-01	35308 35401	5.83000E-01	39308 39401	5.83000E-01
43308 43401	5.83000E-01	47308 47401	5.83000E-01	51308 51401	5.83000E-01
55308 55401	5.83000E-01	19309 19402	4.97000E-01	23309 23402	4.97000E-01
27309 27402	4.97000E-01	31309 31402	4.97000E-01	35309 35402	4.97000E-01
39309 39402	4.97000E-01	43309 43402	4.97000E-01	47309 47402	4.97000E-01
51309 51402	4.97000E-01	55309 55402	4.97000E-01	19310 19402	4.97000E-01
23310 23402	4.97000E-01	27310 27402	4.97000E-01	31310 31402	4.97000E-01
35310 35402	4.97000E-01	39310 39402	4.97000E-01	43310 43402	4.97000E-01
47310 47402	4.97000E-01	51310 51402	4.97000E-01	55310 55402	4.97000E-01
19311 19403	4.08000E-01	23311 23403	4.08000E-01	27311 27403	4.08000E-01
31311 31403	4.08000E-01	35311 35403	4.08000E-01	39311 39403	4.08000E-01

43311	43403	4.08000E-01	47311	47403	4.08000E-01	51311	51403	4.08000E-01
55311	55403	4.08000E-01	19305	19403	4.08000E-01	23305	23403	4.08000E-01
27305	27403	4.08000E-01	31305	31403	4.08000E-01	35305	35403	4.08000E-01
39305	39403	4.08000E-01	43305	43403	4.08000E-01	47305	47403	4.08000E-01
51305	51403	4.08000E-01	55305	55403	4.08000E-01	19307	19100	2.70977E-01
23307	23100	2.78256E-01	27307	27100	2.86398E-01	31307	31100	2.93931E-01
35307	35100	3.00497E-01	39307	39100	3.06696E-01	43307	43100	3.12568E-01
47307	47100	3.18086E-01	51307	51100	3.23264E-01	55307	55100	3.27989E-01
19125	19126	9.01747E-01	23125	23126	9.12761E-01	27125	27126	9.21157E-01
31125	31126	9.29367E-01	35125	35126	9.37109E-01	39125	39126	9.44378E-01
43125	43126	9.51163E-01	47125	47126	9.76025E-01	51125	51126	1.01246E+00
55125	55126	1.02178E+00	20308	20401	5.83000E-01	24308	24401	5.83000E-01
28308	28401	5.83000E-01	32308	32401	5.83000E-01	36308	36401	5.83000E-01
40308	40401	5.83000E-01	44308	44401	5.83000E-01	48308	48401	5.83000E-01
52308	52401	5.83000E-01	56308	56401	5.83000E-01	20309	20402	4.97000E-01
24309	24402	4.97000E-01	28309	28402	4.97000E-01	32309	32402	4.97000E-01
36309	36402	4.97000E-01	40309	40402	4.97000E-01	44309	44402	4.97000E-01
48309	48402	4.97000E-01	52309	52402	4.97000E-01	56309	56402	4.97000E-01
20310	20402	4.97000E-01	24310	24402	4.97000E-01	28310	28402	4.97000E-01
32310	32402	4.97000E-01	36310	36402	4.97000E-01	40310	40402	4.97000E-01
44310	44402	4.97000E-01	48310	48402	4.97000E-01	52310	52402	4.97000E-01
56310	56402	4.97000E-01	20311	20403	4.08000E-01	24311	24403	4.08000E-01
28311	28403	4.08000E-01	32311	32403	4.08000E-01	36311	36403	4.08000E-01
40311	40403	4.08000E-01	44311	44403	4.08000E-01	48311	48403	4.08000E-01
52311	52403	4.08000E-01	56311	56403	4.08000E-01	20305	20403	4.08000E-01
24305	24403	4.08000E-01	28305	28403	4.08000E-01	32305	32403	4.08000E-01
36305	36403	4.08000E-01	40305	40403	4.08000E-01	44305	44403	4.08000E-01
48305	48403	4.08000E-01	52305	52403	4.08000E-01	56305	56403	4.08000E-01
20307	20100	2.72323E-01	24307	24100	2.79884E-01	28307	28100	2.88103E-01
32307	32100	2.95307E-01	36307	36100	3.01817E-01	40307	40100	3.07939E-01
44307	44100	3.13749E-01	48307	48100	3.19184E-01	52307	52100	3.24328E-01
56307	56100	3.28837E-01	20125	20126	9.02497E-01	24125	24126	9.13255E-01
28125	28126	9.21662E-01	32125	32126	9.29813E-01	36125	36126	9.37576E-01
40125	40126	9.44780E-01	44125	44126	9.51579E-01	48125	48126	9.82562E-01
52125	52126	1.01315E+00	56125	56126	1.02226E+00	4307	4100	2.34537E-01
3307	3100	2.34543E-01	2307	2100	1.47100E-02	1307	1100	7.27020E-02
1102	1103	1.52832E-02	5308	5401	5.83000E-01	5309	5402	4.97000E-01
5310	5402	4.97000E-01	5311	5403	4.08000E-01	5305	5403	4.08000E-01
5307	5100	2.33837E-01						

*** axial and radial heat loss summary ***

nods	nods b	qloss
5305	1000	0.00000E+00
5311	1000	0.00000E+00
5310	1000	0.00000E+00
5309	1000	0.00000E+00
5308	1000	0.00000E+00
6305	1000	0.00000E+00
7305	1000	0.00000E+00
8305	1000	0.00000E+00
9305	1000	0.00000E+00
10305	1000	0.00000E+00
11305	1000	0.00000E+00
12305	1000	0.00000E+00
13305	1000	0.00000E+00
14305	1000	0.00000E+00
15305	1000	0.00000E+00
16305	1000	0.00000E+00
17305	1000	0.00000E+00
18305	1000	0.00000E+00
19305	1000	0.00000E+00
20305	1000	0.00000E+00
21305	1000	0.00000E+00

22305	1000	0.00000E+00
23305	1000	0.00000E+00
24305	1000	0.00000E+00
25305	1000	0.00000E+00
26305	1000	0.00000E+00
27305	1000	0.00000E+00
28305	1000	0.00000E+00
29305	1000	0.00000E+00
30305	1000	0.00000E+00
31305	1000	0.00000E+00
32305	1000	0.00000E+00
33305	1000	0.00000E+00
34305	1000	0.00000E+00
35305	1000	0.00000E+00
36305	1000	0.00000E+00
37305	1000	0.00000E+00
38305	1000	0.00000E+00
39305	1000	0.00000E+00
40305	1000	0.00000E+00
41305	1000	0.00000E+00
42305	1000	0.00000E+00
43305	1000	0.00000E+00
44305	1000	0.00000E+00
45305	1000	0.00000E+00
46305	1000	0.00000E+00
47305	1000	0.00000E+00
48305	1000	0.00000E+00
49305	1000	0.00000E+00
50305	1000	0.00000E+00
51305	1000	0.00000E+00
52305	1000	0.00000E+00
53305	1000	0.00000E+00
54305	1000	0.00000E+00
55305	1000	0.00000E+00
56305	1000	0.00000E+00
57305	1000	0.00000E+00
6311	1000	0.00000E+00
7311	1000	0.00000E+00
8311	1000	0.00000E+00
9311	1000	0.00000E+00
10311	1000	0.00000E+00
11311	1000	0.00000E+00
12311	1000	0.00000E+00
13311	1000	0.00000E+00
14311	1000	0.00000E+00
15311	1000	0.00000E+00
16311	1000	0.00000E+00
17311	1000	0.00000E+00
18311	1000	0.00000E+00
19311	1000	0.00000E+00
20311	1000	0.00000E+00
21311	1000	0.00000E+00
22311	1000	0.00000E+00
23311	1000	0.00000E+00
24311	1000	0.00000E+00
25311	1000	0.00000E+00
26311	1000	0.00000E+00
27311	1000	0.00000E+00
28311	1000	0.00000E+00
29311	1000	0.00000E+00
30311	1000	0.00000E+00
31311	1000	0.00000E+00
32311	1000	0.00000E+00
33311	1000	0.00000E+00
34311	1000	0.00000E+00
35311	1000	0.00000E+00

