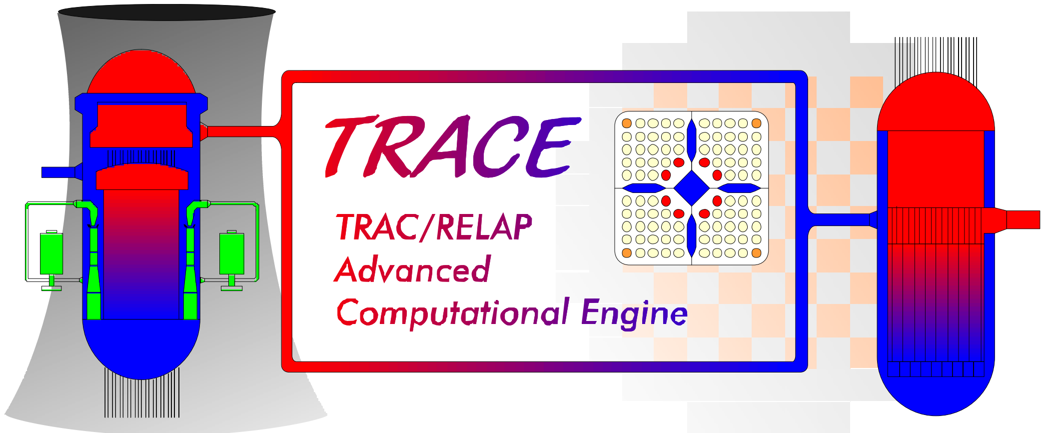
NUREG/BR-????



TRACE V5.0
USER'S MANUAL

Volume 1: Input Specification

Division of Risk Assessment and Special Projects
Office of Nuclear Regulatory Research
U. S. Nuclear Regulatory Commission
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Preface

Advanced computing plays a critical role in the design, licensing and operation of nuclear power plants. The modern nuclear reactor system operates at a level of sophistication whereby human reasoning and simple theoretical models are simply not capable of bringing to light full understanding of a system's response to some proposed perturbation, and yet, there is an inherent need to acquire such understanding. Over the last 30 years or so, there has been a concerted effort on the part of the power utilities, the U. S. Nuclear Regulatory Commission (USNRC), and foreign organizations to develop advanced computational tools for simulating reactor system behavior during real and hypothetical transient scenarios. The lessons learned from simulations carried out with these tools help form the basis for decisions made concerning plant design, operation, and safety.

The TRAC/RELAP Advanced Computational Engine (TRACE - formerly called TRAC-M) is the latest in a series of advanced, best-estimate reactor systems codes developed by the U.S. Nuclear Regulatory Commission for analyzing transient and steady-state neutronic-thermal-hydraulic behavior in light water reactors. It is the product of a long term effort to combine the capabilities of the NRC’s four main systems codes (TRAC-P, TRAC-B, RELAP5 and RAMONA) into one modernized computational tool..

This manual is one of three documents that comprise the basic TRACE documentation set. The other two are the Theory Manual and Developmental Assessment Manual.

Overview of TRACE

TRACE has been designed to perform best-estimate analyses of loss-of-coolant accidents (LOCAs), operational transients, and other accident scenarios in pressurized light-water reactors (PWRs) and boiling light-water reactors (BWRs). It can also model phenomena occuring in experimental facilities designed to simulate transients in reactor systems. Models used include multidimensional two-phase flow, nonequilibrium thermo-dynamics, generalized heat transfer, reflood, level tracking, and reactor kinetics. Automatic steady-state and dump/restart capabilities are also provided.

The partial differential equations that describe two-phase flow and heat transfer are solved using finite volume numerical methods. The heat-transfer equations are evaluated using a semi-implicit time-differencing technique. The fluid-dynamics equations in the spatial one-dimensional (1D), and three-dimensional (3D) components use, by default, a multi-step time-differencing procedure that allows the material Courant-limit condition to be exceeded. A more straightforward semi-implicit time-differencing method is also available, should the user demand it. The finite-difference equations for hydrodynamic phenomena form a system of coupled, nonlinear equations that are solved by the Newton-Raphson iteration method. The resulting linearized equations are solved by direct matrix inversion. For the 1D network matrix, this is done by a direct full-matrix solver; for the multiple-vessel matrix, this is done by the capacitance-matrix method using a direct banded-matrix solver.

TRACE takes a component-based approach to modeling a reactor system. Each physical piece of equipment in a flow loop can be represented as some type of component, and each component can be further nodalized into some number of physical volumes (also called cells) over which the fluid, conduction, and kinetics equations are averaged. The number of reactor components in the problem and the manner in which they are coupled is arbitrary. There is no built-in limit for the number of components or volumes that can be modeled; the size of a problem is theoretically only limited by the available computer memory. Reactor hydraulic components in TRACE include PIPEs, PLENUMs, PRIZERs (pressurizers), CHANs (BWR fuel channels), PUMPs, JETPs (jet pumps), SEPDs (separators), TEEs, TURBs (turbines), HEATRs (feedwater heaters), CONTANs (containment), VALVEs, and VESSELs (with associated internals). HTSTR (heat structure) and REPEAT-HTSTR components modeling fuel elements or heated walls in the reactor system are available to compute two-dimensional conduction and surface-convection heat transfer in Cartesian or cylindrical geometries. POWER components are available as a means for delivering energy to the fluid via the HTSTR or hydraulic component walls. FLPOWER (fluid power) components are capable of delivering energy directly to the fluid (such as might happen in waste transmutation facilities). RADENC (radiation enclosures) components may be used to simulate radiation heat transfer between multiple arbitrary surfaces. FILL and BREAK components are used to apply the desired coolant-flow and pressure boundary conditions, respectively, in the reactor system to perform steady-state and transient calculations. EXTERIOR components are available to facilitate the development of input models designed to exploit TRACE's parallel execution features.

The code's computer execution time is highly problem dependent and is a function of the total number of mesh cells, the maximum allowable timestep size, and the rate of change of the neutronic and thermal-hydraulic phenomena being evaluated. The stability-enhancing two-step (SETS) numerics in hydraulic components allows the material Courant limit to be exceeded. This allows very large time steps to be used in slow transients. This, in turn, can lead to significant speedups in simulations (one or two orders of magnitude) of slow-developing accidents and operational transients.

While we do not wish to overstate the performance of the numerical techniques incorporated in TRACE, we believe that the current schemes demonstrate exceptional stability and robustness that will serve adequately in codes like TRACE for years to come. However, the models and correlations in the code can have a significant impact on the speed of a calculation; they can (and frequently do) affect adversely the time-step size and the number of iterations used. Because of the impact on the speed of the calculation and because the models and correlations greatly affect the accuracy of the results, the area of model/correlation development may result in significant improvements in the overall code performance.

TRACE Characteristics

Some distinguishing characteristics of the code are summarized below.

Multi-Dimensional Fluid Dynamics

A 3D (x, y, z) Cartesian- and/or (r, θ, z) cylindrical-geometry flow calculation can be simulated within the reactor vessel or other other reactor components where 3D phenomena take place. All 3D components, such as Reactor Water Storage Tank, where 3D phenomena are modeled, are named VESSEL although they may not have any relationship with the reactor vessel. Flows within a coolant loop are usually modeled in one dimension using PIPE and TEE components. The combination of 1D and 3D components allows an accurate modeling of complex flow networks as well as local multidimensional flows. This is important in determining emergency core coolant (ECC) downcomer penetration during blowdown, refill, and reflood periods of a LOCA. The mathematical framework exists to directly treat multidimensional plenum- and core-flow effects, and upper-plenum pool formation and core penetration during reflood.

Non-homogeneous, Non-equilibrium Modeling

A full two-fluid (six-equation) hydrodynamic model evaluates gas-liquid flow, thereby allowing important phenomena such as countercurrent flow to be simulated explicitly. A stratified-flow regime has been added to the 1D hydrodynamics; a seventh field equation (mass balance) describes a noncondensable gas field; and an eighth field equation tracks dissolved solute in the liquid field that can plated out on surfaces when solubility in the liquid is exceeded.

Flow-Regime-Dependent Constitutive Equation Package

The thermal-hydraulic equations describe the transfer of mass, energy, and momentum between the steam-liquid phases and the interaction of these phases with heat flow from the modeled structures. Because these interactions are dependent on the flow topology, a flow-regime-dependent constitutive-equation package has been incorporated into the code. Assessment calculations performed to date indicate that many flow conditions can be calculated accurately with this package.

Comprehensive Heat Transfer Capability

TRACE can perform detailed heat-transfer analyses of the vessel and the loop components. Included is a 2D (r,z) treatment of conduction heat transfer within metal structures. Heat conduction with dynamic fine-mesh rezoning during reflood simulates the heat transfer characteristics of quench fronts. Heat transfer from the fuel rods and other structures is calculated using flow-regime-dependent heat transfer coefficients (HTC) obtained from a generalized boiling curve based on a combination of local conditions and history effects. Inner- and/or outer-surface convection heat-transfer and a tabular or point-reactor kinetics with reactivity feedback volumetric power source can be modeled. One-dimensional or three-dimensional reactor kinetics capabilities are possible through coupling with the Purdue Advanced Reactor Core Simulator (PARCS) program.

Component and Functional Modularity

The TRACE code is completely modular by component. The components in a calculation are specified through input data; available components allow the user to model virtually any PWR or BWR design or experimental configuration. Thus, TRACE has great versatility in its range of applications. This feature also allows component modules to be improved, modified, or added without disturbing the remainder of the code. TRACE component modules currently include BREAKs, FILLs, CHANs, CONTANs, EXTERIORs, FLPOWERs, HEATRs, HTSTRs, JETPs, POWERs, PIPEs, PLENUMs, PRIZERs, PUMPs, RADENCs, REPEAT-HTSTRs, SEPDs, TEEs, TURBs, VALVEs, and VESSELs with associated internals (downcomer, lower plenum, reactor core, and upper plenum).

The TRACE program is also modular by function; that is, the major aspects of the calculations are performed in separate modules. For example, the basic 1D hydrodynamics solution algorithm, the wall-temperature field solution algorithm, heat transfer coefficient (HTC) selection, and other functions are performed in separate sets of routines that can be accessed by all component modules. This modularity allows the code to be upgraded readily with minimal effort and minimal potential for error as improved correlations and test information become available.

Physical Phenomena Considered

As part of the detailed modeling in TRACE, the code can simulate physical phenomena that are important in large-break and small-break LOCA analyses, such as:

1) ECC downcomer penetration and bypass, including the effects of countercurrent flow and hot walls;
2) lower-plenum refill with entrainment and phase-separation effects;
3) bottom-reflood and falling-film quench fronts;

4) multidimensional flow patterns in the reactor-core and plenum regions;
5) pool formation and countercurrent flow at the upper-core support-plate (UCSP) region;
6) pool formation in the upper plenum;
7) steam binding;
8) water level tracking,
9) average-rod and hot-rod cladding-temperature histories;
10) alternate ECC injection systems, including hot-leg and upper-head injection;
11) direct injection of subcooled ECC water, without artificial mixing zones;
12) critical flow (choking);
13) liquid carryover during reflood;
14) metal-water reaction;
15) water-hammer pack and stretch effects;
16) wall friction losses;
17) horizontally stratified flow, including reflux cooling,
18) gas or liquid separator modeling;
19) noncondensable-gas effects on evaporation and condensation;
20) dissolved-solute tracking in liquid flow;
21) reactivity-feedback effects on reactor-core power kinetics;
22) two-phase bottom, side, and top offtake flow of a tee side channel; and reversible and irreversible form-loss flow effects on the pressure distribution

Limitations on Use

As a general rule, computational codes like TRACE are really only applicable within their assessment range. TRACE has been qualified to analyze the ESBWR design as well as conventional PWR and BWR large and small break LOCAs (excluding B&W designs). At this point, assessment has not been officially performed for BWR stability analysis, or other operational transients.

The TRACE code is not appropriate for modeling situations in which transfer of momentum plays an important role at a localized level. For example, TRACE makes no attempt to capture, in detail, the fluid dynamics in a pipe branch or plenum, or flows in which the radial velocity profile across the pipe is not flat.

The TRACE code is not appropriate for transients in which there are large changing asymmetries in the reactor-core power such as would occur in a control-rod-ejection transient unless it is used in conjunction with the PARCS spatial kinetics module. In TRACE, neutronics are evaluated on a core-wide basis by a point-reactor kinetics model with reactivity feedback, and the spatially local neutronic response associated with the ejection of a single control rod cannot be modeled.

The typical system model cannot be applied directly to those transients in which one expects to observe thermal stratification of the liquid phase in the 1D components. The VESSEL component can resolve the thermal stratification of liquid only within the modeling of its multidimensional noding when horizontal stratification is not perfect.

TRACE is incapable of modeling circulation patterns within a large open region, regardless of the choice of mesh size.

TRACE does not evaluate the stress/strain effect of temperature gradients in structures. The effect of fuel-rod gas-gap closure due to thermal expansion or material swelling is not modeled explicitly. TRACE can be useful as a support to other, more detailed, analysis tools in resolving questions such as pressurized thermal shock.

The TRACE field equations are derived such that viscous heating terms within the fluid is generally ignored. A special model is, however, available within the PUMP component to account for direct heating of fluid by the pump rotor.

Approximations in the wall and interface heat flux terms prevent accurate calculations of such phenomena as collapse of a steam bubble blocking natural circulation through a B&W candy-cane, or of the details of steam condensation at the water surface in an AP1000 core makeup tank.

Intended Audience

This manual has been written to reflect the needs of the those who desire to develop TRACE input models and run simulations with those models. It is written for both novice and advanced TRACE users, alike. While we have attempted to present the information in this manual as plainly as possible, we cannot guarantee that we have succeeded. If you find some section or blurb of text to be particularly difficult to understand, please make sure this information is commnunicated back to the development team so the issue can be rectified. Suggestions and actual rewritten text will be shamelessly accepted

Organization of This Manual

This manual is Volume 1 in a two-volume set. It is designed to present the actual input format and information needed to be able to actually run the code and interpret its output. Volume 2 is designed to 1) serve as a learning tool for understanding general modeling techniques, 2) present the conceptual model behind each component type and key subsystem, and 3) present specific user guidelines for each component type, model or major code feature.

Topics of discussion addressed in this manual include the overall input format and structure, how to actually run the code, the various input files TRACE expects and output files TRACE writes information to, the graphics information, and any functionality that has become deprecated as a result of the code consolidation process.

Reporting Code Errors

It is vitally important that the USNRC receive feedback from the TRACE user community. To that end, we have established a support website at *http://www.nrccodes.com*. It contains the TRACEZilla bug tracking system, latest documentation, a list of the updates currently waiting to be integrated into the main development trunk (called the HoldingBin), and the recent build history showing what changes have been made, when, and by whom. Access to the TRACE-specific areas of the site are password-protected. Details for obtaining access are provided on the public portion of the site.

Conventions Used in This Manual

In general. items appearing in this manual use the Times New Roman font. Sometimes, text is given a special appearance to set it apart from the regular text. Here's how they look (colored text will, of course, not appear colored when printed in black and white)

ALL CAPS

Used for TRACE component names and input variable names

BOLD RED, ALL CAPS

Used for TRACE variable identifiers in the component card tables (column 2)

Bold Italic

Used for chapter and section headings

Bold Blue

Used for TRACE card titles, note headings, table headings, cross references

Plain Red

Used for XTV graphics variable names

Bold

Used for filenames, pathnames, table titles, headings for some tables, and AcGrace dialog box names

Italic

Used for references to a website URL and AcGrace menu items

`Fixed Width Courier`

Used to indicate user input, command lines, file listings, or otherwise, any text that you would see or type on the screen

Note – This icon represents a Note. It is used to emphasize various informational messages that might be of interest to the reader.