36311	1000	0.00000E+00
37311	1000	0.00000E+00
38311	1000	0.00000E+00
39311	1000	0.00000E+00
40311	1000	0.00000E+00
41311	1000	0.00000E+00
42311	1000	0.00000E+00
43311	1000	0.00000E+00
44311	1000	0.00000E+00
45311	1000	0.00000E+00
46311	1000	0.00000E+00
47311	1000	0.00000E+00
48311	1000	0.00000E+00
49311	1000	0.00000E+00
50311	1000	0.00000E+00
51311	1000	0.00000E+00
52311	1000	0.00000E+00
53311	1000	0.00000E+00
54311	1000	0.00000E+00
55311	1000	0.00000E+00
56311	1000	0.00000E+00
57311	1000	0.00000E+00
6310	1000	0.00000E+00
7310	1000	0.00000E+00
8310	1000	0.00000E+00
9310	1000	0.00000E+00
10310	1000	0.00000E+00
11310	1000	0.00000E+00
12310	1000	0.00000E+00
13310	1000	0.00000E+00
14310	1000	0.00000E+00
15310	1000	0.00000E+00
16310	1000	0.00000E+00
17310	1000	0.00000E+00
18310	1000	0.00000E+00
19310	1000	0.00000E+00
20310	1000	0.00000E+00
21310	1000	0.00000E+00
22310	1000	0.00000E+00
23310	1000	0.00000E+00
24310	1000	0.00000E+00
25310	1000	0.00000E+00
26310	1000	0.00000E+00
27310	1000	0.00000E+00
28310	1000	0.00000E+00
29310	1000	0.00000E+00
30310	1000	0.00000E+00
31310	1000	0.00000E+00
32310	1000	0.00000E+00
33310	1000	0.00000E+00
34310	1000	0.00000E+00
35310	1000	0.00000E+00
36310	1000	0.00000E+00
37310	1000	0.00000E+00
38310	1000	0.00000E+00
39310	1000	0.00000E+00
40310	1000	0.00000E+00
41310	1000	0.00000E+00
42310	1000	0.00000E+00
43310	1000	0.00000E+00
44310	1000	0.00000E+00
45310	1000	0.00000E+00
46310	1000	0.00000E+00
47310	1000	0.00000E+00
48310	1000	0.00000E+00
49310	1000	0.00000E+00

50310	1000	0.00000E+00
51310	1000	0.00000E+00
52310	1000	0.00000E+00
53310	1000	0.00000E+00
54310	1000	0.00000E+00
55310	1000	0.00000E+00
56310	1000	0.00000E+00
57310	1000	0.00000E+00
6309	1000	0.00000E+00
7309	1000	0.00000E+00
8309	1000	0.00000E+00
9309	1000	0.00000E+00
10309	1000	0.00000E+00
11309	1000	0.00000E+00
12309	1000	0.00000E+00
13309	1000	0.00000E+00
14309	1000	0.00000E+00
15309	1000	0.00000E+00
16309	1000	0.00000E+00
17309	1000	0.00000E+00
18309	1000	0.00000E+00
19309	1000	0.00000E+00
20309	1000	0.00000E+00
21309	1000	0.00000E+00
22309	1000	0.00000E+00
23309	1000	0.00000E+00
24309	1000	0.00000E+00
25309	1000	0.00000E+00
26309	1000	0.00000E+00
27309	1000	0.00000E+00
28309	1000	0.00000E+00
29309	1000	0.00000E+00
30309	1000	0.00000E+00
31309	1000	0.00000E+00
32309	1000	0.00000E+00
33309	1000	0.00000E+00
34309	1000	0.00000E+00
35309	1000	0.00000E+00
36309	1000	0.00000E+00
37309	1000	0.00000E+00
38309	1000	0.00000E+00
39309	1000	0.00000E+00
40309	1000	0.00000E+00
41309	1000	0.00000E+00
42309	1000	0.00000E+00
43309	1000	0.00000E+00
44309	1000	0.00000E+00
45309	1000	0.00000E+00
46309	1000	0.00000E+00
47309	1000	0.00000E+00
48309	1000	0.00000E+00
49309	1000	0.00000E+00
50309	1000	0.00000E+00
51309	1000	0.00000E+00
52309	1000	0.00000E+00
53309	1000	0.00000E+00
54309	1000	0.00000E+00
55309	1000	0.00000E+00
56309	1000	0.00000E+00
57309	1000	0.00000E+00
6308	1000	0.00000E+00
7308	1000	0.00000E+00
8308	1000	0.00000E+00
9308	1000	0.00000E+00
10308	1000	0.00000E+00
11308	1000	0.00000E+00

12308	1000	0.00000E+00
13308	1000	0.00000E+00
14308	1000	0.00000E+00
15308	1000	0.00000E+00
16308	1000	0.00000E+00
17308	1000	0.00000E+00
18308	1000	0.00000E+00
19308	1000	0.00000E+00
20308	1000	0.00000E+00
21308	1000	0.00000E+00
22308	1000	0.00000E+00
23308	1000	0.00000E+00
24308	1000	0.00000E+00
25308	1000	0.00000E+00
26308	1000	0.00000E+00
27308	1000	0.00000E+00
28308	1000	0.00000E+00
29308	1000	0.00000E+00
30308	1000	0.00000E+00
31308	1000	0.00000E+00
32308	1000	0.00000E+00
33308	1000	0.00000E+00
34308	1000	0.00000E+00
35308	1000	0.00000E+00
36308	1000	0.00000E+00
37308	1000	0.00000E+00
38308	1000	0.00000E+00
39308	1000	0.00000E+00
40308	1000	0.00000E+00
41308	1000	0.00000E+00
42308	1000	0.00000E+00
43308	1000	0.00000E+00
44308	1000	0.00000E+00
45308	1000	0.00000E+00
46308	1000	0.00000E+00
47308	1000	0.00000E+00
48308	1000	0.00000E+00
49308	1000	0.00000E+00
50308	1000	0.00000E+00
51308	1000	0.00000E+00
52308	1000	0.00000E+00
53308	1000	0.00000E+00
54308	1000	0.00000E+00
55308	1000	0.00000E+00
56308	1000	0.00000E+00
57308	1000	0.00000E+00
401	3000	0.00000E+00
402	3000	0.00000E+00
403	3000	0.00000E+00

the total radial heat loss is 0.00000E+00 kw
the total axial heat loss is 0.00000E+00 kw
the total miscellaneous heat loss is 0.00000E+00 kw