Warning – This icon represents a Warning. It is used to emphazize important information that you need to be aware of while you are working with TRACE.

Tip – This icon represents a Tip. It is used to dispense bits of wisdom that might be of particular interest to the reader.

For brevity, when we refer to filenames that TRACE either takes as input or outputs, we will generally refer to it using its default internal hardwired name (as opposed to the prefix naming convention to which you will be introduced in the following chapters). So for example, references to the TRACE input file name would use **tracin**; references to the output file would use **trcout**, etc.

In the individual component description sections (see **Chapter 6**), in the card titles for each card, the formatting convention expected for each of the input parameters is provided using standard Fortran field specification identifiers. The identifiers A, I and E refer to alphanumeric, integer number and real (floating point) number entries, respectively. Numbers appearing after those identifiers refer to the field length while numbers appearing before those identifiers indicate multiple entries of the field. For example, a data field specification of "5I14" indicates five fields of 14 characters each, containing integer numbers; a data field specification of "2E14.4" indicates two real numbers of, at most, 14 characters each, with 4 characters reserved for the exponential notation portion of the string (E-01, for example)

1

Execution Details

General Concepts

TRACE is a general thermal-hydraulics computational modeling system for nuclear power systems and other two-phase flow loop apparatus or experimental rigs. In layman's terms, it is simply an executable program that a person can run on a computer to simulate what goes on inside a nuclear power plant during normal and/or off-normal conditions. The person running the code (i.e. the user - that's you) is responsible for creating a virtual mock-up of the reactor system in the form of geometry information (volumes, lengths, areas, etc), fluid state information (pressures, temperatures, etc), lookup tables, control system information, and numerical flags or triggers that tell the code what to do, when, and how to do it. The user collects all this information into a computer file and supplies it as input to the TRACE program when it is executed. We refer to these files by a number of different names, such as, "input decks", "input files", "input models", or sometimes, just "models".

From a user's perspective, there are three major phases in a full TRACE calculation - input processing, initialization, and the solution itself. Figure 1-1 visually illustrates this process. Input processing is the first stage of a calculation. At this point, TRACE reads in your input model and checks to make sure that the data is properly formatted and that all the information required for the calculation is actually present. Once your model has passed input processing, it is initialized to ready it for the transient solution procedure. During initialization, the code performs the necessary bookkeeping functions to ensure that data is managed properly during the actual solution. It also checks your input data to make sure that all initial & boundary conditions are self-consistent (for example, the initial velocities at a component's output face are checked to make sure they are identical to the initial velocities of the adjoining component's inlet).

Once all the input data has been processed, and the calculation has been initialized, the code proceeds to the actual solution procedure. The solution is advanced forward in time in small increments (called timesteps). The run ends when any one of the following three conditions are met — the user-specified transient end time is reached, a steady-state is declared (only during steady-state runs), or some fatal error in the calculation takes place.

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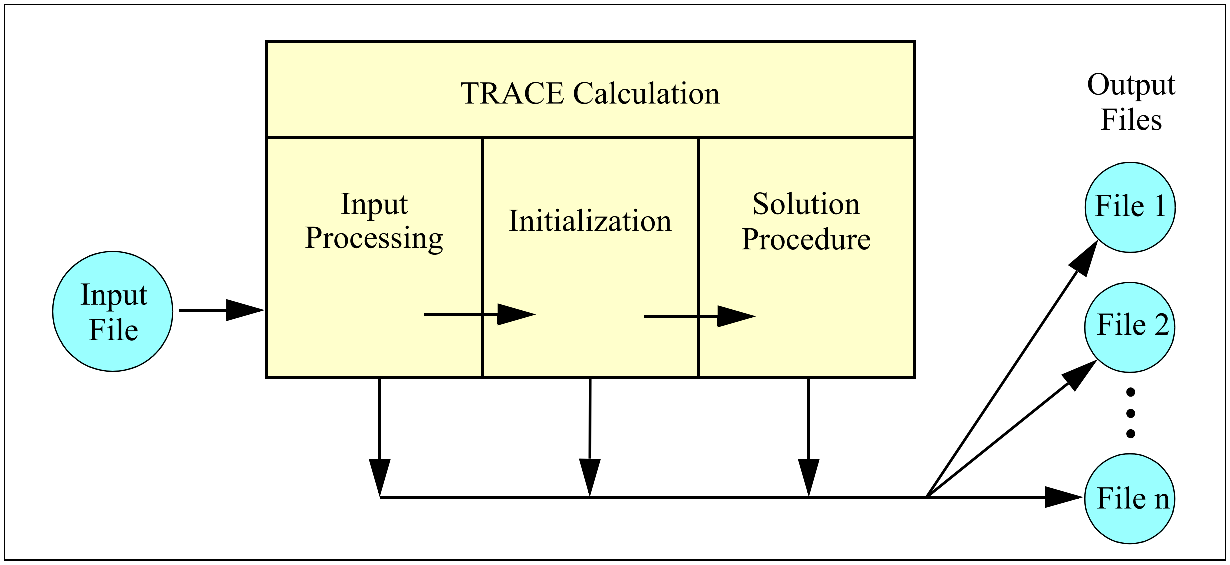


Figure. 1-1. Phases of a TRACE calculation

TRACE supports both serial and parallel execution. You can think of serial execution as being defined by a single TRACE input-output process running on a single computer chip. This is how TRACE and other codes of its ilk have traditionally been run over the past thirty-five or so years. Parallel execution, insofar as TRACE is concerned, is defined by two or more input-output processes executing at the same time and coupled together by sharing information back and forth between the processes. These separate processes can take the form of 1) TRACE running in parallel with other TRACE processes, or 2) TRACE running in tandem with one or more other codes. In other words, it can do coarse-grained multi-tasking. TRACE specifically does not support more fine-grained parallel methodologies like threading or High-Performance Fortran (HPF) in which individual lines of code are tuned to run across multiple processors. It is, however, possible to run on shared-memory computers and the code will attempt to make use of the shared memory buffer if one is available (rather than always moving data through the networking stack, which can be slow), but you are always limited by the coarse-grained nature of the methodology.

An example of a multi-task mode of operation might be the TRACE simulation of a 200% double-ended cold leg break in a full-sized power plant coupled with a CONTAIN calculation of the behavior in the containment. During this mode of operation parameters such as mass and enthalpy are fed into the CONTAIN calculation from TRACE and pressure and temperature are returned to the TRACE calculation from CONTAIN.

Getting Started

Performing a calculation with TRACE on a single processor is a pretty simple affair. By itself, TRACE is really designed to be run from a command line. When run in this mode, all calculations are performed from a single working directory. The process can be broken down into the following steps:

- Install TRACE on your computer. Instructions are included on the TRACE distribution CD-ROM. Keep track of the directory location where the executable is stored.
- Open a command window if you are running Microsoft Windows or X-Windows. On a Windows PC, you can either use the DOS command prompt that comes pre-installed with the operating system (OS), or you can install the Cygwin package (a free UNIX emulation environment) and use the bash shell program that comes with it. On a UNIX/Linux workstation running X-Windows, just start an X-terminal.
- Create or otherwise determine a location on your hard drive where you want to store the input and output files for the simulation you plan to run - this will become your working directory
- Change to that working directory (using the "cd" command)
- Copy the input file(s) that you wish to run into this working directory. This, of course, assumes that you already have an existing input file you wish to run. If you don't, then you need to create one. That is what this manual is designed to help you do.
- Rename or copy your input file to the name **tracin** if it is not already called that
- Run TRACE. You do this by simply typing the full path to the TRACE command name at the command prompt and hitting a return keystroke.

A typical command session illustrating this process might look like this:

```
~>pwd
/home/caretaker

~>mkdir TRACE_Simulation

~>cd TRACE_Simulation

~/TRACE_Simulation>cp /d/work/advcode/Test/MasterList/w4loopn.inp .

~/TRACE_Simulation>cp w4loopn.inp tracin

~/TRACE_Simulation>/d/work/advcode/v4155/Debug/v4155.exe > screen_output

~/TRACE_Simulation>ls
total 9641
-rw-r--r--    1 caretake None        45121 Feb 25 09:27 screen_output
-rwxr-xr-x    1 caretake None        84728 Feb 25 09:26 tracin*
-rwxr-xr-x    1 caretake None      1081344 Feb 25 09:27 trcdmp*
-rwxr-xr-x    1 caretake None       122312 Feb 25 09:27 trcinp*
-rwxr-xr-x    1 caretake None        75627 Feb 25 09:27 trcmsg*
-rwxr-xr-x    1 caretake None      2698815 Feb 25 09:27 trcout*
```

```
-rwxr-xr-x    1 caretake None       5548036 Feb 25 09:27 trcxtv*
-rwxr-xr-x    1 caretake None         84728 Feb 25 09:25 w4loopn.inp*
~/TRACE_Simulation>
```

As you can see, once TRACE has been run, it creates a series of output files. They contain all the information necessary to analyze the simulation and/or debug problems that may have occured during the course of the run. The **tracin** file is, of course, the plant or facility input-data model. There are five standard output files that you will generally need to work with – **trcmsg**, **trcout**, **trcdmp**, **trcxtv** and **trcinp**. The **trcmsg**, **trcout**, and **trcinp** files only contain ascii text so they may be reviewed with any kind of text editor or word processor. The **trcinp** file is an un-annotated echo of the input model. It is usually only useful if there is some error in the input model and you need to track it down. The remaining output files, **trcxtv** and **trcdmp**, are binary files and cannot be reviewed with a text editor.

File **trcmsg** contains information mostly of a diagnostic nature. The level of detail that is contained in **trcmsg** can be controlled in part by the user. File **trcout** contains results of a calculation in the form of "large and short edits", which are written at user-specified intervals (via the time-domain input described in **Chapter 6**).

Most of the day-to-day analysis of TRACE's results is done via the graphics binary-format file **trcxtv**, which is used as input to the separate post-processing software AcGrace. Edit intervals to file **trcxtv** are specified via the time-domain input in the input-data file. A complete list of the data written to file **trcxtv** is given in **Chapter 3**. File **trcdmp** is also written at user-specified intervals as a calculation proceeds. It contains data-dumps that can be used to initialize subsequent restart runs (there will be more on that later).

The input file, **tracin,** and the output files **trcmsg**, **trcout**, **trcxtv**, and **trcinp** can be in either SI or English units. The **trcdmp** file is always SI units.

There are many other optional output files that may get generated during a run; they will not be discussed here. All files that TRACE uses for input and output are explained in greater depth in **Chapter 2**.

Running TRACE - The Finer Details

The normal way that codes like TRACE are typically run is to perform the simulation on a single processor. **Figure 1-2** illustrates a typical workflow for such a simulation. It depicts the two basic types of runs that may be performed — a base calculation and a restart calculation. Also shown are some of the output files generated during the calculation process. The figure identifies input files for performing a base calculation, output files from that calculation, inputs and outputs for subsequent restart calculations, and depicts the post-processing phase for producing graphics. The input and output file names that are shown conform to the default naming conventions built into the code.

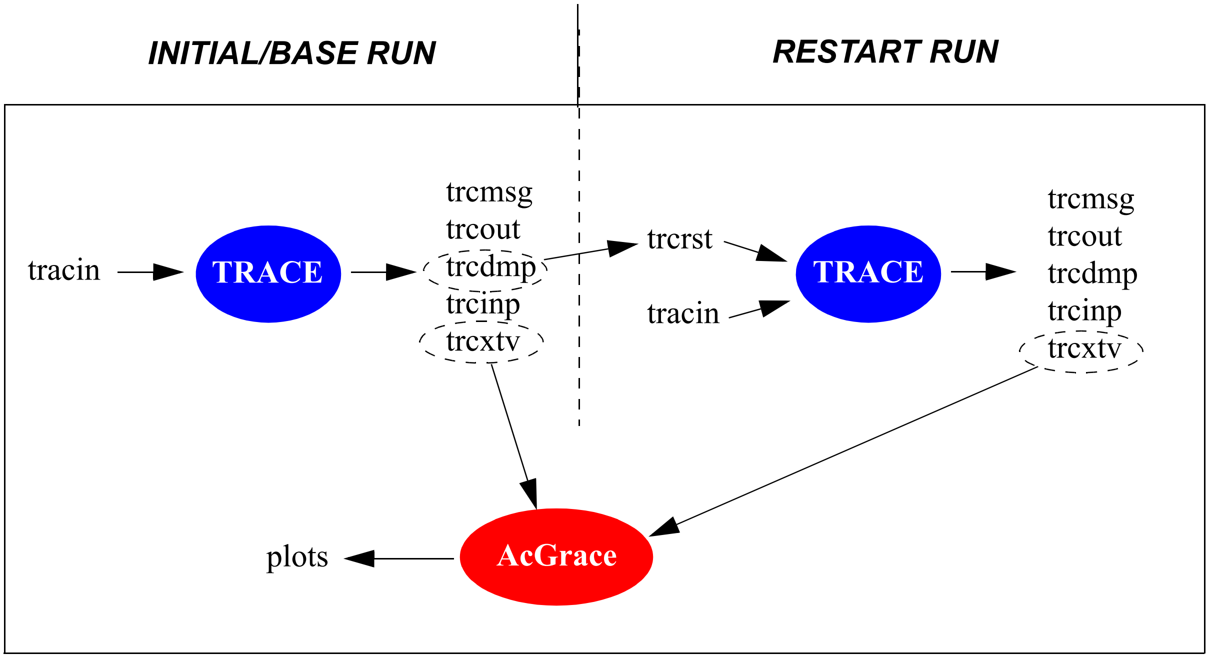


Figure. 1-2. Lifecycle of a TRACE Simulation.

TRACE is a console application. In other words, it is meant to be executed from the command line. Given this, one way to execute TRACE, is to copy the TRACE input file to a file named **tracin**. Then, at the command prompt, the name of the TRACE executable (for instance **trace.exe**) is entered followed by a return key-stroke. For example, for an input file called **test.inp**, you would copy it to **tracin** and then enter the following:

```
> trace.exe
```

The code executes the problem **tracin** and outputs the files listed in **Figure 1-2**. Generally, you should first look at the message and output file (**trcmsg** and **trcout**) in a text editor to first determine whether the simulation ran to completion. Assuming that it did, a good way to analyze the results is then to read the graphics file (**trcxtv**) into AcGrace and plot the necessary parameters that will help you to understand what is happening in the facility.

Tip – You do have the option of overriding the default file names that are built into TRACE with your own using the "--prefix" (or "-p") command line options (see **Table 1-2** in the section **Command Line Options** below). In a nutshell, you supply a string that denotes the base name of the input file and TRACE will establish a new naming convention that uses that base name plus a set of pre-defined file extensions for each file type. In particular, TRACE expects that the input file shall have a "**.inp**" extension. **Table 1-1** shows the file extensions used for the input and output files shown in **Figure 1-2**. Use of this feature will allow you to establish a workflow in which you won't have to manually copy your input decks to **tracin** before each run. It also allows you to launch multiple simulations at the same time from within the same working directory.

Table 1-1. File extensions for some common TRACE input and output files.

Default Naming Convention	Prefix Naming Convention	Comment
tracin	test.inp	Input file. Required
trcrst	test.rst	Restart dump file. Required for restart
trcmsg	test.msg	Standard Messages Output
trcout	test.out	Standard Edit Output
trcdmp	test.dmp	Standard Dump Output
trcxtv	test.xtv	Standard Graphics Output
trcinp	test.echo	Standard echo of stripped down input with line numbers

Command Line Options

TRACE understands a wide range of command line options. These options and their descriptions are listed in **Table 1-2**. You can also use the "--help" option from the command line itself to get a full list of the available options. We generally recommend that you rely on them as much as possible because they give you greater flexibility in maintaining your input and output files as well as greater control over code behavior.

Table 1-2. TRACE command line argument options and their description.

Argument	Description
-?, or --help	Print this help message
-v, --version	Print out the version number for the code.
-x, --nocpu	Set NAMELIST variable CPUFLG to 1; suppress output of CPU times and other run dependent parameters. Note that this command line option overrides the NAMELIST option.
-t, --cpu	Set NAMELIST variable CPUFLG to 0; output CPU times and other run dependent parameters. Note that this command line option overrides the NAMELIST option and the presence of the nocpu file in the working directory

Table 1-2. TRACE command line argument options and their description. (Continued)

Argument	Description
--dif	Set NAMELIST variable TRCDIF to 1; create a **trcdif** file containing parameters useful for determining when code changes affect code results. Note that this command line option overrides the NAMELIST option TRCDIF
--nodif	Set NAMELIST variable TRCDIF to 0; suppress output **trcdif** file containing parameters useful for determining when code changes affect code results. Note that this command line option overrides the NAMELIST option TRCDIF
-g, --snapon, --gui	Flag to take place of .snapon file in current working directory. This argument indicates that the SNAP runtime control module initiated this run and is waiting to communicate with TRAC. ⚠ Warning – You should not use this flag directly — it is designed to be used only by SNAP when it starts a TRACE run.
-c, --ce, --isCompEngine	Function as if the executable is the computational engine only. This reads input from the TPR formatted **trcrst** file as the sole source of input; the **tracin** file is bypassed. RELAP5 decks from SNAP are converted this way.
-i, --ip, --isInputRun	Function as if TRACE is an input processor only. This reads the **tracin** file, performs input checking and conversion as necessary, generates a dump file and stops.
--useTpr	Forces TRACE to create a dump file in TPR format (**trctpr** replaces **trcdmp**).
-b, --bell	Causes an audible bell to sound with each warning or error message that is written to the standard output.
-d `TIMESTEPSIZE`, --dtstrt `TIMESTEPSIZE`	Set NAMELIST variable DTSTRT to `TIMESTEPSIZE`. This will force the initial time step size to be `TIMESTEPSIZE` as long as `TIMESTEPSIZE` is between the minimum and maximums for the current time step domain. Note that `TIMESTEPSIZE` must be in fixed point notation (e.g. 0.03) and the value will override an entry for the NAMELIST variable DTSTRT in the input (**tracin**) file.

Table 1-2. TRACE command line argument options and their description. (Continued)

Argument	Description
-p PREFIX, --prefix PREFIX	Don't use the default built-in naming convention for input and output files. Instead, all filenames will follow the pattern PREFIX.<extension> where the specific value for <extension> is set by TRACE and unique for each input or output file type. Refer to **Table 2-1** for a full list of the file extensions that TRACE will use for each file type. Filename prefixes should be limited to a maximum of 35 characters.
--runStats	Forces TRACE to create a file (**trcstats**) containing basic information on execution of the program (cpu time, number of time steps, etc.)
--norand	Turn off any random control blocks that might exist in the input deck. This makes their output values constant from run to run, to facilitate the generation null comparisons during verification testing
--significantd	Turns on the significant difference logic. This is a developer-only option that should not be used under normal circumstances. It allows the developer to write some extra parameters to a file in an effort to determine whether changes in results from one code version to the next are "significant".

Dump/Restart Capability

As **Figure 1-2** attempts to show, it is possible for a new calculation to pick up from where some previous calculation left off. This is generally referred to as "restarting the calculation". Let's discuss this feature in more depth.

During any given simulation, TRACE automatically generates a dump file (**trcdmp**, by default) which contains snapshots of the state of the model at various time points. Any one of these snapshots, called a data-dump, may be used to initialize all or part of the model for subsequent calculations. The times when dumps are generated are determined by several criteria:

- A zero-time data dump is automatically generated at the start of the run. You can generally think of this dump as being generated at the end of the initialization stage. Specifically, it is generated part way through the solution of the first timestep after all the necessary parameters for a successful restart have been calculated, but users should generally not need to be concerned with this nuance.
- A data-dump is automatically generated at the end of the steady-state or transient calculation.
- Data-dumps are generated at regular intervals based upon a user-supplied dump frequency. This time interval is given by the DMPINT variable on the timestep data

cards. A data dump will be generated whenever this time interval has elapsed since the last data dump.

- A data dump also may be initiated by the user with one or more designated trips (see **Chapter 6**, Trip Data). At the time the status of any of those trips is set to "ON", a dump is appended to the end of the dump file. This permits the restart of a problem when a trip-signal monitored particular event of interest occurs.

All data dumps are added sequentially to the end of the dump file. The solution results written to the dump file are always in metric SI units.

A restart calculation requires two input files - a restart-dump file (or simply "restart file", for short) and a normal input file. The restart file is nothing more than the dump file for the calculation that you want to restart from. To use the dump file to initialize a subsequent calculation, the file must be copied or renamed from trcdmp to trcrst (or **test.dmp** to **test.rst**, if you are using the "--prefix" command line option). The input file is just a stripped-down version of the original input file. The general idea is that it should only contain information that is new or has changed from your original model. Be aware, however, that there is some information, like the main data cards, that must appear in every input file, regardless of whether it is a restart run or not.

The specific data that gets retrieved from the restart-dump file depends upon the information that has been provided by the input file. Any component not defined in the input file is initialized from the restart file. Also, any signal variable, control block, and trip with an ID number that has not already been defined by the input file will be initialized with its defined state from the data dump.

⚠ Warning – Be aware that the value of some input parameters cannot be changed in a restart calculation. These include NAMELIST variable IELV, IKFAC, ITHD, NDIA1, NEWRFD, NFRC1, NFRC3 (see **Main-Data Card 4**), and ISOLUT (Word 3 on **Main-Data Card 9**). If any of their values change, TRACE will generate an error message and abort the calculation.

Because the restart file will undoubtedly contain more than one block of dump information for the system, you will need to choose which specific block of information you want to actually restart from. You do this by figuring out the timestep number of that specific data-dump and set that value for the DSTEP variable (Word 1 on **Main-Data Card 6**) in your input file. The message (**trcmsg**) and output **(trcout)** files from the previous run can be searched for the phrase "`restart dump`" to show all output messages of the problem times and timestep numbers when data dumps were generated during the calculation. Since you will normally be interested in choosing the very last data-dump, TRACE allows some shorthand here — if the timestep number that you specify is negative, TRACE will read in the final data-dump and overwrite that negative DSTEP value with the timestep number taken from that data-dump.

Steady-State vs Transient Execution

TRACE may be executed in either steady-state or transient mode. In terms of the numerical scheme employed, there is nothing inherently different between the two modes. A steady-state run simply has some extra intelligence designed to detect whether the rate of change of various parameters throughout the model is essentially zero (within some user-specified tolerance), and if so, it ends the run. Additionally, steady-state input models are generally not allowed to perform actions that would explicitly lead to changes in the time-derivative terms in the basic equations.

TRACE determines whether or not an acceptable steady-state solution has been evaluated in a two-step process. First, TRACE determines every fifth timestep the maximum fractional change per second of seven key parameters (total pressure, liquid and steam velocities, steam volume fraction, liquid and steam temperatures, and noncondensable-gas pressure) over the entire hydraulic-system model. Then TRACE requires that all seven maximum rate-of-change values be less than or equal to a user-specified convergence criterion (EPSS) for steady-state convergence to be satisfied. This test feature also is provided in transient calculations that evaluate an asymptotic steady-state solution by the NAMELIST variable ISSCVT as described in **Chapter 6**.

If steady-state conditions cannot be attained within the period of time selected by the user; i.e., calculations do not converge and/or the results are not satisfactory, the calculation may have to be restarted. You might also consider just re-running the entire calculation from time zero with a larger end time if the amount of wasted wall-clock time is not considerable. Once an acceptable steady-state solution is obtained, a transient calculation can be initiated from the last steady-state calculation's dump file. The input file for the transient calculation contains those changes (relative to the steady-state model) that will initiate the desired transient behavior. This can include such modifications as new trip actions, new or modified control-system behavior, new components (for example, the addition of a BREAK component), or the modification of existing components to achieve some off-normal component action (e.g. valve opening/closing, pump coastdown, reactor scram, etc).

This describes the most typical use of TRACE. Sometimes performing a steady-state run is not necessary, and a transient run can be the first run. In this case, the input file will contain all transient information and the restart process is not necessary.

Running Legacy TRAC-P Input Files

If the input file has been created for a code version earlier than version 3.840 (TRACE was called TRAC-M at that time), the input deck may contain ROD/SLAB heat structure components. In Version 3.840, ROD/SLAB heat structure components were eliminated and replaced by HTSTR and POWER components. Fortunately, a mechanism is in place which will allow a user to convert input decks that contain the old ROD/SLAB components to input decks that use the new HTSTR and POWER components. First and foremost, it should be mentioned that it is not strictly necessary to actually convert the old ROD/SLAB components into new HTSTR and POWER components. The code will execute if fed an input deck containing old ROD/SLAB components.

TRACE is able to convert these heat structures on the fly. The disadvantage to this is that the user will generally find it very difficult to correlate the old heat structures as seen in the input deck with the heat structure information provided in the output file as well as the descriptions provided in the input & theory manuals. Also, SNAP is not able to directly read in input decks that use the old ROD/SLAB format.

The recommended course of action is to convert the original input decks themselves, rather than maintain the old formats. This is a relatively painless process. All that is needed is to simply create an empty file called **newhsinput** in the current working directory (i.e. the directory from which the code is executed) and then run the code with the input deck you would like to convert.. On a UNIX system the following command:

```
> touch newhsinput
```

will accomplish this. If the "--prefix" command line option is used, then the code will expect the filename to be **<prefix>.nhs** rather than **newhsinput**. TRACE will recognize the existence of this file and convert the old input deck containing ROD/SLAB heat structure components to an equivalent new deck with HTSTR and POWER components. The new input deck is written back out to **newhsinput** (or **<prefix>.nhs**). In addition to **newhsinput**, a second file called **sigvarinp** (or **<prefix>.svi**) is created to show the user which signal variables may have been modified in response to changes made to the heat structures they reference. In order to run TRACE, simply replace the old input deck with **newhsinput** (or **<prefix>.nhs**), remembering to actually remove **newhsinput** so the code does not attempt a second conversion run on the newly converted input deck.

Another area of concern to the user when attempting to execute old input decks relates to the signal variable input in the control system. Because there are so many different possibilities for specifying the signal variable input, input checking in TRACE has been severely strengthened over that of the original TRAC-P logic. One of the traits of the TRAC-P signal-variable capability was the flexibility afforded the user when specifying the input. This flexibility, unfortunately, carried with it the likely possibility of masking input errors without the user ever realizing that they exist. Such errors could be in the form of simple typos as well as a more fundamental lack of understanding.of how the signal capability should work. The TRACE input scheme has sought to rectify these problems by placing more stringent requirements on the user to specify consistent, meaningful input, without actually changing in any significant way the meaning of the input parameters. As such, there may be some instances where input decks will require small modifications to the signal variable input in order to allow them to execute. TRACE will generate error messages that contain the necessary amount of detail to allow the user to manually correct any such input found to be incorrect.

Running Legacy TRAC-B Input Files

TRACE is able to read and execute native TRAC-B models. They are treated exactly like native TRACE or TRAC-P models in terms of naming convention. You should, however, beware that TRACE is not able to perform the same level of diagnostic checks on the input data that TRAC-B would have performed. For that reason, it is imperative that you first make sure that your native TRAC-B model actually run in TRAC-B before attempting to run it with TRACE.

The following are issues the user should be prepared to deal with when attempting to run legacy TRAC-B decks with TRACE:

- The meaning of the CPOWR array has been redefined. In TRAC-B, it is possible for the first rod group to be given a relative power of 0.0, indicating that it is a water rod. In TRACE, there is a requirement that the first rod group must not be a water rod. As such, it will be necessary to restructure any TRAC-B decks in which the first value of the CPOWR array is set to 0.0.
- While TRAC-B supports the ability to model a SEPD component as just a dryer with no actual separator section (i.e. swirl vanes) (NDRYR > 0 and NSEPS =0), TRACE does not currently allow this configuration.

Running Legacy RELAP5 Input Files

TRACE has the capability to convert and run most RELAP5 models. We must stress that this capability is still very much under development; it should be considered experimental and not yet ready for production use. Executing a RELAP5 model with TRACE is a three-step process. If you are a brave soul and would like to test the waters, the process you must follow is outlined as follows:

- Import your native ascii RELAP5 model into SNAP
- Export a RELAP5 TPR file
- Execute TRACE using the "--useTPR" and "--isCompEngine" command line options.

The following are issues the user should be prepared to deal with when attempting to run legacy RELAP5 decks with TRACE:

- need to add a list of the issues

Running with IAPWS-IF97 (RELAP5) Steam Tables

TRACE has two different steam table formulations that the user may choose from when performing a simulation. By default, TRACE relies on legacy built-in curve-fit formulations that were used in TRAC-PF1. Users also have the option to run TRACE in a mode that relies on an interpolation scheme based on the 1997 International Association for the Properties of Water and Steam (IAPWS) Industrial Formulation (IF97) standard. It is essentially the same method as that used in RELAP5 (although the possibility for minor differences exists due to bug fixes/ improvements that may have made it into one code but not the other). This is accomplished by setting the NAMELIST variable USE_IAPWS_ST = .TRUE.

In terms of code execution details, when USE_IAPWS_ST = .TRUE., the user has the option of either supplying an external steam table binary file generated according to the IAPWS-IF97 standard[1] or simply letting TRACE default to using built-in steam table data (extracted from the external IAPWS steam table file and hardcoded into the executable). TRACE follows a cascading series of steps that determines how it will get its steam table properties. If the "--prefix" command line argument is used, the code will first search for a file called "**<prefix>.h2o**". This file is equivalent to the **tpfh2onew** file that all RELAP5 users should be used to using. If the code fails to find it, or if the "--prefix" option is not used, then it will look for a file called **trch2o**. If the code, in turn, fails to find this file, then it will try to open **tpfh2onew**. If it then fails to find that file, then the code will finally default to using the hardcoded IAPWS steam table data. Without the "--prefix" option, the code will first start looking for **trch2o** and proceed through the same cascading set of steps. In all cases, the steam table binary file is expected to be in the same directory as the TRACE input file (i.e. the current working directory). This scheme preserves the legacy RELAP5 workflow as well as the ability to test out different versions of the IAPWS standard without needing to rebuild the entire code.

It should be noted that while the **tpfh2onew** data file (or its equivalents) has, in general, more digits of numerical precision than the hardcoded IAPWS steam tables, from an engineering standpoint, the level of accuracy you get from the hardcoded IAPWS steam tables is essentially the same as that of the external data files.

Running TRACE from SNAP

For a complete description of this execution mode, please consult the SNAP User's Guide.

Multi-Task Mode of Operation

The multi-task (parallel) features of TRACE are provided through the Exterior Communications Interface (ECI). Users of this capability are strongly encouraged to study the documentation and examples directly associated with the ECI (examples are in the HTML-based ECI training material on the TRACE release CD). One mode of multi-task simulation involves splitting a standard single (serial) process TRACE input deck into two or more input decks that can be used to spread the work across more than one TRACE process. This is a way to cut runtime of a large plant simulation. Another mode involves extension of capabilities by tightly coupling other programs such as CONTAIN to the system simulation. This section focuses on actions needed to use more than one TRACE task in a multi-task calculation.