stratio= 1.00000E+00

```

=====
total q zrh2o reaction= 0.00000E+00 kw
total q from fission = 1.49696E+01 kw
total q input = 1.49696E+01 kw
total q lost radially = 0.00000E+00 kw
total q lost axially = 0.00000E+00 kw

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total q lost vaporize = 0.00000E+00 kw
total q lost convect = 1.73993E+01 kw
total q output = 1.00000E-12 kw

percent q zrh2o react = 0.000
percent q loss radial = 0.000
percent q loss convect = *****
percent q loss misc = 0.000
percent q loss axially = 0.000

energy balance:
residual (qout-qin) = -1.49696E+01 kw
percent qin = 1.00000E+02

time = 2886.00 seconds

8.01667E-01 3.16655E-02 3.16655E-02 1.61524E-02 3.33333E-02 1.68746E-15 1 1

**** phase change summary ****

node	temp	da	dca	npc	a
6001	3.4946E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
8001	3.7576E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
10001	3.9808E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
12001	4.1471E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
14001	4.3718E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
16001	4.6431E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
18001	4.7547E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
6002	3.4922E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
8002	3.7537E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
10002	3.9763E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
12002	4.1430E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
14002	4.3678E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
16002	4.6391E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
18002	4.7525E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
6003	3.6150E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
8003	4.0106E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
10003	4.3470E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
12003	4.5993E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
14003	4.9209E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
16003	5.2934E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
18003	5.4437E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
6004	3.6173E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
8004	4.0157E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
10004	4.3549E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
12004	4.6095E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
14004	4.9333E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
16004	5.3077E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
18004	5.4595E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
22001	5.1824E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
26001	5.6963E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
30001	6.2455E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
34001	6.8212E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
38001	7.3968E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
42001	7.9742E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
46001	8.5419E+02	0.0000E+00	0.0000E+00	1	1.0000E+00

node	temp	da	dca	npc	a
50001	9.0740E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
54001	9.5490E+02	0.0000E+00	0.0000E+00	1	1.0000E+00

22002	5.1820E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
26002	5.6975E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
30002	6.2486E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
34002	6.8266E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
38002	7.4041E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
42002	7.9821E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
46002	8.5501E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
50002	9.0824E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
54002	9.5575E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
22003	5.9913E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
26003	6.6200E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
30003	7.2596E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
34003	7.8841E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
38003	8.4637E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
42003	9.0174E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
46003	9.5444E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
50003	1.0017E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
54003	1.0413E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
22004	6.0094E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
26004	6.6395E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
30004	7.2798E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
34004	7.9036E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
38004	8.4817E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
42004	9.0335E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
46004	9.5584E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
50004	1.0029E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
54004	1.0423E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
7001	3.6635E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
9001	3.8674E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
11001	4.0785E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
13001	4.2483E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
15001	4.5098E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
17001	4.7292E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
node	temp	da	dda	npc	a
7002	3.6599E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
9002	3.8632E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
11002	4.0740E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
13002	4.2443E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
15002	4.5058E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
17002	4.7259E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
7003	3.8645E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
9003	4.1788E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
11003	4.4944E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
13003	4.7474E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
15003	5.1127E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
17003	5.4099E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
7004	3.8683E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
9004	4.1853E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
11004	4.5035E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
13004	4.7587E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
15004	5.1261E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
17004	5.4251E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
21001	5.0692E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
25001	5.5681E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
29001	6.1102E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
33001	6.6800E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
37001	7.2632E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
41001	7.8343E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
45001	8.4075E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
49001	8.9501E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
53001	9.4415E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
57001	9.8527E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
21002	5.0684E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
25002	5.5688E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
29002	6.1128E+02	0.0000E+00	0.0000E+00	1	1.0000E+00

33002	6.6848E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
37002	7.2700E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
41002	7.8421E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
45002	8.4157E+02	0.0000E+00	0.0000E+00	1	1.0000E+00

node	temp	da	dda	npc	a
49002	8.9584E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
53002	9.4500E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
57002	9.8613E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
21003	5.8493E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
25003	6.4663E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
29003	7.1064E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
33003	7.7358E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
37003	8.3342E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
41003	8.8853E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
45003	9.4219E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
49003	9.9096E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
53003	1.0327E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
57003	1.0643E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
21004	5.8669E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
25004	6.4855E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
29004	7.1264E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
33004	7.7556E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
37004	8.3525E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
41004	8.9019E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
45004	9.4365E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
49004	9.9221E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
53004	1.0337E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
57004	1.0651E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
19001	4.8284E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
23001	5.3090E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
27001	5.8354E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
31001	6.3919E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
35001	6.9736E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
39001	7.5435E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
43001	8.1233E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
47001	8.6839E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
51001	9.2037E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
55001	9.6565E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
19002	4.8270E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
23002	5.3090E+02	0.0000E+00	0.0000E+00	1	1.0000E+00

node	temp	da	dda	npc	a
27002	5.8370E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
31002	6.3956E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
35002	6.9794E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
39002	7.5510E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
43002	8.1314E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
47002	8.6922E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
51002	9.2121E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
55002	9.6651E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
19003	5.5398E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
23003	6.1492E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
27003	6.7858E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
31003	7.4235E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
35003	8.0423E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
39003	8.6062E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
43003	9.1581E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
47003	9.6732E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
51003	1.0129E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
55003	1.0496E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
19004	5.5562E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
23004	6.1677E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
27004	6.8056E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
31004	7.4436E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
35004	8.0615E+02	0.0000E+00	0.0000E+00	1	1.0000E+00

39004	8.6237E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
43004	9.1737E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
47004	9.6868E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
51004	1.0140E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
55004	1.0505E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
20001	4.9455E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
24001	5.4332E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
28001	5.9672E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
32001	6.5303E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
36001	7.1154E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
40001	7.6837E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
44001	8.2612E+02	0.0000E+00	0.0000E+00	1	1.0000E+00

node	temp	da	dda	npc	a
48001	8.8136E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
52001	9.3206E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
56001	9.7487E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
20002	4.9443E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
24002	5.4335E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
28002	5.9694E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
32002	6.5346E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
36002	7.1218E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
40002	7.6914E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
44002	8.2693E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
48002	8.8219E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
52002	9.3290E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
56002	9.7573E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
20003	5.6906E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
24003	6.3013E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
28003	6.9399E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
32003	7.5741E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
36003	8.1860E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
40003	8.7406E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
44003	9.2859E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
48003	9.7884E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
52003	1.0227E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
56003	1.0562E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
20004	5.7076E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
24004	6.3201E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
28004	6.9598E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
32004	7.5940E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
36004	8.2048E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
40004	8.7577E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
44004	9.3010E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
48004	9.8014E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
52004	1.0237E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
56004	1.0570E+03	0.0000E+00	0.0000E+00	1	1.0000E+00
5001	3.3056E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
5002	3.3051E+02	0.0000E+00	0.0000E+00	1	1.0000E+00

node	temp	da	dda	npc	a
5003	3.3443E+02	0.0000E+00	0.0000E+00	1	1.0000E+00
5004	3.3452E+02	0.0000E+00	0.0000E+00	1	1.0000E+00

restart file created at 8.01667E-01 hrs
time step 1610
number of nodes 1668

tape5 file contains special output nodes:
5001 10001 14001 18001 22001 30001 38001 44001 46001 54001

5003 10003 14003 18003 22003 30003 38003 44003 46003 54003
 5306 10306 14306 18306 22306 30306 38306 44306 46306 54306
 5101 10101 53003 57001 57003 53001 50001 50003 42001 42003

number of writes to tape5 file = 44

*** final system summary ***

node	temp	oxthik	oxarea	zrthik	gen
6001	3.49456E+02	0.00000E+00	3.70000E-02	1.75000E-01	2.44123E+01
8001	3.75756E+02	0.00000E+00	3.70000E-02	1.75000E-01	4.53361E+01
10001	3.98081E+02	0.00000E+00	3.70000E-02	1.75000E-01	5.97621E+01
12001	4.14707E+02	0.00000E+00	3.70000E-02	1.75000E-01	6.58020E+01