Options are scheduled for SNAP that will largely automate the creation of input and execution of multi-task jobs. This section describes the steps necessary to manually split standard input into an equivalent set of multiple input decks. It also describes the additional input file (**taskList**) used to

1. This file is typically called **tpfh2onew** in RELAP5 land, and is supplied as part of the code distribution package

specify the configuration of the multi-task job. Because input features supporting multi-task simulations are new to TRACE, users starting from archival input decks for RELAP5 or TRAC-B must use SNAP to convert them to native TRACE input before splitting the input model.

Preparation of Input for Multiple TRACE Processes

The first step in splitting an input model is to understand your target parallel computer. There is no advantage in creating more TRACE calculations than the number of CPU's on your computer (or computer cluster). Another related consideration is parallel efficiency. You should consider a study of TRACE's parallel efficiency on your computer. For the majority of configurations at the moment, the incremental increase in speed associated with splitting a system simulation into more than four parts is probably not worth your effort. For computers linked by a standard Ethernet, expect relatively poor parallel performance.

The second step is to understand your system nodalization, and look for ways to split the system that balance the computational load between processors. If your modeled system has a mixture of 1D and 3D components, you should run some simple timing studies to determine the ratio of computational times required by these volumes. We've found enough variation in the ratio of 3D to 1D cost per cell per step between computers and compilers, that it is not worth giving specific guidelines here. In most circumstances the relative computational cost for heat conduction nodes is low enough that heat structures should simply be placed on the same processor as one of the fluid components with which they exchange heat. However, if large numbers of heat structures are associated with one fluid component, timing studies may be justified to determine the value of allocating some or all of these heat structures to their own processor.

Once you have selected the basic distribution of components between separate TRACE calculations, the next step is to clearly note connection paths for flow of fluid and/or heat between the separate processes. For example assume that "PIPE 1" is in one of the new input decks and "PIPE 2" is in another. If fluid can flow from one to the other, you need to add an EXTERIOR component (see **Chapter 6**) to each of the new decks to mark the component missing from the other side of that flow connection. The input deck containing a full description of "PIPE 1" will contain the component "EXTERIOR 2" to note that a component connected to "PIPE 1" exists in some other process. The input deck containing a full description of "PIPE 2" will contain the component "EXTERIOR 1" to note that a component connected to "PIPE 2" exists in some other process. A similar procedure exists if a heat structure and fluid component exchange heat, but are calculated by different tasks.

Use of EXTERIOR components has one other level of complexity. One task in the multi-task calculation must be designated as "central". It will have the responsibility of sorting out the task to task fluid flow path topology. As a result, the input for that task must include an EXTERIOR component corresponding every real component in every other task's input that has a flow junction to a different computational task. If "PIPE 1" and "PIPE 2" in the example above are contained in two non-central (satellite) tasks, then the central task must have input for components "EXTERIOR 1" and "EXTERIOR 2", containing information indicating that the two components share a flow junction.

Construction or adaptation of control systems for multi-task simulations should be done with care. It is a good idea to configure input decks so control block clusters that span processes are placed in the input for the central process. This will limit the potential for unpredictable consequences when evaluation of a string of interdependent control blocks is spread across several processes. Any signal variables used as input to control blocks should be defined within the process containing that control block. Access to signal variables that are defined in other processes does not function properly in the current code release. However, a signal variable defined in one task may request information from a component that is evaluated in another task. Transfer of that information will be automatically scheduled during the initialization of the calculation.

Description of Contributing Processes

A clear definition is required for all tasks contributing to a system simulation, and for the location of execution and input information for those tasks. This is done in a file named **taskList**. The file consists of pairs of task descriptor lines and any number of blank or comment (starts with # or !) lines. The first line in a task descriptor pair contains an arbitrary but unique name for the task, a path to the program used for this task, and, if appropriate, any command line arguments for the program. The second line in the task descriptor pair contains the name of the host on which the program will be executed, and the working directory for the job. The first active line pair in **taskList** describes the central process. A sample **taskList** file is shown below.

```
#################################
#  HERE IS THE INFO FOR TASK #1
################################
# taskname     program name                          arguments
  trac1        D:\work\code\v31181\Debug\tracx.exe

# Hostname             Working Directory
  mowgli.psu.edu       D:\work\code\exterior\example1

################################
#  HERE IS THE INFO FOR TASK #2
################################
# taskname       program name                        arguments
  output         D:\work\code\exterior\getvars\Debug\getvars.exe

# Hostname             Working Directory
  mowgli.psu.edu       D:\work\code\exterior\getvars
#
```

TaskList Descriptor Card Pairs

Fields in the **taskList** file are defined as follows:

Card Number	TaskName	ProgName	Arguments
1 (Program information)	Arbitrary name uniquely identifying the task in the multitask system simulation.	Full path name of the executable used for this task.	Any command line arguments used by the program (For TRACE, see **Table 1-2**).
	MachName	**WorkDir**	
2 (Execution Environment)	Network name for the machine used to run this task.	Name of the working directory for this task. Input files must already exist in this directory. All output will be placed in this directory.	

One important restriction in the current ECI is that all machines listed in a given **taskList** file must have the same flavor of operating system. All must be running a Microsoft Windows system, or all must be running a Unix or Linux system. If you are running Unix/Linux on a mixture of hardware having different internal representations of numbers, you need to rebuild your computer code with a definition added in CIpcInclude.h of "#define XDRtest" (CIpcInclude.h is a header file in the "tracc" library). If all values of **MachName** are the same, reflecting a shared memory parallel computer, you should consider rebuilding TRACE with "#define SOCKETS" replaced by "#define SHARED" (also in CIpcInclude.h). This will typically cut message passing overhead by at least a factor of two.

Running the Multi-Task Job

The first step in running a multi-task job is to be certain that the input files for each task are located in the working directory listed for that task in the **taskList** file. The **taskList** file itself must be located in the directory from which the central process is started.

The next step is to be certain that the driver program (named "ParallelDriver") for the ECI is running on every machine listed in the **taskList** file. The driver program functions as a daemon for sending messages back and forth, much like the pvmd daemon used in PVM. This program stays alive after each use, unless cancelled by a "Ctrl-C" keypress. However, as currently configured, the driver only supports one ECI job at a time on a given processor. This restriction will be relaxed in later releases. Eventually, the current driver program will be replaced by equivalent functionality in the SNAP Execution Monitor.

The final step is to start your central process (first process in the **taskList** file). Normally this would be started in the first working directory listed in the **taskList** file. However, you can start the process in any working directory as long as the **taskList** file resides in that directory. Once it has read the **taskList** file, the central process switches to it’s designated working directory, and transmits the contents of **taskList** to all driver programs. The drivers start all remaining tasks for the simulation on the correct machines, then go into an idle state. Communications between tasks from that point forward is automated, and governed by each task's need for missing information.

Each TRACE task creates it's own set of output files. However, the edit and dump intervals are controlled by the central process and synchronized by the ECI. If a restart is required, the dump file must be copied to a restart file (e.g. **trcdmp** => **trcrst**), and an appropriate restart input file must replace the original input file in every working directory.

2

Input and Output Files

For console applications like TRACE (i.e. those that you run from a command line), interaction between the user and the application generally takes place through the use of computer files. The user is responsible for supplying as input to the program one or more files that contain all the data necessary to perform a simulation. TRACE is responsible for performing that simulation and saving all the relevant information that it generates into one or more output files so that it may be analyzed by the user. The purpose of this section is to introduce you to all the various input and output files that TRACE expects from the user or creates on its own during the course of a calculation. See **Table 2-1** for a concise reference.

There are two distinct file naming conventions you can use when working with TRACE input and output files. By default, the code has its own hardwired naming scheme for all files that it processes. These default names are given in column 3 of **Table 2-1**. Unless you do something to tell TRACE otherwise, this is the scheme that it will use. Alternatively, you can override this default naming scheme when invoking TRACE from the command line. Using the --prefix command line option, you are able to establish a common base name that all files created or read-in by TRACE will share. The individual file types are differentiated by a unique file extension (hardwired into the code). For example, if TRACE were invoked from the command line like this:

```
> trace.exe --prefix test
```

then the code would expect to take as input a file called **test.inp**. It would create a series of output files like **test.out**, **test.msg**, **test.xtv**, etc. Column 4 in **Table 2-1** provides a listing of the exact file extensions used by TRACE, assuming a common run name called "test"

Input File

The **tracin** (**test.inp**) file specifies the problem input data for a calculation and is a required input file for all TRACE calculations. For a new calculation this file contains all of the model input data. For a restart calculation this file contains input only for the model features which the user desires to change at the problem restart time. Data for the remaining model features are obtained from the restart file (described below) at a restart edit specified by the user.

Restart File

The **trcrst** (**test.rst**) file contains data from a prior calculation from which a restart run is to be made. This TRACE input file is only required for restart calculations. Typically this file is created by copying the dump file (described below) from the prior run and renaming it to **trcrst** (**test.rst**). The times at which restart calculations may be made correspond to the restart edit times requested by the user in the preceding calculation. Note that the restart file is never modified as a result of executing a restart calculation. Also, note that the dump file produced by a restart calculation only includes data covering the period of the restart calculation and not the period of the prior calculation before the restart time.

Output File

The **trcout** (**test.out**) file contains output data representing “snapshots” of the calculation variables at specific times during the calculation. Short and large edits are produced during the calculation at frequencies requested by the user on the time-step data cards. The edits include values for the calculation variables (such as pressures, temperatures and control block data). This file also contains an echo of the problem input and some, but not all, warning and error messages. For the initial calculation, the initial condition of the thermal-hydraulic system model is that specified in the input file. For subsequent restart calculations, the initial condition is that obtained from the restart file (the dump file from the previous calculation) with an overlaid modification of selected control parameters and components from the input file.

A short edit is a half-page display. The initial line outputs the current problem time, timestep size, and timestep number and the number of iterations required to converge the last outer iteration. This is followed by the maximum convective power difference, the component and its location limiting the current timestep size, the minimum, average, and maximum number of outer iterations since the last short edit, the number of timesteps that each component was the last to converge its outer-iteration solution, and the current-calculation and accumulated-calculation’s CPU execution times. This information conveys how well the numerical solution is doing and where in the model the solution convergence is most limited and the timestep size controlled.

Dump File

TRACE generates a dump file called **trcdmp** (**test.dmp**) that contains snapshots of the solution state of the model. These snapshots are output at user-specified time intervals (using the timestep data cards or special trips designed to force a dump snapshot to be taken at a specific point) during the course of a calculation. Any one of these snapshots, called a restart data dump, may be used to initialize all or part of the system model for subsequent restart calculations from its data-dump edit time. This file is typically copied and renamed to the restart file (see above). That file is then it is used as the input file containing restart edit data required for subsequent restart problems. The solution results output to the dump file are always in metric SI units. The file contains unformatted binary data that and, as such, is not intended to be visually examined.

The file **trctpr** has the same functionality as **trcdmp**. It is intended to be platform-independent such that a TPR file generated under one operating system (e.g. Windows) can be read on another (e.g. Linux). The command line argument "--usetpr" (see **Table 1-2**) causes the code to generate the trctpr file instead of trcdmp. The TPR file may also be used as a means for importing a TRACE model into SNAP.

Graphics File

The **trcxtv** (**test.xtv**) file contains calculation output in a format that can be directly used by the graphics-analysis tool AcGrace (see **Chapter 3** for more information). The file consists of header information in text format and a series of graphics data edits in binary format. The edit frequency can be controlled by the user from the input file. The data in this file can be output in either SI units or English units. Plot axis labels for dependent variables are provided in the corresponding units.

Input Echo File

The **trcinp** (**test.echo**) file is an echo of the input-data file with out comments. It contains the problem input rearranged into a standard TRACE format and only includes the input data that is actually used by the code. All comment cards are removed. At the end of each card read, two pieces of information are listed: the format the data should be entered in for that card [i.e. integer (i) or real (r)] and the number of the card as it lies in the input-data file. This file can provide some help in diagnosing the sources of input errors relating to data entry fields and format. For example, some error messages refer to the card number to reference the place of input error in the input-data file. The numbered cards in the echo file makes it easy to find the error in the tracin file.

Message File

The **trcmsg** (**test.msg**) file contains condensed output on the behavior of the numerical calculation and warning error messages that are produced during input processing, initialization, and the computational sequence. In other words, it documents the progress of the calculation and any numerical difficulties that were encountered. Solution results output to the message file are in SI units.

Run-time Statistics File

The **trcstats** (**test.stats**) contains some very basic statistics on a run such as CPU time, total number of time steps, and mean time step size. The CPU time in this file only reflects cost of time advancement through a transient, and does not include time associated with input processing and initialization of the calculation. This CPU time is printed even if the "--nocpu" command line argument is selected or the NAMELIST variable CPUFLG is 1. Each line of this ASCII file begins with a number. Next is an equals sign, followed by a descriptive name associated with the value at the beginning of the line. The remainder of the line contains a simple description of this run statistic.

Difference File

The **trcdif** (**test.dif**) file is an output file containing a history of the inner and outer iteration and time step parameter data during the calculation. The values that are printed are in full numerical precision. This file is of limited value to the TRACE user. The purpose of this file is to assist the code developer in helping to identify from one code version to the next, whether a code modification has perturbed the calculation in a way that was not intended. The values printed to the output file are not printed with sufficient precision to guarantee that an unintended perturbation will cause a non-null comparision for a particular input deck between two consecutive code versions. It can sometimes take several hundred timesteps for an error to propagate into the output file. The **trcdif** file allows the developer to identify the exact point (timestep) where two runs might have diverged. This file is created by using the command line argument "--dif" (see **Table 1-2**) or setting the NAMELIST variable TRCDIF to 1 (see **Main-Data Card 4**).

Labeled Echo File

The **inlab** (**test.lab**) file is an optional (i.e. user-requested) output file that contains the same input data as the **trcinp** (**test.echo**) file but in a free format with all the TRACE variables names provided within asterisk-delimited comments. The comment labels for scalar variables are on a comment line above the line containing their values. The comment labels for the array variables are asterisk-delimited in a left-justified nine-column field on each line having load-format data. Existing user-defined comments in the **tracin** file are not preserved in the **inlab** file, however. You will need to transfer them over manually should you so desire.

In essence, the labeled echo file becomes a new “cleaned up” version of the input file when it is renamed **tracin** (**test.inp**). This provides a convenient way for the user to clean up the appearance of an input file for better readability of the input data.

By default, the input-data parameter values are in written to this file in SI units, but the user has the ability to override this and request that they be written, instead, in English units. This provides a convenient way for the units of the input data to be changed conveniently from metric SI to English or from English to metric SI. The **tracin**-file units are metric SI or English depending upon NAMELIST variable IOINP being 0 (default) or 1; the **inlab**-file units are metric SI or English depending upon NAMELIST variable IOLAB being 0 (default) or 1, respectively.

Heat Structure Conversion Files

The **newhsInput** (**test.nhs**) and **sigvarinp** (**test.svi**) files are optional output files that are generated when a heat structure conversion run is attempted. To initiate this process, the user must first create an empty **newhsInput** (**test.nhs**) file in the current working directory. When TRACE finds this file, it will attempt to convert all old ROD/SLAB components to the new HTSTR and POWER components, and write the resulting input file back out to **newhsInput**. The **sigvarinp** (**test.svi**) file contains information pertaining to any signal variables whose input was modified to reference the new heat structure or power components.

Extract File

The **trcext** (**test.extr**) file is an optional output file that is generated when a TRAC-B extract run is attempted. At this point, this functionality is only partially enabled so its use is not recommended.

Stop File

The **StopCode** file is used a means for terminating execution of a code run prematurely, but do so in a graceful way. As such, the output, dump, and graphics files are left in a usable state. Each timestep, TRACE checks for the existence of this file. If it is found, then the run is terminated (and **StopCode** is deleted), otherwise, execution proceeds.