14001	4.37180E+02	0.00000E+00	3.70000E-02	1.75000E-01	7.66692E+01
16001	4.64305E+02	0.00000E+00	3.70000E-02	1.75000E-01	8.99097E+01
18001	4.75465E+02	0.00000E+00	3.70000E-02	1.75000E-01	8.45424E+01
6002	3.49222E+02	0.00000E+00	1.00000E-01	1.75000E-01	3.65928E+01
8002	3.75365E+02	0.00000E+00	1.00000E-01	1.75000E-01	6.79567E+01
10002	3.97631E+02	0.00000E+00	1.00000E-01	1.75000E-01	8.95805E+01
12002	4.14299E+02	0.00000E+00	1.00000E-01	1.75000E-01	9.86340E+01
14002	4.36780E+02	0.00000E+00	1.00000E-01	1.75000E-01	1.14923E+02
16002	4.63907E+02	0.00000E+00	1.00000E-01	1.75000E-01	1.34770E+02
18002	4.75255E+02	0.00000E+00	1.00000E-01	1.75000E-01	1.26725E+02
6003	3.61500E+02	0.00000E+00	1.34000E-01	1.58500E-01	7.48802E+01
8003	4.01060E+02	0.00000E+00	1.34000E-01	1.58500E-01	1.39060E+02
10003	4.34704E+02	0.00000E+00	1.34000E-01	1.58500E-01	1.83309E+02
12003	4.59932E+02	0.00000E+00	1.34000E-01	1.58500E-01	2.01835E+02
14003	4.92088E+02	0.00000E+00	1.34000E-01	1.58500E-01	2.35169E+02
16003	5.29336E+02	0.00000E+00	1.34000E-01	1.58500E-01	2.75782E+02
18003	5.44370E+02	0.00000E+00	1.34000E-01	1.58500E-01	2.59318E+02
6004	3.61728E+02	0.00000E+00	1.91000E-01	1.58500E-01	8.75717E+01
8004	4.01573E+02	0.00000E+00	1.91000E-01	1.58500E-01	1.62630E+02
10004	4.35486E+02	0.00000E+00	1.91000E-01	1.58500E-01	2.14379E+02
12004	4.60951E+02	0.00000E+00	1.91000E-01	1.58500E-01	2.36045E+02
14004	4.93326E+02	0.00000E+00	1.91000E-01	1.58500E-01	2.75028E+02
16004	5.30769E+02	0.00000E+00	1.91000E-01	1.58500E-01	3.22524E+02
18004	5.45948E+02	0.00000E+00	1.91000E-01	1.58500E-01	3.03271E+02
6301	3.48511E+02	0.00000E+00	3.76000E-01	2.00000E-02	4.67503E-02
8301	3.73943E+02	0.00000E+00	3.76000E-01	2.00000E-02	8.68202E-02
10301	3.95642E+02	0.00000E+00	3.76000E-01	2.00000E-02	1.14446E-01
12301	4.11931E+02	0.00000E+00	3.76000E-01	2.00000E-02	1.26013E-01
14301	4.33895E+02	0.00000E+00	3.76000E-01	2.00000E-02	1.46824E-01
16301	4.60416E+02	0.00000E+00	3.76000E-01	2.00000E-02	1.72180E-01
18301	4.71624E+02	0.00000E+00	3.76000E-01	2.00000E-02	1.61901E-01
6302	3.48271E+02	0.00000E+00	1.00500E+00	3.00000E-02	1.40573E-01
8302	3.73615E+02	0.00000E+00	1.00500E+00	3.00000E-02	2.61059E-01
10302	3.95371E+02	0.00000E+00	1.00500E+00	3.00000E-02	3.44128E-01
12302	4.11856E+02	0.00000E+00	1.00500E+00	3.00000E-02	3.78907E-01
14302	4.33991E+02	0.00000E+00	1.00500E+00	3.00000E-02	4.41484E-01
16302	4.60700E+02	0.00000E+00	1.00500E+00	3.00000E-02	5.17727E-01
18302	4.72313E+02	0.00000E+00	1.00500E+00	3.00000E-02	4.86820E-01
6303	3.60320E+02	0.00000E+00	1.33600E+00	2.00000E-02	1.40466E-01
8303	3.98794E+02	0.00000E+00	1.33600E+00	2.00000E-02	2.60861E-01
10303	4.31662E+02	0.00000E+00	1.33600E+00	2.00000E-02	3.43866E-01
12303	4.56470E+02	0.00000E+00	1.33600E+00	2.00000E-02	3.78619E-01
14303	4.88049E+02	0.00000E+00	1.33600E+00	2.00000E-02	4.41149E-01
16303	5.24658E+02	0.00000E+00	1.33600E+00	2.00000E-02	5.17333E-01
18303	5.39789E+02	0.00000E+00	1.33600E+00	2.00000E-02	4.86450E-01
6304	3.60955E+02	0.00000E+00	1.90500E+00	2.50000E-02	1.87717E-01
8304	4.00186E+02	0.00000E+00	1.90500E+00	2.50000E-02	3.48611E-01
10304	4.33743E+02	0.00000E+00	1.90500E+00	2.50000E-02	4.59539E-01
12304	4.59129E+02	0.00000E+00	1.90500E+00	2.50000E-02	5.05982E-01
14304	4.91262E+02	0.00000E+00	1.90500E+00	2.50000E-02	5.89545E-01

*ver2.17 trump bd full power spiked hot channel reflood station blackout (hygen.

41

time (sec)

50001
10001
14001
18001
22001
30001
38001
44001
46001
54001
5003
10003
14003
18003
22003
30003
38003
44003
46003
54003
5306
10306
14306
18306
22306
30306
38306
44306
46306
54306
5101
10101
53003
57001
57003
53001
50001
50003
42001
42003
6.1044E+01 6.1586E+02 7.9221E+02 8.4767E+02 8.7445E+02 9.0635E+02 9.7581E+02 1.0003E+03 1.0041E+03 1.0033E+03 9.7577E+02 6.0703E+02
8.1725E+02
8.8330E+02 9.1519E+02 9.5317E+02 1.0359E+03 1.0650E+03 1.0696E+03 1.0686E+03 1.0358E+03 6.3938E+02 6.5861E+02 6.5930E+02 6.5933E+02
6.5957E+02
6.6044E+02 6.6074E+02 6.5571E+02 6.6078E+02 6.6043E+02 7.8506E+02 8.1605E+02 1.0429E+03 9.5305E+02 1.0088E+03 9.8175E+02 9.9510E+02
1.0588E+03
1.0033E+03 1.0686E+03
1.2400E+02 5.6859E+02 8.1002E+02 8.8764E+02 9.2611E+02 9.6958E+02 1.0663E+03 1.1007E+03 1.1059E+03 1.1047E+03 1.0665E+03 5.5953E+02
8.3666E+02
9.2553E+02 9.6952E+02 1.0193E+03 1.1301E+03 1.1694E+03 1.1753E+03 1.1740E+03 1.1302E+03 6.7037E+02 7.0782E+02 7.0872E+02 7.0745E+02
7.0712E+02
7.0823E+02 7.0863E+02 6.9175E+02 7.0867E+02 7.0823E+02 7.8731E+02 8.3852E+02 1.1396E+03 1.0350E+03 1.0942E+03 1.0746E+03 1.0934E+03
1.1610E+03
1.1047E+03 1.1740E+03
1.8762E+02 5.4283E+02 8.1103E+02 8.9860E+02 9.4266E+02 9.9086E+02 1.0997E+03 1.1385E+03 1.1443E+03 1.1430E+03 1.1000E+03 5.3603E+02
8.3591E+02
9.3335E+02 9.8222E+02 1.0360E+03 1.1571E+03 1.2002E+03 1.2066E+03 1.2052E+03 1.1574E+03 6.7586E+02 7.2710E+02 7.2813E+02 7.2492E+02
7.2412E+02
7.2540E+02 7.2585E+02 6.9948E+02 7.2590E+02 7.2540E+02 7.8299E+02 8.5068E+02 1.1674E+03 1.0647E+03 1.1181E+03 1.1090E+03 1.1302E+03
1.1910E+03
1.1430E+03 1.2052E+03
2.4864E+02 5.2880E+02 8.0502E+02 8.9616E+02 9.4245E+02 9.9205E+02 1.1052E+03 1.1455E+03 1.1515E+03 1.1502E+03 1.1055E+03 5.2431E+02
8.2779E+02

9.2721E+02 9.7743E+02 1.0318E+03 1.1552E+03 1.1991E+03 1.2057E+03 1.2042E+03 1.1555E+03 6.7387E+02 7.3555E+02 7.3669E+02 7.3160E+02
 7.3037E+02 7.3177E+02 7.3223E+02 7.3233E+02 7.3178E+02 7.3586E+02 8.5668E+02 1.1657E+03 1.0690E+03 1.1156E+03 1.1148E+03 1.1370E+03
 1.1898E+03 1.1502E+03 1.2042E+03 3.1164E+02 5.2023E+02 7.9533E+02 8.8677E+02 9.3345E+02 9.8287E+02 1.0962E+03 1.1367E+03 1.1427E+03 1.1414E+03 1.0966E+03 5.1751E+02
 8.1615E+02 9.1448E+02 9.6433E+02 1.0178E+03 1.1397E+03 1.1832E+03 1.1896E+03 1.1882E+03 1.1401E+03 6.6907E+02 7.3949E+02 7.4073E+02 7.3393E+02
 7.3225E+02 7.3377E+02 7.3432E+02 7.0045E+02 7.3438E+02 7.3378E+02 7.6697E+02 8.5910E+02 1.1501E+03 1.0601E+03 1.1007E+03 1.1059E+03 1.1281E+03
 1.1740E+03 1.1414E+03 1.1882E+03 3.8303E+02 5.1433E+02 7.8464E+02 8.7496E+02 9.2120E+02 9.6980E+02 1.0817E+03 1.1217E+03 1.1276E+03 1.1263E+03 1.0821E+03 5.1305E+02
 8.0412E+02 9.0024E+02 9.4906E+02 1.0012E+03 1.1203E+03 1.1628E+03 1.1691E+03 1.1677E+03 1.1207E+03 6.6226E+02 7.4071E+02 7.4206E+02 7.3370E+02
 7.3151E+02 7.3316E+02 7.3375E+02 6.9958E+02 7.3381E+02 7.3316E+02 7.5615E+02 8.5885E+02 1.1305E+03 1.0461E+03 1.0823E+03 1.0912E+03 1.1132E+03
 1.1538E+03 1.1263E+03 1.1677E+03 4.4364E+02 5.1138E+02 7.7625E+02 8.6496E+02 9.1043E+02 9.5807E+02 1.0679E+03 1.1072E+03 1.1130E+03 1.1117E+03 1.0683E+03 5.1081E+02
 7.9502E+02 8.8898E+02 9.3671E+02 9.8766E+02 1.1040E+03 1.1456E+03 1.1517E+03 1.1504E+03 1.1044E+03 6.5603E+02 7.4008E+02 7.4151E+02 7.3210E+02
 7.2950E+02 7.3124E+02 7.3187E+02 6.9859E+02 7.3194E+02 7.3125E+02 7.4686E+02 8.5702E+02 1.1140E+03 1.0330E+03 1.0669E+03 1.0773E+03 1.0989E+03
 1.1368E+03 1.1117E+03 1.1504E+03 5.1000E+02 5.0896E+02 7.6710E+02 8.5369E+02 8.9809E+02 9.4455E+02 1.0517E+03 1.0901E+03 1.0957E+03 1.0945E+03 1.0521E+03 5.0893E+02
 7.8524E+02 8.7665E+02 9.2308E+02 9.7263E+02 1.0858E+03 1.1262E+03 1.1322E+03 1.1309E+03 1.0862E+03 6.4914E+02 7.3830E+02 7.3983E+02 7.2953E+02
 7.2648E+02 7.2833E+02 7.2899E+02 6.9730E+02 7.2907E+02 7.2834E+02 7.3687E+02 8.5394E+02 1.0955E+03 1.0177E+03 1.0497E+03 1.0609E+03 1.0820E+03
 1.1176E+03 1.0945E+03 1.1309E+03 5.7273E+02 5.0750E+02 7.5967E+02 8.4429E+02 8.8768E+02 9.3306E+02 1.0378E+03 1.0753E+03 1.0808E+03 1.0796E+03 1.0382E+03 5.0773E+02
 7.7750E+02 8.6674E+02 9.1206E+02 9.6043E+02 1.0709E+03 1.1103E+03 1.1162E+03 1.1149E+03 1.0712E+03 6.4281E+02 7.3593E+02 7.3755E+02 7.2662E+02
 7.2318E+02 7.2512E+02 7.2583E+02 6.9593E+02 7.2590E+02 7.2514E+02 7.2776E+02 8.5037E+02 1.0803E+03 1.0045E+03 1.0356E+03 1.0467E+03 1.0673E+03
 1.1020E+03 1.0795E+03 1.1149E+03 6.3429E+02 5.0636E+02 7.5301E+02 8.3579E+02 8.7822E+02 9.2262E+02 1.0250E+03 1.0617E+03 1.0671E+03 1.0659E+03 1.0254E+03 5.0673E+02
 7.7058E+02 8.5784E+02 9.0214E+02 9.4946E+02 1.0575E+03 1.0960E+03 1.1018E+03 1.1005E+03 1.0578E+03 6.3671E+02 7.3324E+02 7.3493E+02 7.2352E+02
 7.1972E+02 7.2175E+02 7.2248E+02 6.9446E+02 7.2256E+02 7.2176E+02 7.1915E+02 8.4647E+02 1.0667E+03 9.9252E+02 1.0230E+03 1.0338E+03 1.0539E+03
 1.0879E+03 1.0659E+03 1.1005E+03 7.0286E+02 5.0522E+02 7.4583E+02 8.2657E+02 8.6794E+02 9.1126E+02 1.0111E+03 1.0469E+03 1.0521E+03 1.0510E+03 1.0115E+03 5.0571E+02
 7.6312E+02 8.4824E+02 8.9143E+02 9.3761E+02 1.0430E+03 1.0806E+03 1.0862E+03 1.0849E+03 1.0433E+03 6.3027E+02 7.2989E+02 7.3168E+02 7.1989E+02
 7.1572E+02 7.1785E+02 7.1862E+02 6.9269E+02 7.1870E+02 7.1786E+02 7.1000E+02 8.4183E+02 1.0520E+03 9.7943E+02 1.0093E+03 1.0196E+03 1.0393E+03
 1.0726E+03 1.0510E+03 1.0849E+03 7.8000E+02 5.0423E+02 7.3877E+02 8.1743E+02 8.5772E+02 8.9995E+02 9.9725E+02 1.0321E+03 1.0372E+03 1.0361E+03 9.9759E+02 5.0476E+02
 7.5583E+02 8.3882E+02 8.8092E+02 9.2597E+02 1.0287E+03 1.0653E+03 1.0708E+03 1.0696E+03 1.0290E+03 6.2343E+02 7.2592E+02 7.2780E+02 7.1574E+02
 7.1121E+02 7.1343E+02 7.1424E+02 6.9057E+02 7.1433E+02 7.1345E+02 7.0027E+02 8.3642E+02 1.0374E+03 9.6636E+02 9.9588E+02 1.0055E+03 1.0247E+03
 1.0576E+03 1.0361E+03 1.0696E+03 8.4139E+02 3.8082E+02 5.4100E+02 6.3120E+02 7.1217E+02 7.9103E+02 9.5117E+02 1.0618E+03 1.1153E+03 1.1285E+03 1.1468E+03 3.9145E+02
 6.0238E+02 7.1212E+02 7.9866E+02 8.7356E+02 1.0180E+03 1.1050E+03 1.1407E+03 1.1490E+03 1.1466E+03 5.3024E+02 6.6745E+02 7.1127E+02 7.3815E+02
 7.5818E+02 7.9799E+02 8.2443E+02 8.1838E+02 8.3843E+02 8.4230E+02 6.8489E+02 8.2683E+02 1.1499E+03 1.1366E+03 1.1285E+03 1.1478E+03 1.1453E+03

1.1553E+03
 1.0994E+03 1.1308E+03
 9.0178E+02 3.4022E+02 4.5194E+02 5.2354E+02 5.9701E+02 6.7743E+02 8.6243E+02 1.0237E+03 1.1217E+03 1.1499E+03 1.2300E+03 3.4919E+02
 5.1893E+02
 6.1981E+02 7.1121E+02 7.9810E+02 9.7517E+02 1.1085E+03 1.1804E+03 1.2006E+03 1.2448E+03 4.9508E+02 6.2680E+02 6.7722E+02 7.1640E+02
 7.5036E+02
 8.1721E+02 8.6856E+02 8.8078E+02 9.0336E+02 9.2293E+02 6.6781E+02 8.1271E+02 1.2425E+03 1.2435E+03 1.2445E+03 1.2235E+03 1.1972E+03
 1.2301E+03
 1.0909E+03 1.1588E+03
 9.6214E+02 3.3381E+02 4.3103E+02 4.9148E+02 5.5387E+02 6.2478E+02 8.0020E+02 9.7082E+02 1.0848E+03 1.1197E+03 1.2308E+03 3.4114E+02
 4.9441E+02
 5.8497E+02 6.6837E+02 7.5167E+02 9.3090E+02 1.0798E+03 1.1693E+03 1.1959E+03 1.2470E+03 4.8383E+02 6.0943E+02 6.5764E+02 6.9627E+02
 7.3247E+02
 8.0742E+02 8.7024E+02 8.9331E+02 9.1768E+02 9.4846E+02 6.5524E+02 8.0091E+02 1.2470E+03 1.2470E+03 1.2470E+03 1.2206E+03 1.1821E+03
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 1.0222E+03 3.3273E+02 4.2548E+02 4.8156E+02 5.3854E+02 6.0341E+02 7.6692E+02 9.3314E+02 1.0490E+03 1.0854E+03 1.2078E+03 3.3944E+02
 4.8624E+02
 5.7159E+02 6.4953E+02 7.2831E+02 9.0141E+02 1.0512E+03 1.1458E+03 1.1747E+03 1.2477E+03 4.7733E+02 5.9987E+02 6.4677E+02 6.8427E+02
 7.2016E+02
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 1.0111E+03 1.1158E+03
 1.0836E+03 3.3246E+02 4.2315E+02 4.7730E+02 5.3178E+02 5.9348E+02 7.4900E+02 9.0921E+02 1.0226E+03 1.0588E+03 1.1840E+03 3.3889E+02
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 1.2051E+03
 9.8534E+02 1.0943E+03
 1.1437E+03 3.3233E+02 4.2158E+02 4.7463E+02 5.2776E+02 5.8773E+02 7.3847E+02 8.9421E+02 1.0049E+03 1.0403E+03 1.1649E+03 3.3858E+02
 4.7920E+02
 5.6012E+02 6.3330E+02 7.0736E+02 8.7113E+02 1.0153E+03 1.1087E+03 1.1379E+03 1.2470E+03 4.6764E+02 5.8681E+02 6.3316E+02 6.7019E+02
 7.0577E+02
 7.8330E+02 8.5265E+02 8.8607E+02 9.1027E+02 9.5637E+02 6.2719E+02 7.7334E+02 1.2292E+03 1.2002E+03 1.2474E+03 1.1518E+03 1.1066E+03
 1.1890E+03
 9.6847E+02 1.0788E+03
 1.2039E+03 3.3222E+02 4.2014E+02 4.7230E+02 5.2442E+02 5.8316E+02 7.3051E+02 8.8301E+02 9.9151E+02 1.0262E+03 1.1489E+03 3.3832E+02
 4.7654E+02
 5.5604E+02 6.2789E+02 7.0065E+02 8.6176E+02 1.0039E+03 1.0961E+03 1.1249E+03 1.2289E+03 4.6354E+02 5.8136E+02 6.2765E+02 6.6480E+02
 7.0048E+02
 7.7871E+02 8.4888E+02 8.8387E+02 9.0760E+02 9.5507E+02 6.1942E+02 7.6548E+02 1.2095E+03 1.1848E+03 1.2470E+03 1.1356E+03 1.0913E+03
 1.1756E+03
 9.5578E+02 1.0665E+03
 1.2646E+03 3.3212E+02 4.1874E+02 4.7009E+02 5.2133E+02 5.7902E+02 7.2362E+02 8.7363E+02 9.8044E+02 1.0146E+03 1.1350E+03 3.3807E+02
 4.7400E+02
 5.5220E+02 6.2288E+02 6.9455E+02 8.5352E+02 9.9407E+02 1.0854E+03 1.1139E+03 1.2070E+03 4.5969E+02 5.7618E+02 6.2240E+02 6.5972E+02
 6.9552E+02
 7.7451E+02 8.4553E+02 8.8200E+02 9.0527E+02 9.5329E+02 6.1204E+02 7.5790E+02 1.1963E+03 1.1716E+03 1.2470E+03 1.1223E+03 1.0787E+03
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 1.3252E+03 3.3201E+02 4.1737E+02 4.6792E+02 5.1834E+02 5.7507E+02 7.1721E+02 8.6511E+02 9.7056E+02 1.0043E+03 1.1231E+03 3.3783E+02
 4.7154E+02
 5.4849E+02 6.1807E+02 6.8873E+02 8.4580E+02 9.8507E+02 1.0757E+03 1.1040E+03 1.1946E+03 4.5607E+02 5.7125E+02 6.1739E+02 6.5485E+02
 6.9077E+02
 7.7051E+02 8.4238E+02 8.8026E+02 9.0309E+02 9.5185E+02 6.0504E+02 7.5061E+02 1.1855E+03 1.1593E+03 1.2470E+03 1.1106E+03 1.0676E+03
 1.1540E+03
 9.3582E+02 1.0466E+03
 1.3873E+03 3.3190E+02 4.1595E+02 4.6569E+02 5.1525E+02 5.7101E+02 7.1064E+02 8.5645E+02 9.6059E+02 9.9395E+02 1.1113E+03 3.3760E+02
 4.6903E+02
 5.4472E+02 6.1319E+02 6.8281E+02 8.3794E+02 9.7597E+02 1.0659E+03 1.0940E+03 1.1838E+03 4.5257E+02 5.6638E+02 6.1241E+02 6.5000E+02
 6.8601E+02
 7.6645E+02 8.3914E+02 8.7839E+02 9.0081E+02 9.5040E+02 5.9820E+02 7.4336E+02 1.1752E+03 1.1467E+03 1.2204E+03 1.0991E+03 1.0565E+03
 1.1438E+03
 9.2628E+02 1.0370E+03
 1.4480E+03 3.3182E+02 4.1478E+02 4.6382E+02 5.1264E+02 5.6755E+02 7.0499E+02 8.4899E+02 9.5203E+02 9.8504E+02 1.1013E+03 3.3739E+02

4.6689E+02
 5.4147E+02 6.0895E+02 6.7265E+02 8.3109E+02 9.6805E+02 1.0575E+03 1.0854E+03 1.1748E+03 4.4931E+02 5.6179E+02 6.0771E+02 6.4540E+02
 6.8152E+02
 7.6260E+02 8.3607E+02 8.7660E+02 8.9864E+02 9.4905E+02 5.9180E+02 7.3645E+02 1.1662E+03 1.1356E+03 1.1987E+03 1.0892E+03 1.0470E+03
 1.1350E+03
 9.1807E+02 1.0287E+03
 1.5120E+03 3.3173E+02 4.1370E+02 4.6209E+02 5.1022E+02 5.6432E+02 6.9967E+02 8.4190E+02 9.4385E+02 9.7653E+02 1.0918E+03 3.3719E+02
 4.6486E+02
 5.3837E+02 6.0491E+02 6.7274E+02 8.2455E+02 9.6050E+02 1.0494E+03 1.0772E+03 1.1663E+03 4.4604E+02 5.5712E+02 6.0294E+02 6.4074E+02
 6.7701E+02
 7.5874E+02 8.3302E+02 8.7483E+02 8.9651E+02 9.4778E+02 5.8534E+02 7.2933E+02 1.1578E+03 1.1254E+03 1.1879E+03 1.0797E+03 1.0379E+03
 1.1266E+03
 9.1024E+02 1.0208E+03
 1.5800E+03 3.3165E+02 4.1255E+02 4.6026E+02 5.0766E+02 5.6092E+02 6.9407E+02 8.3442E+02 9.3522E+02 9.6755E+02 1.0816E+03 3.3699E+02
 4.6270E+02
 5.3509E+02 6.0064E+02 6.6755E+02 8.1765E+02 9.5252E+02 1.0409E+03 1.0685E+03 1.1574E+03 4.4273E+02 5.5229E+02 5.9800E+02 6.3592E+02
 6.7233E+02
 7.5474E+02 8.2984E+02 8.7295E+02 8.9428E+02 9.4645E+02 5.7876E+02 7.2194E+02 1.1489E+03 1.1149E+03 1.1786E+03 1.0697E+03 1.0283E+03
 1.1177E+03
 9.0198E+02 1.0124E+03
 1.6533E+03 3.3156E+02 4.1133E+02 4.5832E+02 5.0496E+02 5.5733E+02 6.8819E+02 8.2655E+02 9.2613E+02 9.5809E+02 1.0710E+03 3.3677E+02
 4.6043E+02
 5.3165E+02 5.9615E+02 6.6210E+02 8.1040E+02 9.4414E+02 1.0320E+03 1.0594E+03 1.1480E+03 4.3932E+02 5.4723E+02 5.9280E+02 6.3083E+02
 6.6739E+02
 7.5046E+02 8.2643E+02 8.7086E+02 8.9184E+02 9.4494E+02 5.7197E+02 7.1415E+02 1.1395E+03 1.1039E+03 1.1693E+03 1.0591E+03 1.0182E+03
 1.1084E+03
 8.9328E+02 1.0036E+03
 1.7400E+03 3.3145E+02 4.0994E+02 4.5612E+02 5.0190E+02 5.5328E+02 6.8156E+02 8.1768E+02 9.1590E+02 9.4745E+02 1.0590E+03 3.3653E+02
 4.5787E+02
 5.2776E+02 5.9108E+02 6.5595E+02 8.0221E+02 9.3466E+02 1.0219E+03 1.0491E+03 1.1374E+03 4.3553E+02 5.4146E+02 5.8686E+02 6.2500E+02
 6.6172E+02
 7.4552E+02 8.2244E+02 8.6832E+02 8.8895E+02 9.4313E+02 5.6433E+02 7.0515E+02 1.1289E+03 1.0917E+03 1.1591E+03 1.0473E+03 1.0068E+03
 1.0979E+03
 8.8349E+02 9.9369E+02
 1.8001E+03 3.3138E+02 4.0899E+02 4.5462E+02 4.9982E+02 5.5055E+02 6.7713E+02 8.1176E+02 9.0909E+02 9.4037E+02 1.0511E+03 3.3637E+02