View Factors File

The **trcgvf_xxxx** (**test.gvf_xxxx**) files are a set of output files that contain the calculated grouped view factors and path lengths for each CHAN component. One file is created for each CHAN component. The "**_xxxx**" suffix denotes the specific ID number of a single CHAN component in the input deck. Once the grouped view factors and path lengths have been determined for a given code run, they can be inserted back into the input deck so that the code does not need to recalculate them for each code run. This is important because for CHANs that contain square and/or water cross water rods, the view factors are calculated using a cpu-intensive ray tracing methodology, that requires at least 100,000 randomly selected rays for each rod surface to determine view factors with an acceptable level of accuracy. Experience has shown that such calculations can take on the order of several CPU minutes. For really accurate view factors, approximately 1,000,000 rays are needed. Such a calculation may take several CPU hours to complete (for just the view factors alone).

Steam Table Properties File

The **trch2o** (**test.h2o**) file contains the IAPWS steam table data and can be used as an input file to supercede the built-in water property interpolation data when the steam table NAMELIST option is engaged (USE_IAPWS_ST = .TRUE.). If the "--prefix" command line argument is used, the code will first search for **test.h2o**. If the code fails to find it, then it will look for a file called **trch2o**. If the code, in turn, fails to find this file, then it will try to open **tpfh2onew**. If it then fails to find that file, then the code will use IAPWS steam table data that has been stripped from the **tpfh2onew**/**trch2o** file and hardcoded straight into the executable. Without the --prefix option, the code will first start looking for **trch2o** and proceed through the same cascading set of steps. The ability to make the steam table file conform to the prefix of the actual input file is useful in situations where multiple code runs are launched from the same directory. Otherwise, multiple TRACE processes will compete for the same file, causing errors (at least under Windows).

If USE_IAPWS_ST = .FALSE. (the default), then none of the above applies - the code will use built-in legacy water property curve fits.

Parallel TaskList File

As explained in **Chapter 1**, TRACE can be executed in parallel with itself or with other codes. In these situations, a clear definition of all the tasks contributing to a system simulation is required, as well as the location of all input files and working directory where execution is to take place. This is done in a file named **taskList**. There is no equivalent prefix naming convention option for this file.

Parallel Error File

The **central.err** file contains error messages that may be produced during a parallel run. The messages that appear here will generally be related to problems in the data flow and/or handshaking that takes place between separate processes. There is no equivalent prefix naming convention option for this file. This file is only produced if TRACE is the central process of the simulation.

Table 2-1. Summary of TRACE Input and Output Files.

File Type	File Content or Function	Default Naming Convention	Prefix Naming Convention	File Contents, Comments
Input	Calculation Input File	tracin	test.inp	Problem input deck.
Input	Restart Data Input File	trcrst	test.rst	Only used for restart problems. Contains data from which the calculation is initiated. Generally created by copying the **trcdmp** (**test.dmp**) file from the prior run and renaming the copied file **trcrst** (**test.rst**).
Input	Terminates code execution gracefully	StopCode	StopCode	The existence of this file will cause TRACE to terminate the run prematurely, but do so in a graceful way
Input	Steam table data file	trch2o	test.h2o	This file contains steam table data that conforms to the IAPWS-IF97 standard. TRACE looks for this file when NAMELIST option USE_IAPWS_ST = .TRUE.. If it isn't found, then TRACE will use its own built-in IAPWS steam table data.
Input	parallel task setup information	taskList	N/A	Contains bookkeeping information for managing a parallel simulation (task, working directory location, input file names, etc). This file is only required when running TRACE in multi-task mode.
Output	Calculation Printed Output File	trcout	test.out	Contains the TRACE small and large edit output information at intervals requested by the user on the time-step data cards.
Output	Restart Data Output File	trcdmp	test.dmp	Contains the TRACE restart edit data at intervals requested by the user on the time-step data cards.

Table 2-1. Summary of TRACE Input and Output Files.

File Type	File Content or Function	Default Naming Convention	Prefix Naming Convention	File Contents, Comments
Output	Plot Data Output File	trcxtv	test.xtv	Contains the TRACE calculation plot edit data at intervals requested by the user on the time-step data cards. This file is directly read and used by the AcGrace plotting routine. (File is also usable with the XMGR5 plotting routine).
Output	Input Echo File	trcinp	test.echo	Contains the problem input modified to appear in a standard format which only includes the data that is actually used by the code.
Output	Warning and Error Message File	trcmsg	test.msg	Contains various diagnostic warning and error messages from both the input processing and execution stages of a calculation. Note that not all warning and messages are contained in this file; some may be written only to the **trcout (test.out)** and **trcinp** (**test.echo**) files.
Output	Reformatted Input File	inlab	test.lab	Contains a reformatted version of the problem input. Only input data actually used in the calculation and a standard-format comment structure are included.
Output	Converted heat structures	newHSInput	test.nhs	Problem input deck containing heat structures converted from old into new format
Output	Converted signal variables	sigvarinp	test.svi	List of signal variables modified during the heat structure conversion process
Output	Extract Information	trcext	test.extr	Contains a problem input deck using state data extracted from the dump file.

Table 2-1. Summary of TRACE Input and Output Files.

File Type	File Content or Function	Default Naming Convention	Prefix Naming Convention	File Contents, Comments
Output	Run time statistics	trcstats	test.stats	The existence of this file will cause TRACE to terminate the run prematurely, but do so in a graceful way
Output	Null testing statistics (full precision)	trcdif	test.dif	This file contains some global solution parameters in full precision to aid the developer when performing null testing from one code version to the next.
Output	Calculated view factors	trcgvf_xxxx	test.gvf_xxxx	Contains the calculated, ray-traced view factors that the user can merge back into the original input deck (replacing the CHAN mrod array). One file is written out for each CHAN component. The "**_xxxx**" suffix denotes the ID number of the CHAN component to which the view factors apply.
Output	Central process error messages	central.err	N/A	This file is only produced during a parallel simulation. It contains error messages produced by the central process concerning data flow & handshaking between processes

3

XTV Graphics

At the request of the user, TRACE will create a binary graphics file that contains essentially all of the parameters a user might find useful while analyzing the results of a simulation. By default, this file is named **trcxtv**. If the prefix file naming conventions are used (see **Chapter 1**), then the filename conforms to the following pattern: **<prefix>.xtv**.

Being a binary formatted file, the graphics file is generally not readable by mere humans. In other words, it is not simply possible to open the file up in your favorite text editor or spreadsheet and start selecting or manipulating fields or columns of numbers to be plotted. Instead, the file is formatted using a special format, called the XTV (X-TRAC-View) format, that organizes and compresses the data in a way that minimizes the file storage requirements (i.e. how much disk space it consumes). The result of this, though, is that special visualization tools are required in order to be able to read from and write to files of this type.

Visualization Tools

There are currently three ways to visualize TRACE results — using AcGrace, SNAP, or AVScript[1]. While each tool defines its own distinct workflow for working with, and manipulating, the TRACE graphics information, they are all built upon the same underlying visualization technology.

AcGrace

At present, AcGrace is the main workhorse for performing graphical analysis of TRACE results. The name stands for "*Analysis Code, GRaphing, Advanced Computation and Exploration of data*". AcGrace is a customized version of the popular Grace plotting software, developed specifically for use with NRC analysis codes, NRC Databank files, and SNAP, and to provide an easier means of performing calculations using data from these files.

1. Some of you may also remember the old XTV graphical user interface developed by Los Alamos National Laboratory for the TRAC-PF1 code. Unfortunately, the current XTV graphics format is not compatible with that program, although many of its capabilities are now a part of SNAP.

Installing and Running AcGrace

Before a plot of a TRACE variable can be performed, AcGrace must, of course, be installed on your computer system. In addition to being included on the TRACE distribution media, the latest version of the software, as well as any installation instructions, can always be obtained from the AcGrace website: *http://www.acgracehome.com*.

Note – In order to be able to run AcGrace under Windows NT/XP/2000/9*/ME, you need to make sure that some kind of X Server is installed and running on your computer. An excellent free X Server is distributed as part of the Cygwin package. See *http://www.cygwin.com* for all the details related to downloading, installing, and configuring Cygwin and all its constituent software packages (including the .xorg X server) for your computer.

Using AcGrace

Assuming that you have run TRACE (which has generated a graphics file) and AcGrace is up and running, the next step would naturally be to generate some plots. To do that, you first need to read in the **trcxtv** graphics file.

To read in a TRACE graphics file:

1) Choose *File* > *Read* > *TRAC Data...* from the menu bar.
2) Make sure the "XTV File Type" button is selected.
3) Type the full path and name of the graphics file in the entry box at the botton of the dialog box.
4) Click OK.

This will bring up the Edit TRAC data dialog box shown in **Figure 3-1**. It is the means by which you are able to select which data channels you want to plot and the mesh locations to which they correspond. The exact variables that are available for you to plot depend upon the various options and input parameters that you enable/disable as part of your TRACE input model.

Warning – Some users have reported problems, noting that the size of the AcGrace dialog boxes are too big for the screen, causing some of the buttons and other widgets to be pushed off-screen, becoming unreachable with the mouse cursor. This has been observed to happen to some people who use lower screen resolutions. Until this issue can be resolved programmatically, one way to fix the problem is to increase your screen resolution to 1280x1024. If you are unwilling to change your resolution, there is second, more complicated, temporary fix that may also bring relief under certain circumstances. It involves making changes to the .Xdefaults or .Xresources file. Rather than explain that procedure here, please contact the TRACE development team for the necessary instructions.

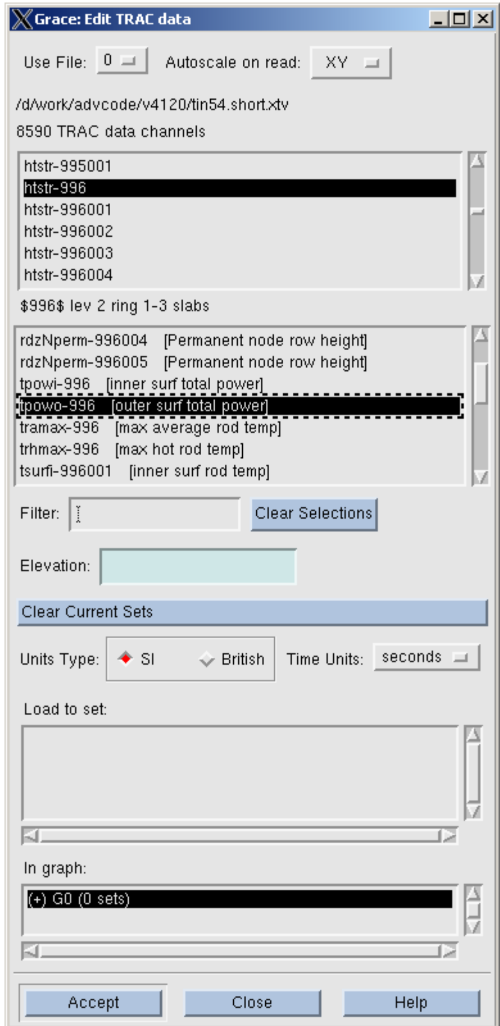


Figure. 3-1. AcGrace Screenshot: Edit TRAC Data Dialog Box. When viewing this figure on-screen, you may need to zoom-in in order to achieve an acceptable level of resolution.

In the upper selection area of the dialog box, a list of components and associated component number is presented. The identifiers conform to the convention: "**comp-ccc**" (e.g. **htstr-996**) where "**ccc**" refers to the component number. In some cases, TRACE may spawn its own internal sub-components that you can think of, in some sense, as "belonging to", or being "children of" some parent component that is part of the input deck. In these situations, the component ID conforms to the convention "**comp-cccsss**", where "**ccc**" refers to the parent component number and "**sss**" refers to the spawned sequence number (set by TRACE). Selecting a particular component will present the list of plot-able variables in the lower inset consistent with those shown in **Table 3-3** through **Table 3-29**.

Table 3-1 provides the key for understanding the component and mesh indices used for the TRACE data channels in AcGrace. Note that for spawned components, the variable name "**var-ccc**" would be replaced by "**var-cccsss**".

Table 3-1. AcGrace Indices for Plotting Component Data

Component Type	Dimension	Variable	ccc	iii	jjj	kkk
Hydraulic	0D	var-ccc	comp. #			
	1D Cell-Centered	var-ccciii	comp. #	cell index		
	1D Face-Centered	var-ccciii	comp. #	face index		
	2D	var-ccciiijjj	comp. #	axial index	radial index	
	3D	var-ccciiijjjkkk	comp. #	axial index	radial index	theta index
Heat Struct. Slabs	0D	var-ccc	comp. #			
	1D	var-ccciii	comp. #	axial index of cell		
Heat Struct. Rods	0D	var-ccciii	comp. #	rod sub-component number		
	1D	var-ccciiijjj	comp. #	rod sub-component number	axial index	
	2D	var-ccciiijjjkkk	comp. #	rod sub-component number	axial index	radial index

An elevation value may be supplied for heat structure slab and rod variables that contain an axial index. This will be used to calculate the value of the variable at a fixed elevation (the one specified by the user) as TRACE performs coarse/fine re-nodalization of the model. In order to do so, the first axial elevation should be selected and then the elevation value should be specified in the AcGrace window dialog box. When running AcGrace in batch mode, the elevation may be specified by adding @elev to the end of the variable name, such as "**var-ccc001kkk@1.0**".

Improving responsiveness

One of the perpetual sources of frustration for users is how quickly AcGrace is able to generate plots once the XTV file has been loaded and the desired data channels have been selected.

Responsiveness is generally a function of two things: the amount of data that is in the graphics file and the method by which that data is stored. There are three techniques that you can use to control these two factors:

- Demultiplex the file. This changes the way the data is stored internally in the XTV file. By default, most timestep-marching codes like TRACE write their data to files in discrete chunks grouped by timestep (i.e. one chunk containing all relevant variables for each timestep). By spreading the data for each data channel out like this, it makes it very slow for a tool like AcGrace to process. That is because the software has to load and unload lots of information into memory (a notoriously slow operation in computer space) as it attempts to locate and retrieve the data to be plotted. By demultiplex'ing the data, you end up reorganizing the data in the file so it is grouped by data channel rather than timeslice. This puts the all data for each channel next to each other, making it very fast and easy for AcGrace to locate.

  Ok, so by now you are probably thinking - "How do I demultiplex my data?" Well, fortunately, AcGrace is distributed with a demultiplex'ing tool called **xtv2dmx**. It is located in the same directory as the acgrace executable itself. Details concerning its usage can be found in the AcGrace documentation, or you can type "xtv2dmx.exe -h" at the command line to get a list of options.

  Once you have demultiplexed the data, you open it up in AcGrace like you would a regular XTV file except that you must change the file type to "Demux" rather than "XTV" in the "Read TRAC" dialog box.

- Adjust the graphics interval in the input deck. This changes the rate at which information is written to the XTV file, leading to an overall smaller file size and thus making it easier for AcGrace to parse.

- Adjust the GRAPHLEVEL NAMELIST option in the input deck to a lower level of verbosity (i.e. "limited" or "minimal"). Doing so decreases the total number of data channels written to the graphics file, leading to an overall smaller file size and thus making it easier for AcGrace to parse. It also makes it easier for the user to scroll through and find the right data channels to plot in the dialog box shown in **Figure 3-1**.

Performing calculations across entire data channels

AcGrace allows you to perform many different sorts of mathematical transformations to the data sets that you have plotted on-screen. As a TRACE analyst, one such transformation that you inevitably will need to perform on a regular basis will be to add/subtract/multiply/divide two (or more) entire data sets. A good example of this might be the need to plot Δp (pressure difference) across the core.