 4.5612E+02
 5.2511E+02 5.8765E+02 6.5179E+02 7.9667E+02 9.2827E+02 1.0151E+03 1.0422E+03 1.1303E+03 4.3302E+02 5.3753E+02 5.8279E+02 6.2100E+02
 6.5778E+02
 7.4209E+02 8.1967E+02 8.6650E+02 8.8691E+02 9.4183E+02 5.5927E+02 6.9904E+02 1.1218E+03 1.0836E+03 1.1522E+03 1.0394E+03 9.9920E+02
 1.0908E+03
 8.7697E+02 9.8700E+02
 1.8637E+03 3.3130E+02 4.0792E+02 4.5295E+02 4.9754E+02 5.4758E+02 6.7243E+02 8.0549E+02 9.0197E+02 9.3299E+02 1.0429E+03 3.3619E+02
 4.5421E+02
 5.2223E+02 5.8393E+02 6.4729E+02 7.9067E+02 9.2132E+02 1.0077E+03 1.0347E+03 1.1227E+03 4.3048E+02 5.3345E+02 5.7856E+02 6.1682E+02
 6.5365E+02
 7.3845E+02 8.1668E+02 8.6448E+02 8.8468E+02 9.4038E+02 5.5411E+02 6.9268E+02 1.1142E+03 1.0753E+03 1.1448E+03 1.0313E+03 9.9138E+02
 1.0832E+03
 8.7012E+02 9.7977E+02
 1.9281E+03 3.3122E+02 4.0687E+02 4.5128E+02 4.9523E+02 5.4454E+02 6.6754E+02 7.9892E+02 8.9450E+02 9.2526E+02 1.0344E+03 3.3602E+02
 4.5236E+02
 5.1940E+02 5.8022E+02 6.4277E+02 7.8457E+02 9.1422E+02 1.0002E+03 1.0271E+03 1.1149E+03 4.2803E+02 5.2946E+02 5.7441E+02 6.1270E+02
 6.4956E+02
 7.3478E+02 8.1362E+02 8.6232E+02 8.8233E+02 9.3880E+02 5.4908E+02 6.8636E+02 1.1064E+03 1.0667E+03 1.1370E+03 1.0229E+03 9.8320E+02
 1.0754E+03
 8.6294E+02 9.7234E+02
 1.9896E+03 3.3118E+02 4.0630E+02 4.5031E+02 4.9379E+02 5.4255E+02 6.6410E+02 7.9404E+02 8.8875E+02 9.1924E+02 1.0275E+03 3.3591E+02
 4.5112E+02
 5.1744E+02 5.7759E+02 6.3952E+02 7.8012E+02 9.0893E+02 9.9449E+02 1.0212E+03 1.1088E+03 4.2574E+02 5.2569E+02 5.7051E+02 6.0886E+02
 6.4578E+02
 7.3142E+02 8.1085E+02 8.6040E+02 8.8023E+02 9.3744E+02 5.4444E+02 6.8042E+02 1.1003E+03 1.0595E+03 1.1309E+03 1.0161E+03 9.7670E+02
 1.0694E+03
 8.5746E+02 9.6675E+02
 2.0607E+03 3.3113E+02 4.0566E+02 4.4928E+02 4.9234E+02 5.4059E+02 6.6083E+02 7.8949E+02 8.8342E+02 9.1368E+02 1.0211E+03 3.3577E+02
 4.4973E+02
 5.1530E+02 5.7477E+02 6.3610E+02 7.7558E+02 9.0366E+02 9.8888E+02 1.0155E+03 1.1029E+03 4.2323E+02 5.2150E+02 5.6618E+02 6.0462E+02
 6.4165E+02

7.2782E+02 8.0797E+02 8.5845E+02 8.7813E+02 9.3616E+02 5.3928E+02 6.7369E+02 1.0944E+03 1.0529E+03 1.1250E+03 1.0098E+03 9.7069E+02
 1.0635E+03
 8.5239E+02 9.6123E+02
 2.1223E+03 3.3109E+02 4.0509E+02 4.4837E+02 4.9107E+02 5.3891E+02 6.5809E+02 7.8577E+02 8.7915E+02 9.0923E+02 1.0161E+03 3.3566E+02
 4.4853E+02
 5.1346E+02 5.7238E+02 6.3321E+02 7.7178E+02 8.9934E+02 9.8435E+02 1.0109E+03 1.0982E+03 4.2114E+02 5.1795E+02 5.6253E+02 6.0105E+02
 6.3818E+02
 7.2482E+02 8.0563E+02 8.5692E+02 8.7650E+02 9.3526E+02 5.3499E+02 6.6797E+02 1.0897E+03 1.0478E+03 1.1204E+03 1.0048E+03 9.6594E+02
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 8.4829E+02 9.5675E+02
 2.1853E+03 3.3104E+02 4.0449E+02 4.4740E+02 4.8971E+02 5.3711E+02 6.5516E+02 7.8179E+02 8.7459E+02 9.0450E+02 1.0108E+03 3.3555E+02
 4.4730E+02
 5.1155E+02 5.6989E+02 6.3020E+02 7.6783E+02 8.9485E+02 9.7966E+02 1.0062E+03 1.0935E+03 4.1909E+02 5.1440E+02 5.5884E+02 5.9744E+02
 6.3467E+02
 7.2176E+02 8.0323E+02 8.5532E+02 8.7483E+02 9.3435E+02 5.3074E+02 6.6221E+02 1.0850E+03 1.0424E+03 1.1157E+03 9.9958E+02 9.6090E+02
 1.0541E+03
 8.4392E+02 9.5211E+02
 2.2615E+03 3.3099E+02 4.0381E+02 4.4632E+02 4.8819E+02 5.3509E+02 6.5188E+02 7.7732E+02 8.6950E+02 8.9922E+02 1.0050E+03 3.3542E+02
 4.4589E+02
 5.0939E+02 5.6706E+02 6.2678E+02 7.6331E+02 8.8971E+02 9.7431E+02 1.0008E+03 1.0881E+03 4.1673E+02 5.1021E+02 5.5449E+02 5.9317E+02
 6.3051E+02
 7.1811E+02 8.0035E+02 8.5337E+02 8.7281E+02 9.3323E+02 5.2581E+02 6.5538E+02 1.0796E+03 1.0365E+03 1.1105E+03 9.9381E+02 9.5532E+02
 1.0487E+03
 8.3902E+02 9.4681E+02
 2.3218E+03 3.3095E+02 4.0327E+02 4.4545E+02 4.8699E+02 5.3349E+02 6.4930E+02 7.7383E+02 8.6552E+02 8.9511E+02 1.0005E+03 3.3532E+02
 4.4477E+02
 5.0767E+02 5.6482E+02 6.2406E+02 7.5974E+02 8.8564E+02 9.7008E+02 9.9649E+02 1.0838E+03 4.1493E+02 5.0697E+02 5.5112E+02 5.8986E+02
 6.2728E+02
 7.1526E+02 7.9811E+02 8.5183E+02 8.7123E+02 9.3237E+02 5.2206E+02 6.5009E+02 1.0753E+03 1.0319E+03 1.1063E+03 9.8933E+02 9.5097E+02
 1.0444E+03
 8.3519E+02 9.4262E+02
 2.3839E+03 3.3091E+02 4.0267E+02 4.4449E+02 4.8565E+02 5.3172E+02 6.4644E+02 7.6995E+02 8.6109E+02 8.9052E+02 9.9543E+02 3.3521E+02
 4.4358E+02
 5.0582E+02 5.6239E+02 6.2113E+02 7.5584E+02 8.8119E+02 9.6543E+02 9.9179E+02 1.0792E+03 4.1316E+02 5.0370E+02 5.4770E+02 5.8648E+02
 6.2397E+02
 7.1230E+02 7.9573E+02 8.5015E+02 8.6953E+02 9.3139E+02 5.1832E+02 6.4473E+02 1.0706E+03 1.0267E+03 1.1017E+03 9.8431E+02 9.4610E+02
 1.0396E+03
 8.3093E+02 9.3802E+02
 2.4481E+03 3.3086E+02 4.0208E+02 4.4354E+02 4.8431E+02 5.2994E+02 6.4351E+02 7.6591E+02 8.5643E+02 8.8568E+02 9.9005E+02 3.3510E+02
 4.4240E+02
 5.0400E+02 5.6000E+02 6.1821E+02 7.5191E+02 8.7664E+02 9.6063E+02 9.8693E+02 1.0743E+03 4.1138E+02 5.0038E+02 5.4422E+02 5.8303E+02
 6.2058E+02
 7.0922E+02 7.9322E+02 8.4831E+02 8.6768E+02 9.3025E+02 5.1459E+02 6.3927E+02 1.0657E+03 1.0212E+03 1.0969E+03 9.7898E+02 9.4096E+02
 1.0347E+03
 8.2647E+02 9.3329E+02
 2.5085E+03 3.3082E+02 4.0153E+02 4.4267E+02 4.8309E+02 5.2832E+02 6.4087E+02 7.6226E+02 8.5222E+02 8.8130E+02 9.8515E+02 3.3501E+02
 4.4131E+02
 5.0232E+02 5.5779E+02 6.1552E+02 7.4828E+02 8.7243E+02 9.5619E+02 9.8243E+02 1.0697E+03 4.0978E+02 4.9733E+02 5.4101E+02 5.7985E+02
 6.1745E+02
 7.0636E+02 7.9088E+02 8.4657E+02 8.6593E+02 9.2916E+02 5.1120E+02 6.3423E+02 1.0611E+03 1.0162E+03 1.0924E+03 9.7413E+02 9.3629E+02
 1.0302E+03
 8.2243E+02 9.2891E+02
 2.5755E+03 3.3078E+02 4.0093E+02 4.4170E+02 4.8175E+02 5.2655E+02 6.3801E+02 7.5832E+02 8.4767E+02 8.7658E+02 9.7988E+02 3.3490E+02
 4.4013E+02
 5.0049E+02 5.5540E+02 6.1261E+02 7.4436E+02 8.6789E+02 9.5139E+02 9.7757E+02 1.0648E+03 4.0807E+02 4.9403E+02 5.3753E+02 5.7638E+02
 6.1403E+02
 7.0321E+02 7.8828E+02 8.4461E+02 8.6397E+02 9.2790E+02 5.0757E+02 6.2874E+02 1.0562E+03 1.0108E+03 1.0876E+03 9.6890E+02 9.3125E+02
 1.0252E+03
 8.1807E+02 9.2418E+02
 2.6359E+03 3.3073E+02 4.0038E+02 4.4083E+02 4.8055E+02 5.2496E+02 6.3544E+02 7.5479E+02 8.4360E+02 8.7236E+02 9.7518E+02 3.3481E+02
 4.3906E+02
 4.9884E+02 5.5325E+02 6.0999E+02 7.4082E+02 8.6379E+02 9.4707E+02 9.7319E+02 1.0604E+03 4.0657E+02 4.9110E+02 5.3444E+02 5.7330E+02
 6.1098E+02
 7.0039E+02 7.8594E+02 8.4282E+02 8.6220E+02 9.2675E+02 5.0442E+02 6.2388E+02 1.0518E+03 1.0060E+03 1.0832E+03 9.6425E+02 9.2676E+02
 1.0208E+03
 8.1417E+02 9.1992E+02

2.6960E+03	3.3069E+02	3.9982E+02	4.3995E+02	4.7932E+02	5.2334E+02	6.3283E+02	7.5119E+02	8.3947E+02	8.6807E+02	9.7042E+02	3.3471E+02
4.3800E+02											
4.9719E+02	5.5108E+02	6.0735E+02	7.3724E+02	8.5963E+02	9.4269E+02	9.6875E+02	1.0559E+03	4.0514E+02	4.8825E+02	5.3141E+02	5.7026E+02
6.0798E+02											
6.9757E+02	7.8358E+02	8.4098E+02	8.6038E+02	9.2554E+02	5.0138E+02	6.1912E+02	1.0473E+03	1.0012E+03	1.0788E+03	9.5953E+02	9.2221E+02
1.0163E+03											
8.1020E+02	9.1560E+02										
2.7664E+03	3.3065E+02	3.9919E+02	4.3895E+02	4.7793E+02	5.2151E+02	6.2986E+02	7.4711E+02	8.3477E+02	8.6319E+02	9.6501E+02	3.3461E+02
4.3678E+02											
4.9531E+02	5.4861E+02	6.0433E+02	7.3314E+02	8.5485E+02	9.3763E+02	9.6362E+02	1.0507E+03	4.0353E+02	4.8498E+02	5.2793E+02	5.6676E+02
6.0450E+02											
6.9428E+02	7.8079E+02	8.3878E+02	8.5821E+02	9.2406E+02	4.9794E+02	6.1364E+02	1.0421E+03	9.9564E+02	1.0737E+03	9.5416E+02	9.1702E+02
1.0111E+03											
8.0569E+02	9.1062E+02										
2.8291E+03	3.3060E+02	3.9861E+02	4.3803E+02	4.7665E+02	5.1982E+02	6.2712E+02	7.4330E+02	8.3035E+02	8.5860E+02	9.5988E+02	3.3451E+02
4.3570E+02											
4.9363E+02	5.4640E+02	6.0163E+02	7.2942E+02	8.5048E+02	9.3299E+02	9.5891E+02	1.0459E+03	4.0215E+02	4.8213E+02	5.2489E+02	5.6369E+02
6.0144E+02											
6.9135E+02	7.7828E+02	8.3677E+02	8.5623E+02	9.2267E+02	4.9498E+02	6.0886E+02	1.0373E+03	9.9039E+02	1.0689E+03	9.4908E+02	9.1213E+02
1.0063E+03											
8.0146E+02	9.0605E+02										