Let's illustrate how you can accomplish this within AcGrace. We will make the assumption that you have already plotted two pressure traces - one at the bottom of the core and one at the top of the core. **Figure 3-2** illustrates this condition. Given this, the steps to create a plot of Δp are

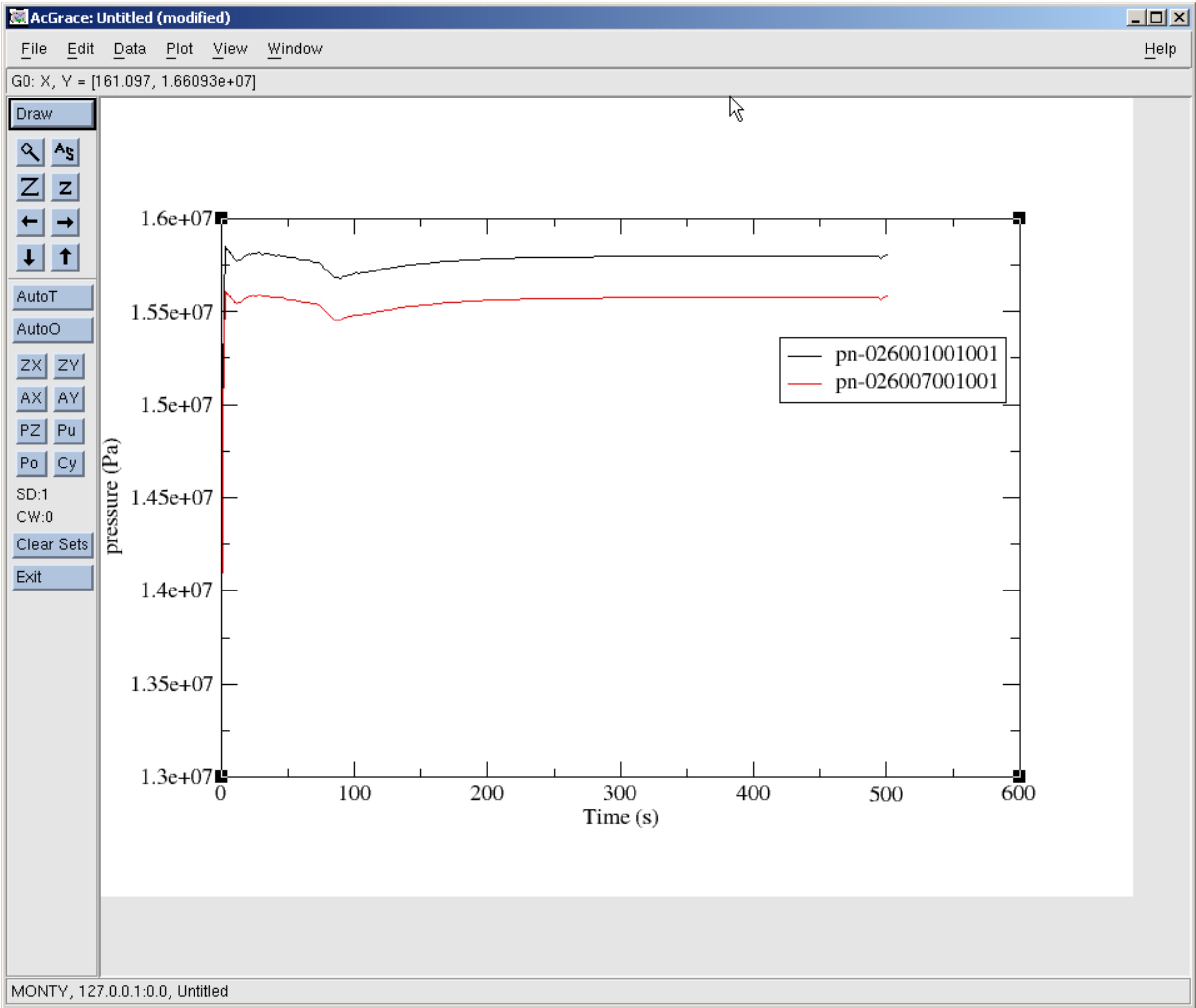


Figure. 3-2. AcGrace Screenshot: Pressure traces at top and bottom of the core. When viewing this figure on-screen, you may need to zoom-in in order to achieve an acceptable level of resolution.

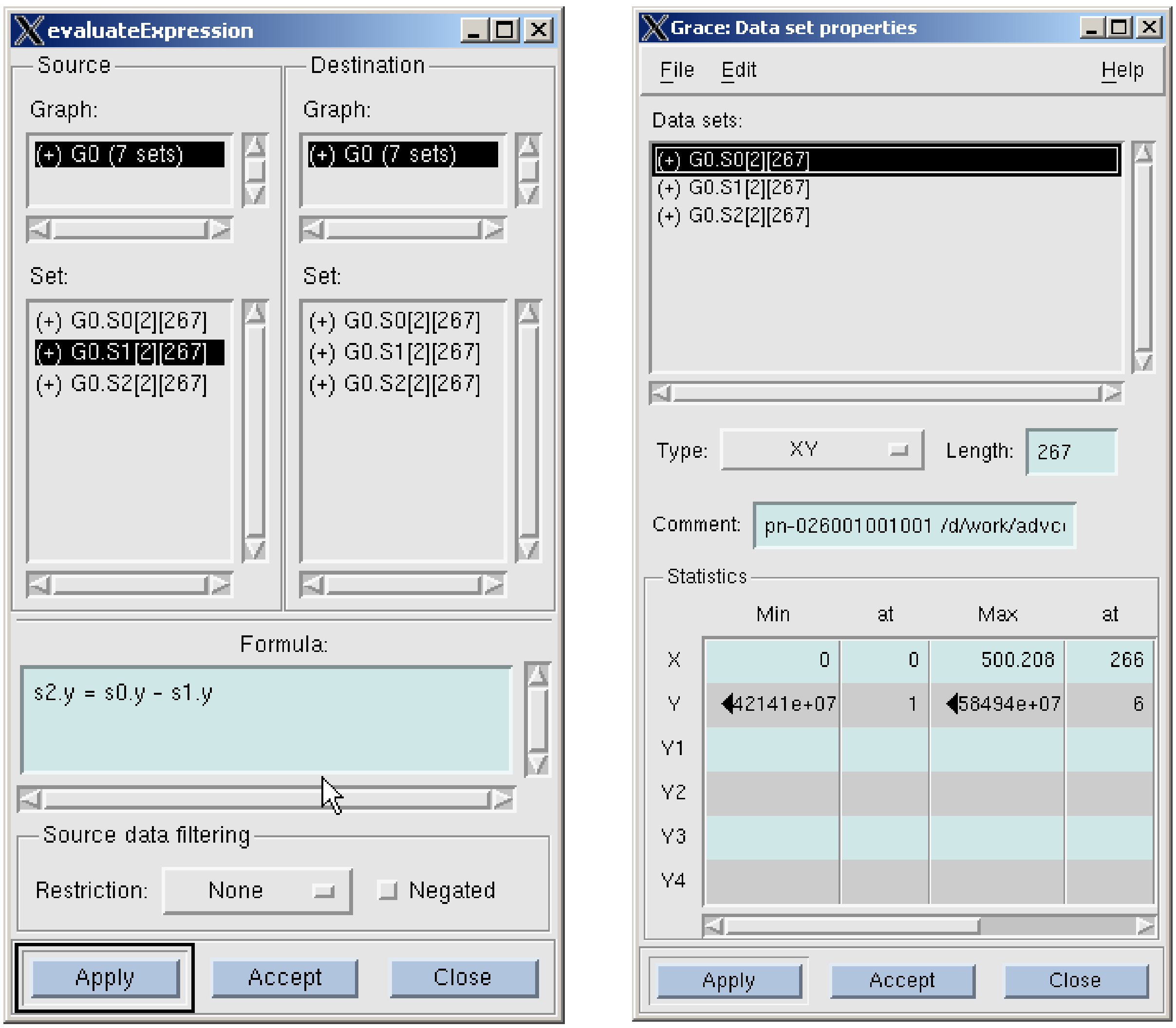
1) From the main menu bar, choose *Data* > *Transformations* > *Evaluate Expression...* to bring up the **evaluateExpression** popup dialog box (shown in **Figure 3-3(a)**).

2) Select one of the sets shown in the "Source" area of the dialog box. AcGrace uses the notation "`S#`" as an ID number for each data set and "`G#`" to indicate which graphics file a data set belongs to. So "`G0.S0`" indicates the first data set for the first XTV file that was read in (as you can see, the count starts with 0, not 1).

3) Type the expression to subtract the two data sets in the Formala area. In this case, the expression is

```
s2.y = s0.y - s1.y
```

This means that you would like to subtract the y-axis values for data set 1 from the y-axis values of data set 0, and will assign them to the y-axis values of data set 2 (which does not yet exist - it will be created automatically). This method assumes that there is a one-to-one correspondence between the y-values in each set and that the x-axis values for each set are identical. You normally shouldn't need to worry about this because it will always be true for data channels retrieved directly from the XTV file. For those situations where this is not necessarily true, you will need to use AcGrace's interpolation functions (*Data > Transformations> Interpolation/splines...*) to precondition your data so that this condition is met.



(a) (b)

Figure. 3-3. AcGrace Screenshot: (a) evaluateExpression pop-up dialog box; (b) Data set properties pop-up dialog box. When viewing this figure on-screen, you may need to zoom-in in order to achieve an acceptable level of resolution.

4) When typing in expressions, it may be necessary to determine which data set corresponds to each data trace that you see on the screen, so that you can perform the mathematical operations in the correct algebraic order. In this instance, click on the *Edit > Data Sets...* menu entry to open the **Grace: Data set properties** dialog box shown in **Figure 3-3(b)**. The Min and Max values that are displayed for each selected set should tell you which set is which.

5) Click Apply in the **evaluateExpression** dialog box. This will put the newly calculated data set on your plot. You may need to click the Autoscale button to bring it into view.

6) You can adjust the line color and legend text of the new data set by clicking on *Plot > Set Appearance...* to bring up the **Grace: Set Appearance** dialog box and adjusting the relevant items there.

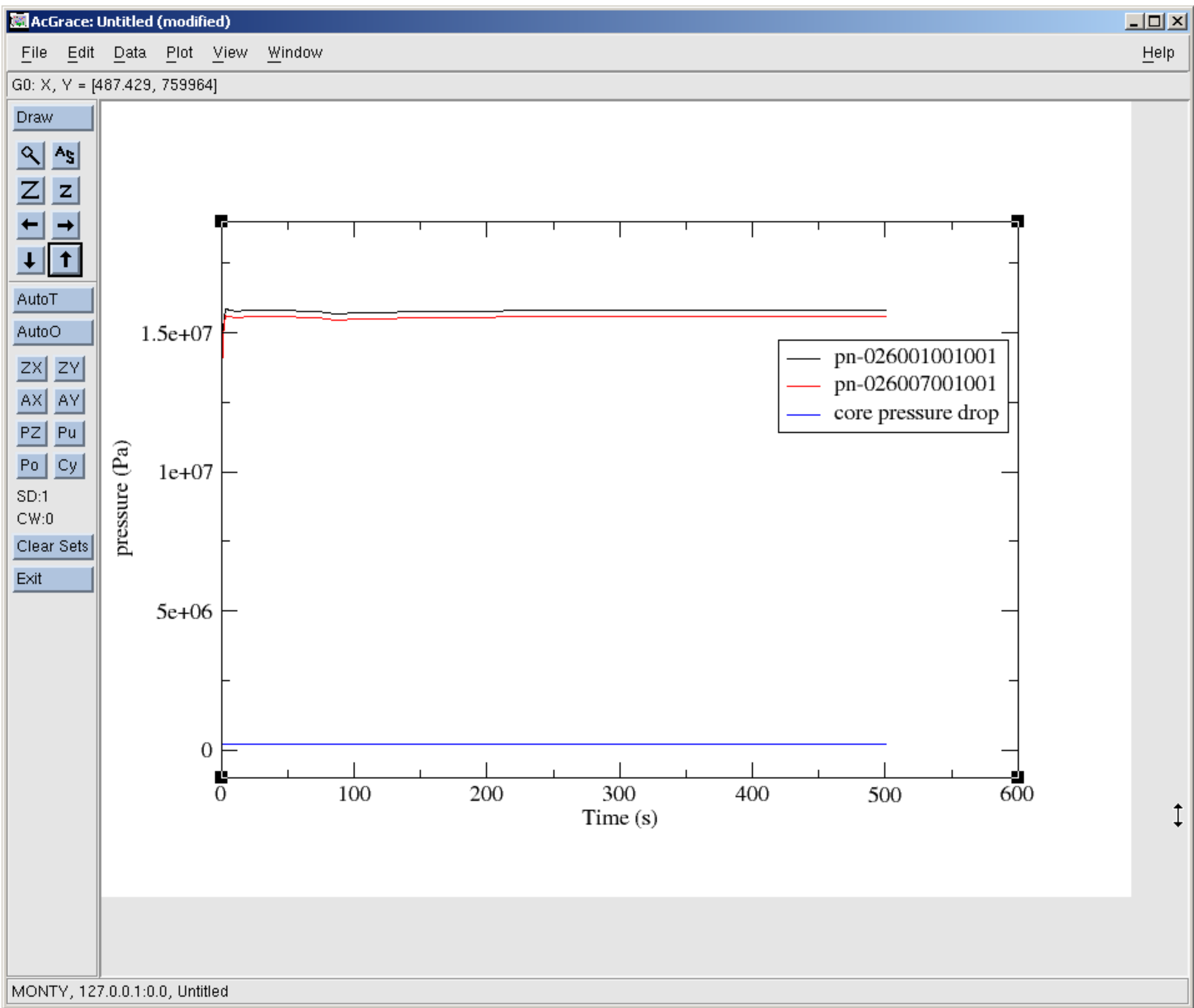


Figure. 3-4. AcGrace Screenshot: Completed plot with pressure differential shown. When viewing this figure on-screen, you may need to zoom-in in order to achieve an acceptable level of resolution.

7) **Figure 3-4** shows the completed plot. It has both the original sets plus the newly created set on the plot canvas. If you like, you can remove the original data sets from the plot by clicking the *Edit > Set Operations...* menu item to bring up the **Grace: Set Operations** dialog box, then selecting the sets you wish to remove, then right-clicking on those sets and then selecting "Kill"

For further information on the subject of performing transformations on data, please consult section 4.5 of the AcGrace User Guide, and section 7.1 of the AcGrace tutorial.

Generating axial plots

In the course of performing an analysis, it is often useful to generate plots of, say, void fraction or temperature, along the axial length of a component. Unfortunately, there is no really easy way to accomplish this in AcGrace. In general, the user must rely on a manual procedure comprised of the following steps:

1) Using the Grace: TRAC Data dialog box, plot the parameter of interest for each of the axial nodes that will be part of your axial plot.
2) From the menu, choose *Data > Export > ASCII...* to open up the **Grace: Write sets** dialog box
3) In the "Write set(s)" area, select all the sets of data that you wish to export. Choose a file name and location in the box at the bottom, and click OK. This will write a text file that contains the actual x-y data pairs for each data set, one after the other.
4) Open up this text file of exported data in your favorite text editor. For the time of interest, manually pick out the y-values for each data set. If the specific time value that you are interested in is not one of the actual x-values that appear, you will need to interpolate the data yourself.
5) Construct a new data file with the axial heights in the x-column and the axial parameter values you just extracted in the y-column.
6) Import your new data file back into AcGrace. To do this, choose the *Data > Import > ASCII...* menu item to open up the **Grace: Read sets** dialog box, type the path & name of your axial plot data file in the text box at the bottom and click OK.

Luckily, all is not lost. AVScript does provide a more automated way of generating axial plots but it is still left up to you to manually identify each of the axial locations of the nodes that you wish to plot, as well as the specific transient time for which the axial information is to be plotted. AVScript will handle all the other steps like extracting the data at the correct nodes, interpolating between time points, and actually generating the plots. For further instructions on how to do this, please consult the AVScript User's Guide.

SNAP

SNAP is also able to assist the TRACE analyst in the area of visualization of a model. It's capabilities are very similar to that of the old Nuclear Plant Analyzer (NPA) and XTV programs. Please consult the SNAP User's Guide for a full description of these capabilities and how to use them.

AVScript

The Automated Validation Script (AVScript) software is the third tool that the TRACE analyst possesses for generating plots from TRACE. Rather than being a tool that parses and manipulates the XTV graphics file directly, AVScript can be thought of as a preprocessor to AcGrace, allowing the analyst to automate a series of code runs and the creation of any plots that he or she might wish to look at.

Given the level of automation this tool provides, AVScript offers great potential for dramatically improving an analyst's productivity. It allows the analyst to establish, up-front, what cases he or she wishes to run, what figures should be generated, and what format those figures should be stored in. This way, as an input deck is developed or some sort of analysis is performed, an entire body of knowledge concerning the performance of the input model can be built up gradually, allowing the analyst to focus on the real engineering and not the manual process of re-creating plots with each new code run.

For further information concerning the installation and use of this software, we refer the reader to the AVScript User's Guide.

Description of Graphics Variables

This section provides a detailed list of all the graphics variables available to the TRACE user for plotting. The variables have been sub-categorized and alphabetized for ease of reference. We have provided definitions, and as appropriate, the corresponding SI and English units.

The graphics facility in TRACE is structured to allow a user to dump information to the XTV file at one of three levels of verbosity. The user specifies which level he or she wants using the 'graphLevel' NAMELIST option. **Table 3-2** summarizes the available options. The default level is 'limited'. This feature was added to TRACE to give the user some means of controlling the overall size of the graphics file while still maintaining the ability to look at some of the more arcane parameters if the need should arise. The level to which each graphics variable belongs is provided in **Table 3-3** through **Table 3-29**.

Table 3-2. Graphics level options that the user may select in input

graphLevel	Description
minimal	This option implies that only a very minimal set of parameters are dumped to the XTV graphics file. Specifically, only the control system parameters and a few global parameters are dumped.
limited	This option implies that only the most commonly used graphics variables or those thought to be genuinely useful during a typical analysis are written to the XTV file. For example, this level includes (but is not necessarilty limited to) such quantities as pressure, temperature, void fraction, density, mass flow rate, velocity, core-averaged quantities, etc. This option is the default.
full	All available graphics variables are actually written to the XTV file.

Global Variable Graphics

The global variables apply to the overall calculation as opposed to specific components or cells within a component. **Table 3-3** lists the global XTV graphics variables.

Table 3-3. Global Graphics Variables

Variable	Dimension	Level	Description
cputot	1	minimal	Total CPU time (s) since time 0.0 s in the calculation.
delt	1	minimal	Timestep size (s).
dprmax	1	full	Maximum fractional pressure change over the current timestep (parameter used in the timestep-control logic).
dtlmax	1	full	Maximum liquid-temperature change (K, °F) over the current timestep (parameter used in the timestep-control logic).
dtrmax	1	full	Maximum HTSTR-component ROD or SLAB element wall temperature change (K, °F) over the current timestep.
dtsmax	1	full	Maximum saturation temperature change (K, °F) over the current timestep.
dtvmax	1	full	Maximum vapor-temperature change (K, °F) over the current timestep (parameter used in the timestep-control logic).
tnstep	1	minimal	Total number of timesteps since time 0.0 s in the calculation.

Signal-Variable, Control-Block, and Trip-Signal Graphics

All signal variables, control blocks, and trip signals specified through input from the input-data file **tracin** and restart-data file **trcrst** are written to the **trcxtv** file in order of increasing magnitude of their ID numbers. The quantities written to the graphics file are:

1) the parameter value of each signal variable at the current timestep along with a figure label having its signal-variable ID number, parameter title, and units of the signal-variable parameter,

2) the output-parameter value from each control block at the current timestep along with a figure label of its control-block ID number and the units of the control-block output parameter, and

3) the trip signal from each trip at the current timestep along with a figure label of its trip ID number and the units of the trip signal.

For TRACE to output control-block output-signal and trip-signal units to the control-block and trip-signal figure labels, the user must specify those units through input by units-name labels. This is done when one or more of the NAMELIST variables I/O-units flags IOGRF, IOINP, IOLAB, and IOOUT has a value of 1 to specify English units. Users desiring all input and output in SI units with control-block output-signal and trip-signal graphics labels with SI units should input NAMELIST variables IOLAB = 1 while leaving INLAB = 0 (default value). Inputting INLAB = 3 would output a comment-labeled input-data file inlab in English units. Table 3-4 lists the XTV graphics variables for the control system.

Table 3-4. Signal-Variable, Control-Block, and Trip-Signal Graphics

Variable	Dimension	Level	Description
sv	1	minimal	Signal-variable data (although the dimension of each is 1, there are ntsv of them and each has its own units-name label).
cb	1	minimal	Control-block output (although the dimension of each is 1, there are ntcb of them and each has its own units-name label based on the user-defined units-name label of cbxmin and cbxmax).
ts	1	minimal	Trip-signal data (although the dimension of each is 1, there are ntrp of them and each has its own units-name label based on the user-defined units name label of setpt(i), i=1 to 2 or 4)

Users familiar with the internal TRACE data structure, can use type 3 signal variables to significantly expand on the state information (described below) that is automatically dumped to the graphics file. All significant fluid state and component information is available via internal pointer association with any variable named in the type 3 signal variable input. For the time being, we specifically do not publish the entire list of available variables this way for two reasons:

- It is a dangerous practice for a user to attempt to reference an internal code variable which, on the surface, looks like it might contain the value you think you want, but actually, due to nuances of the numerical scheme, represents a quantity that is not what you think.
- There is no real point in publishing a list of variable names because the code is changing rapidly enough at this point that the list would quickly become out of date, serving as a source of frustration rather than a help. Once the rate of change in the source base levels out, we will revisit this issue.

Component Graphics

The following subsections describe the component-related XTV graphics variables offered by TRACE.

General One-Dimensional Hydraulic-Component Graphics

Table 3-5 lists the XTV graphics variables that are common to all the 1D hydraulic components. For the HEATR, JETP, SEPD TEE and TURB components, the dimension of cell-centered variables includes space for a phantom cell between the main-tube and side-tube cells. This accounts for the fact that there are more interfaces than cells and side-tube values are stored after main-tube values. In some cases, the outputting of parameter values depends on user-specified options in the TRACE input-data **tracin** file that cause those parameters to be evaluated.

Table 3-5. General 1D Component Graphics

Variable	Dimension	Level	Description
alpE	ncellt[a]	full	Prevailing void fraction at a cell edge used in the field equations only when there is a phase-separation interface upstream or downstream - will always be 0.0 or 1.0. (–).
alpn	ncellt	limited	Cell gas volume fractions (–).
alven	ncellt	full	Cell liquid-side interfacial heat-transfer coefficients (W/K, Btu/(hr °F)) [HTC * interfacial area].
alvn	ncellt	full	Cell-flashing interfacial heat-transfer coefficients (W/K, Btu/(hr °F)) [HTC * interfacial area].
am	ncellt	limited	Cell noncondensable-gas masses (kg, lb_m).

Table 3-5. General 1D Component Graphics (Continued)

Variable	Dimension	Level	Description
chtan	ncellt	full	Cell noncondensable-gas interfacial heat-transfer coefficients (W/K, Btu/(hr °F)) [HTC * interfacial area].
chtin	ncellt	full	Cell gas-side interfacial heat-transfer coefficients (W/K, Btu/(hr °F)) [HTC * interfacial area].
cifn	ncellt+1	full	Interface interfacial-drag coefficients (kg/m^4, lb$_m$ /ft^4).
concn	ncellt	full	Cell dissolved-solute concentration ratio [kg(solute)/kg (liquid), lb$_m$(solute)/ lb$_m$(liquid)].
el	ncellt	limited	liquid internal energy (J/kg, Btu/lb$_m$)
ev	ncellt	limited	gas internal energy (J/kg, Btu/lb$_m$)
elm	ncellt	full	Liquid mechanical energy per unit mass(m^2/s^2, ft^2/s^2)
evm	ncellt	full	Gas mechanical energy per unit mass(m^2/s^2, ft^2/s^2)
fa	ncellt+1	limited	Cell edge flow areas (m^2, ft^2).
gamn	ncellt	full	Mass phase change rate (kg/(m^3 s), lb$_m$/(ft^3 s)).
hgam	ncellt	full	Cell subcooled boiling heat flux (W/m^2, Btu/ (hr ft^2)).
pan	ncellt	limited	Cell noncondensable-gas partial pressures (Pa, psia).
phiL	ncellt+1	full	Distance to phase separation interface (m, ft).
pn	ncellt	limited	Cell total pressures (Pa, psia).
regnm	ncellt+1	limited	Interface flow-regime numbers.
rlmf	ncellt+1	limited	Liquid mass flow (kg/s, lb$_m$/hr)
rmvm	ncellt+1	limited	Interface fluid mass flows (kg/s, lb$_m$/hr).
roan	ncellt	limited	Cell noncondensable-gas densities (kg/m^3, lb$_m$/ft^3).
roln	ncellt	limited	Cell liquid densities (kg/m^3, lb$_m$/ft^3).
rom	ncellt	limited	Cell mixture densities (kg/m^3, lb$_m$/ft^3).
rovn	ncellt	limited	Cell gas densities (kg/m^3, lb$_m$/ft^3).

Table 3-5. General 1D Component Graphics (Continued)

Variable	Dimension	Level	Description
rvmf	ncellt+1	limited	Gas mass flow (kg/s, lb_m/hr)
sn	ncellt	limited	Cell plated-solute mass/fluid volume (kg/m^3, lb_m/ft^3).
tln	ncellt	limited	Cell liquid temperatures (K, °F).
tsat	ncellt	limited	Cell saturation temperatures (K, °F) based on the total pressures.
tssn	ncellt	limited	Cell saturation temperatures (K, °F) based on the steam partial pressures.
tvn	ncellt	limited	Cell gas temperatures (K, °F).
vln	ncellt+1	limited	Interface liquid velocities (m/s, ft/s).
vol	ncellt	limited	Cell volumes (m^3, ft^3).
volM	ncellt	full	Volume of sub-region between the interface and the lower bound cell boundary (m^3, ft^3).
volP	ncellt	full	Volume of sub-region between the interface and the upper bound cell boundary (m^3, ft^3).
vvn	ncellt+1	limited	Interface gas velocities (m/s, ft/s).
wfl	ncellt+1	full	Interface friction factors (–).
xg<name>	ncellt	limited	Mass fraction for gas trace species "name" (–).
xl<name>	ncellt	limited	Mass fraction for liquid trace species "name" (–).

a. ncellt=ncells for non-TEE based components. ncellt includes the side arm and phantom cell for TEEs.

BREAK Component Graphics.

Table 3-6 lists the XTV graphics variables that are output for all BREAK components.

Table 3-6. BREAK Component Graphics

Variable	Dimension	Level	Description
alpn	1	limited	BREAK-cell gas volume fraction (–).
bsa	1	limited	Time-integrated noncondensable-gas mass flow (kg, lb_m).
bsmass	1	limited	Time-integrated mass flow (kg, lb_m) into the BREAK cell.
bxa	1	limited	Noncondensable-gas mass flow (kg/s, lb_m/hr).
bxmass	1	limited	Mass flow (kg/s, lb_m/hr) into the BREAK cell.

Table 3-6. BREAK Component Graphics (Continued)

Variable	Dimension	Level	Description
concn	1	limited	BREAK-cell dissolved-solute concentration ratio [kg(solute)/kg (liquid), lb_m(solute)/ lb_m(liquid)].
enth	1	limited	BREAK-cell fluid enthalpy (J/kg, Btu/lb_m).
pan	1	limited	BREAK-cell noncondensable-gas partial pressure (Pa, psia).
pn	1	limited	BREAK-cell total pressure (Pa, psia).
tln	1	limited	BREAK-cell liquid temperature (K, °F).
tvn	1	limited	BREAK-cell gas temperature (K, °F).
vol	1	limited	BREAK-cell volume (m^3, ft^3).
m<species>	1	limited	mass of trace species out the BREAK (lb_m, kg)
mfr<species>	1	limited	mass fraction of trace species out the BREAK (-)

CHAN Component Graphics

In addition to the variables output for the 1D components (listed in **Table 3-5**), the same XTV graphics variables which are output for the PIPE component are output for all CHAN components. For convenience, this list of additional XTV variables is shown below in **Table 3-7**.

Table 3-7. CHAN Component Graphics

Variable	Dimension	Level	Description
cpow	1	full	Power (W, Btu/hr) from direct heat to the fluid.

CONTAN Component Graphics

Table 3-8 thorough **Table 3-12** list the XTV graphics variables that are output for the CONTAN component.

Table 3-8. CONTAN Component Graphics for Each Compartment

Variable	Dimension	Level	Description
apool	ncompt	limited	Pool surface area (m^2, ft^2).
cl	ncompt	full	Liquid conductivity (W/(m K), Btu/(ft °F hr)).
cpl	ncompt	full	Liquid specific heat (J/(kg K), Btu/(lb_m °F)).
cpv	ncompt	full	Vapor specific heat (J/(kg K), Btu/(lb_m °F)).

Table 3-8. CONTAN Component Graphics for Each Compartment (Continued)

Variable	Dimension	Level	Description
cv	ncompt	full	Vapor conductivity (W/(m K), Btu/(ft °F hr)).
d	ncompt	limited	Pool depth (m, ft).
dpdt	ncompt	full	Pressure change rate (Pa/s, psi/s).
droldt	ncompt	full	Liquid density change rate (kg/(m^3 s), lb_m/(ft^3 hr)).
drovdt	ncompt	full	Steam density change rate (kg/(m^3 s), lb_m/(ft^3 hr)).
ea	ncompt	limited	Air specific internal energy (J, Btu).
el	ncompt	limited	Liquid specific internal energy (J, Btu).
ev	ncompt	limited	Vapor specific internal energy (J, Btu).
hfgp	ncompt	full	Latent heat (J/kg, Btu/lb_m).
hlmfr	ncompt	full	Liquid phase mass change (kg, lb_m).
htmfr	ncompt	full	Gas phase mass change (kg, lb_m).
p	ncompt	limited	Compartment pressure (Pa, pisa).
pa	ncompt	limited	Air partial pressure (Pa, pisa).
rma	ncompt	limited	Air mass (kg, lb_m).
rml	ncompt	limited	Liquid mass (kg, lb_m).
rms	ncompt	limited	Steam mass (kg, lb_m).
rmdota	ncompt	full	Air mass change rate (kg/s, lb_m/hr).
rmdotl	ncompt	full	Liquid mass change rate (kg/s, lb_m/hr).
rmdots	ncompt	full	Steam mass change rate (kg/s, lb_m/hr).
roa	ncompt	limited	Air density (kg/m^3, lb_m/ft^3).
rol	ncompt	limited	Liquid density (kg/m^3, lb_m/ft^3).
rov	ncompt	limited	Vapor density (kg/m^3, lb_m/ft^3).
sig	ncompt	full	Surface tension (N/m, lb_f/ft).
tl	ncompt	limited	Liquid temperature (K, °F).
tsatp	ncompt	limited	Saturate temperature of total pressure (K, °F).
tsats	ncompt	limited	Saturate temperature of partial pressure (K, °F).
tv	ncompt	limited	Gas temperature (K, °F).
udotl	ncompt	full	Liquid energy change rate (W, Btu/hr).
udotv	ncompt	full	Gas energy change rate (W, Btu/hr).
ul	ncompt	limited	Liquid phase internal energy (J, Btu).