```

*var2.17 trump bd full power spiked hot channel reflood station blackout (hygen.
40
height (in)
node 1 t=0.08333 h
node 3 t=0.08333 h
node 306 t=0.08333 h
chemp (kw) t=0.08333 h
zr remain (%) t=0.08333 h
ur remain (%) t=0.08333 h
rad loss (kw) t=0.08333 h
h2 fraction, flow region= 1 at t=0.08333 h
h2 fraction, flow region= 2 at t=0.08333 h
h2 fraction, flow region= 3 at t=0.08333 h
h2 fraction, flow region= 4 at t=0.08333 h
h2 fraction, flow region= 5 at t=0.08333 h
axial level h2 fraction t=0.08333 h
node 1 t=0.27778 h
node 3 t=0.27778 h
node 306 t=0.27778 h
chemp (kw) t=0.27778 h
zr remain (%) t=0.27778 h
ur remain (%) t=0.27778 h
rad loss (kw) t=0.27778 h
h2 fraction, flow region= 1 at t=0.27778 h
h2 fraction, flow region= 2 at t=0.27778 h
h2 fraction, flow region= 3 at t=0.27778 h
h2 fraction, flow region= 4 at t=0.27778 h
h2 fraction, flow region= 5 at t=0.27778 h
axial level h2 fraction t=0.27778 h
node 1 t=0.80166 h
node 3 t=0.80166 h
node 306 t=0.80166 h
chemp (kw) t=0.80166 h
zr remain (%) t=0.80166 h
ur remain (%) t=0.80166 h
rad loss (kw) t=0.80166 h
h2 fraction, flow region= 1 at t=0.80166 h
h2 fraction, flow region= 2 at t=0.80166 h
h2 fraction, flow region= 3 at t=0.80166 h
h2 fraction, flow region= 4 at t=0.80166 h
h2 fraction, flow region= 5 at t=0.80166 h
axial level h2 fraction t=0.80166 h
5.00 0.00000E+00 0.00000E+00 4.50010E+02 0.00000E+00 1.00000E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.0000
0E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 4.50167E+02 0.00000E+00 1.00000E+02 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 4.51013E+02 0.00000E+00 1.00000E+02 0.00000E+00
0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
14.75 0.00000E+00 0.00000E+00 4.50432E+02 0.00000E+00 1.00000E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.0000
0E+00 0.00000E+00
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21.00 0.00000E+00 0.00000E+00 4.53327E+02 0.00000E+00 1.00000E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.0000
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0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
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B.77

B.72


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0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 8.95006E+02 9.90959E+02 8.82150E+02 0.00000E+00 1.00000E+02 1.00000E+02
0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
206.50 1.12994E+03 1.17673E+03 7.34083E+02 0.00000E+00 1.00000E+02 1.00000E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.0000
0E+00 0.00000E+00
0.00000E+00 0.00000E+00 1.16299E+03 1.23072E+03 9.38571E+02 0.00000E+00 1.00000E+02 1.00000E+02 0.00000E+00 0.00000E+00
0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 9.07399E+02 1.00172E+03 8.89606E+02 0.00000E+00 1.00000E+02 1.00000E+02
0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
210.50 1.12349E+03 1.16982E+03 7.00231E+02 0.00000E+00 1.00000E+02 1.00000E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.0000
0E+00 0.00000E+00
0.00000E+00 0.00000E+00 1.17843E+03 1.24117E+03 9.30838E+02 0.00000E+00 1.00000E+02 1.00000E+02 0.00000E+00 0.00000E+00
0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 9.20371E+02 1.01287E+03 8.97962E+02 0.00000E+00 1.00000E+02 1.00000E+02
0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
214.50 1.11702E+03 1.16282E+03 7.00160E+02 0.00000E+00 1.00000E+02 1.00000E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.0000
0E+00 0.00000E+00
0.00000E+00 0.00000E+00 1.19189E+03 1.24700E+03 9.34607E+02 0.00000E+00 1.00000E+02 1.00000E+02 0.00000E+00 0.00000E+00
0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 9.32058E+02 1.02265E+03 9.05130E+02 0.00000E+00 1.00000E+02 1.00000E+02
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0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
218.50 1.10767E+03 1.15282E+03 7.34855E+02 0.00000E+00 1.00000E+02 1.00000E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.0000
0E+00 0.00000E+00
0.00000E+00 0.00000E+00 1.20522E+03 1.24700E+03 9.50608E+02 0.00000E+00 1.00000E+02 1.00000E+02 0.00000E+00 0.00000E+00
0.00000E+00

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0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	9.44154E+02	1.03268E+03	9.14574E+02	0.00000E+00	1.00000E+02	1.00000E+02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
222.50	1.09837E+03	1.14275E+03	7.33664E+02	0.00000E+00	1.00000E+02	1.00000E+02	0.00000E+00	0.00000E+00	0.00000E+00
0E+00	0.00000E+00	0.00000E+00	1.21657E+03	1.24700E+03	9.53970E+02	0.00000E+00	1.00000E+02	1.00000E+02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	9.54897E+02	1.04129E+03	9.21305E+02	0.00000E+00	1.00000E+02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
226.50	1.08435E+03	1.12770E+03	6.99707E+02	0.00000E+00	1.00000E+02	1.00000E+02	0.00000E+00	0.00000E+00	0.00000E+00
0E+00	0.00000E+00	0.00000E+00	1.22734E+03	1.24839E+03	9.44369E+02	0.00000E+00	1.00000E+02	1.00000E+02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	9.65655E+02	1.04955E+03	9.28093E+02	0.00000E+00	1.00000E+02
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230.50	1.07074E+03	1.11267E+03	6.99539E+02	0.00000E+00	1.00000E+02	1.00000E+02	0.00000E+00	0.00000E+00	0.00000E+00
0E+00	0.00000E+00	0.00000E+00	1.23702E+03	1.24866E+03	9.46449E+02	0.00000E+00	1.00000E+02	1.00000E+02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	9.74868E+02	1.05620E+03	9.33994E+02	0.00000E+00	1.00000E+02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
234.50	1.06182E+03	1.10328E+03	7.34266E+02	0.00000E+00	1.00000E+02	1.00000E+02	0.00000E+00	0.00000E+00	0.00000E+00
0E+00	0.00000E+00	0.00000E+00	1.24641E+03	1.24899E+03	9.60828E+02	0.00000E+00	1.00000E+02	1.00000E+02	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	9.85273E+02	1.06434E+03	9.41034E+02	0.00000E+00	1.00000E+02
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

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*ver2.17 trump bd full power spiked station blackout outlet half(nrx/hcr/black)
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[illegible][illegible]

APPENDIX C

BOUNDARY CONDITIONS FOR THE TRUMP-BO N REACTOR STATION BLACKOUT
ACCIDENT ANALYSIS RELAP5 PREDICTIONS

APPENDIX C

BOUNDARY CONDITIONS FOR THE TRUMP-BD N REACTOR STATION BLACKOUT ACCIDENT ANALYSIS RELAP5 PREDICTIONS

FIGURE C.1. RELAP5--Vapor Void Fraction Vs. Time--Inner Flow Channel

FIGURE C.2. RELAP5--Vapor Void Fraction Vs. Time--Middle Flow Channel

FIGURE C.3. RELAP5--Vapor Void Fraction Vs. Time--Outer Flow Channel

FIGURE C.4. RELAP5--Mass Flow Rate Vs. Time--Inner Channel

FIGURE C.5. RELAP5--Mass Flow Rates Vs. Time--Middle Channel

FIGURE C.6. RELAP5--Mass Flow Rate Vs. Time--Outer Channel

FIGURE C.7. RELAP5--Pressure Vs. Time

FIGURE C.8. RELAP5--Void Fraction Vs. Time--Inner Channel

FIGURE C.9. RELAP5--Void Fraction Vs. Time--Middle Channel

FIGURE C.10. RELAP5--Void Fraction Vs. Time--Outer Channel

C.1

FIGURE C.1, RELAP5 - VAPOR VOID FRACTION VS. TIME - INNER FLOW CHANNEL

C.2

FIGURE C.2. RELAP5 - VAPOR VOID FRACTION VS. TIME - MIDDLE FLOW CHANNEL

VAPOR VOID FRACTION

FIGURE C.3. RELAP5 - VAPOR VOID FRACTION VS. TIME - OUTER FLOW CHANNEL

FIGURE C.4. RELAP5 - MASS FLOW RATE VS. TIME - INNER CHANNEL

FIGURE C.5. RELAP5 - MASS FLOW RATE VS. TIME - MIDDLE CHANNEL

FIGURE C.6. RELAP 5- MASS FLOW RATE VS. TIME - OUTER CHANNEL

C.7

FIGURE C.7. RELAP5 PRESSURE VS. TIME

C.8

VAPOR VOID FRACTION

FIGURE C.8 - RELAP5 VOID FRACTION VS. TIME - INNER CHANNEL

VOID VAPOR FRACTION

FIGURE C.9. - RELAP5 VOID FRACTION VS. TIME - MIDDLE CHANNEL

C.10

VAPOR VOID FRACTION

FIGURE C.10. - RELAP5 VOID FRACTION VS. TIME - OUTER CHANNEL

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