Table 3-8. CONTAN Component Graphics for Each Compartment (Continued)

Variable	Dimension	Level	Description
uv	ncompt	limited	Gas phase internal energy (J, Btu).
visl	ncompt	full	Liquid viscosity (kg/(m s), lb_m/(ft hr)).
visv	ncompt	full	Vapor viscosity (kg/(m s), lb_m/(ft hr)).

Table 3-9. CONTAN Component Graphics for Each Cooler

Variable	Dimension	Level	Description
htc	ncool	limited	Heat transfer coefficient times area (W/K, Btu/(°F hr)).
qcl	ncool	limited	Cumulated heat removal (W, Btu/hr)
qcld	ncool	limited	Total heat removal rate (W, Btu/hr).

Table 3-10. CONTAN Component Graphics for Each Passive Junction

Variable	Dimension	Level	Description
rmdap	njct	limited	Air flow rate (kg/s, lb_m/hr).
rmdlp	njct	limited	Liquid flow rate (kg/s, lb_m/hr).
rmdot	njct	limited	Total flow rate (kg/s, lb_m/hr).
rmdsp	njct	limited	Steam flow rate (kg/s, lb_m/hr).

Table 3-11. CONTAN Component Graphics for Each Forced Junction

Variable	Dimension	Level	Description
rmdaf	njctf	limited	Air flow rate (kg/s, lb_m/hr).
rmdlf	njctf	limited	Liquid flow rate (kg/s, lb_m/hr).
rmdsf	njctf	limited	Steam flow rate (kg/s, lb_m/hr).

Table 3-12. CONTAN Component Graphics for Each Liquid Source or Sink

Variable	Dimension	Level	Description
enflo	njuncts	limited	Energy flow rate (W, Btu/hr).
enss	njuncts	limited	Cumulated Energy (J, Btu).
rmain	njuncts	limited	Cumulated air mass (kg, lb_m).
rmdas	njuncts	limited	Air flow rate (kg/s, lb_m/hr).
rmdls	njuncts	limited	Liquid flow rate (kg/s, lb_m/hr).
rmdsin	njuncts	limited	Cumulated steam mass (kg, lb_m).
rmdss	njuncts	limited	Steam flow rate (kg/s, lb_m/hr).
rmlin	njuncts	limited	Cumulated liquid mass (kg, lb_m).

FILL Component Graphics.

Table 3-13 lists the XTV graphics variables that are output for all FILL components.

Table 3-13. FILL Component Graphics

Variable	Dimension	Level	Description
alpn	1	limited	FILL-cell gas volume fraction (–).
concn	1	limited	FILL-cell dissolved-solute concentration ratio [kg(solute)/kg (liquid), lb_m(solute)/ lb_m(liquid)].
enth	1	limited	FILL-cell fluid enthalpy (J/kg, Btu/lb_m).
fxmass	1	limited	Mass flow (kg/s, lb_m/hr) out of the FILL cell.
pan	1	limited	FILL-cell noncondensable-gas partial pressure (Pa, psia).
pn	1	limited	FILL-cell total pressure (Pa, psia).
tln	1	limited	FILL-cell liquid temperature (K, °F).
tvn	1	limited	FILL-cell gas temperature (K, °F).
vln	1	limited	FILL-interface liquid velocity (m/s, ft/s).
vol	1	limited	FILL-cell volume (m^3, ft^3).
vvn	1	limited	FILL-interface gas velocity (m/s, ft/s).
m<species>	1	limited	mass of trace species into the FILL (lb_m, kg)
mfr<species>	1	limited	mass fraction of trace species into the FILL (-)

HEATR Component Graphics

In addition to the variables output for the 1D components (listed in **Table 3-5**), **Table 3-14** lists the XTV graphics variables that are output for all HEATR components.

Table 3-14. HEATR Component Graphics

Variable	Dimension	Level	Description
liqlev	1	limited	Shell liquid level (m).
powr1	1	full	Heater power (W, Btu/hr) to the main-tube fluid.
powr2	1	full	Heater power (W, Btu/hr) to the side-tube fluid.

JETP Component Graphics

In addition to the variables output for the 1D components (listed in **Table 3-5**), **Table 3-15** lists the XTV graphics variables that are output for all JETP components.

Table 3-15. JETP Component Graphics

Variable	Dimension	Level	Description
etapp	1	full	Jet pump application efficiency (-).
eteff	1	full	Jet pump effective efficiency (-).
mr	1	limited	Jet pump flow ratio (-).
nrapp	1	limited	Jet pump application head ratio (-).
nreff	1	full	Jet pump effective head ratio (-).
powr1	1	full	Jet pump power (W, Btu/hr) to the main-tube fluid.
powr2	1	full	Jet pump power (W, Btu/hr) to the side-tube fluid.

PIPE Component Graphics

In addition to the variables output for the 1D components (listed in **Table 3-5**), **Table 3-16** lists the XTV graphics variables that are output for all PIPE components.

Table 3-16. PIPE Component Graphics

Variable	Dimension	Level	Description
cpow	1	full	Power (W, Btu/hr) deposited directly in the fluid.
qout	1	limited	Liquid volume discharged (m^3, ft^3) at the exit (interface ncells+1) when the accumulator flag iacc > 0.
vflow	1	full	Volumetric fluid flow (m^3/s, gpm) at the exit (interface ncells+1) when the accumulator flag iacc > 0.
z	1	limited	Water level (m, ft) in the PIPE component (assumes the component is vertically oriented with cell 1 at the top) when the accumulator flag iacc > 0.

PLENUM Component Graphics

Table 3-17 lists the XTV graphics variables that are output for all PLENUM components

Table 3-17. PLENUM Component Graphics

Variable	Dimension	Level	Description
alpn	1	limited	Cell gas volume fraction (–).
am	1	limited	Cell noncondensable-gas mass (kg, lb_m).
concn	1	limited	Cell dissolved-solute concentration ratio [kg(solute)/kg(liquid), lb_m(solute)/ lb_m(liquid)].
gamn	ncellt	full	Mass phase change rate (kg/(m^3 s), lb_m/ft^3 s)).
pan	1	limited	Cell noncondensable-gas partial pressure (Pa, psia).
pn	1	limited	Cell total pressure (Pa, psia).
roan	1	limited	Cell noncondensable-gas density (kg/m^3, lb_m/ ft^3).
roln	1	limited	Cell liquid density (kg/m^3, lb_m/ft^3).

Table 3-17. PLENUM Component Graphics (Continued)

Variable	Dimension	Level	Description
rom	1	limited	Cell mixture density (kg/m^3, lb_m/ft^3).
rovn	1	limited	Cell gas density (kg/m^3, lb_m/ft^3).
sn	1	limited	Cell plated-solute mass/fluid volume (kg/m^3, lb_m/ft^3).
tln	1	limited	Cell liquid temperature (K, °F).
tsat	1	limited	Cell saturation temperature (K, °F) based on the total pressure.
tvn	1	limited	Cell gas temperature (K, °F).
vol	1	limited	Cell volume (m^3, ft^3).

PRIZER (Pressurizer) Component Graphics

In addition to the variables output for the 1D components (listed in **Table 3-5**), **Table 3-18** lists the XTV graphics variables that are output for all PRIZER components.

Table 3-18. PRIZER Component Graphics

Variable	Dimension	Level	Description
flow	1	full	Volumetric flow (m^3/s, gpm) at the exit (interface ncells+1) of the PRIZER.
qin	1	full	Heater/sprayer power (W, Btu/hr).
qout	1	limited	Liquid volume discharged (m^3, ft^3) at the exit (interface ncells+1) of the PRIZER.
z	1	limited	Water level (m, ft) in the PRIZER component (assumes the component is vertically oriented with cell 1 at the top).

PUMP Component Graphics

In addition to the variables output for the 1D components (listed in **Table 3-5**), **Table 3-19** lists the XTV graphics variables that are output for all PUMP components.

Table 3-19. PUMP Component Graphics

Variable	Dimension	Level	Description
alpha	1	full	Gas volume fraction donored across the second (pump-impeller) interface (weighted 10% new, 90% old).
delp	1	full	PUMP ΔP (Pa, psia) across the second (pump-impeller) interface (pressure of cell 2 minus pressure of cell 1).
flow	1	full	Volumetric fluid flow (m^3/s, gpm) donored across the second (pump-impeller) interface.
head	1	limited	PUMP head (Pa m^3/kg or m^2/s^2 or N m/kg, lb_f ft/lb_m) from the homologous curves and two-phase degradation multiplier.
mflow	1	limited	Fluid mass flow (kg/s, lb_m/hr) across the second (pump-impeller) interface.
omegan	1	limited	Pump-impeller rotational speed (rad/s, rpm).
rho	1	full	Fluid mixture density (kg/m^3, lb_m/ft^3) donored across the second (pump-impeller) interface.
smom	1	full	Momentum source (Pa, psia) applied at the second (pump-impeller) interface based on the PUMP head.
torque	1	full	PUMP hydraulic torque (Pa m^3, lb_f ft) from the homologous curves and two-phase degradation multiplier.

SEPD Component Graphics

In addition to the variables output for the 1D components (listed in **Table 3-5**), **Table 3-20** lists the XTV graphics variables that are output for all SEPD components.

Table 3-20. SEPD Component Graphics

Variable	Dimension	Level	Description
powr1	1	full	Heater power (W, Btu/hr) to the main-tube fluid.
powr2	1	full	Heater power (W, Btu/hr) to the side-tube fluid.
xci	1	limited	Separator inlet quality (-).
xco	1	limited	Liquid carryover quality (-). When the dryer model is activated, xco represents the flow quality after the dryers, not the separator carryover.
xcu	1	limited	Vapor carryunder quality (-).
veldis	1	full	discharge HEM velocity (m/s, ft/s)
vlev	1	full	separator interface velocity (m/s, ft/s)
dpss	1	full	separator pressure drop according the GE separator model (Pa, psia). This Δp is not actually enforced across the SEPD component. It is there just as a reference for the user when no data is available for the pressure drop across the separators. In that case, the user may want to adjust the sepd kloss to obtain the code-indicated pressure drop, dpss.
wlev	1	full	water level outside the separator (m, ft)
dAlp	1	full	separator void error (-)
isSepSep	1	full	flag to indicate whether the separator is actually separating (on a timestep by timestep basis) (-)

TEE Component Graphics

In addition to the variables output for the 1D components (listed in **Table 3-5**), **Table 3-21** lists the XTV graphics variables that are output for all TEE components.

Table 3-21. TEE Component Graphics

Variable	Dimension	Level	Description
powr1	1	full	Heater power (W, Btu/hr) to the main-tube fluid.
powr2	1	full	Heater power (W, Btu/hr) to the side-tube fluid.

TURB Component Graphics

In addition to the variables output for the 1D components (listed in **Table 3-5**), **Table 3-22** lists the XTV graphics variables that are output for all TURB components.

Table 3-22. TURB Component Graphics

Variable	Dimension	Level	Description
omegt	1	limited	Rotor angular speed (rad/s, rpm).
powr1	1	full	Heater power (W, Btu/hr) to the main-tube fluid.
powr2	1	full	Heater power (W, Btu/hr) to the side-tube fluid.
torqt	1	limited	Sum of rotor torques (Pa m^3, lb_f ft.

VALVE Component Graphics

In addition to the variables output for the 1D components (listed in **Table 3-5**), **Table 3-23** lists the XTV graphics variables that are output for all VALVE components.

Table 3-23. VALVE Component Graphics

Variable	Dimension	Level	Description
area	1	limited	Adjustable valve-interface flow area (m^2, ft^2).

VESSEL (Three-Dimensional) Component Graphics

Table 3-24 lists the XTV graphics variables that are output for all VESSEL components. Like the 1D variables, interface variables have one more value than cell variables on the face axis. For example vlnz, the z direction liquid velocity, has NRSX*NTSX*(NASX+1) values. The VESSEL variables output to graphics are very much dependent on the options selected and parameters set in the VESSEL input-data, in NAMELIST, and in other general options. The following abbreviations are used for dimensions in this section:

- ncells = NRSX*NTSX*NASX (values at every cell)
- xrfaces = (NRSX+1)*NTSX*NASX (values at each x/r face)
- ytfaces = NRSX*(NTSX+1)*NASX (values at each y/q face)
- zfaces = NRSX*NTSX*(NASX+1) (values at each z face)

Table 3-24. VESSEL Component Graphics

Variable	Dimension	Level	Description
alpA	ncells	full	Cell gas volume fraction above a water level (-). [for 3D level tracking]
alpB	ncells	full	Cell gas volume fraction below a water level (-). [for 3D level tracking]
alpn	ncells	limited	Cell gas volume fractions (-).
alpxrE	ncells	full	Cell edge gas volume fraction in xr-direction (-). [for 3D level tracking]
alpytE	ncells	full	Cell edge gas volume fraction in yt-direction (-). [for 3D level tracking]
alpzE	ncells	full	Cell edge gas volume fraction in z-direction (-). [for 3D level tracking]
alven	ncells	full	Cell liquid-side interfacial heat-transfer coefficients (W/K, Btu/(°F hr)) [area folded in].
alvn	ncells	full	Cell flashing interfacial heat-transfer coefficients (W/K, Btu/(°F hr)) [area folded in].
am	ncells	limited	Cell noncondensable-gas masses (kg, lb_m).
chtan	ncells	full	Cell noncondensable-gas interfacial heat-transfer coefficients (W/K, Btu/(°F hr)) [area folded in].
chtin	ncells	full	Cell vapor-side interfacial heat-transfer coefficients (W/K, Btu/(°F hr)) [area folded in].
cimfr	1	limited	Reactor-core inlet mass flow (kg/s, lb_m/hr).
cimfrl	1	limited	Reactor-core inlet liquid mass flow (kg/s, lb_m/hr).

Table 3-24. VESSEL Component Graphics (Continued)

Variable	Dimension	Level	Description
cimfrv	1	limited	Reactor-core inlet gas mass flow (kg/s, lb_m/hr).
cixr	ncells	full	Radial or x-direction interfacial-drag coefficients (kg/m^4, lb_m/ft^4).
ciyt	ncells	full	Azimuthal or y-direction interfacial-drag coefficients (kg/m^4, lb_m/ft^4).
ciz	ncells	full	Axial interfacial-drag coefficients (kg/m^4, lb_m/ ft^4).
comfr	1	limited	Reactor-core region outlet mass flow (kg/s, lb_m/ hr).
comfrl	1	limited	Reactor-core outlet liquid mass flow (kg/s, lb_m/ hr).
comfrv	1	limited	Reactor-core outlet gas mass flow (kg/s, lb_m/hr).
concn	ncells	limited	Cell dissolved-solute concentration ratio [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)].
corelq	1	limited	Reactor-core liquid volume fraction (-).
dcflow	1	limited	Downcomer mass flow (kg/s, lb_m/hr) (sums the axial flow out of the downcomer at level IDCL).
dclqvl	1	limited	Downcomer liquid volume fraction.
el	ncellt	limited	liquid internal energy
ev	ncellt	limited	gas internal energy
gamn	ncells	full	Vapor (steam) generation rate (kg/m^3, lb_m/ft^3).
hgam	ncells	full	Cell subcooled boiling heat flux (W/m^2, Btu/(ft^2 hr)).
mmflxr	ncells	limited	Radial mass flow rate (kg/s, lb_m/hr).
mmflyt	ncells	limited	Theta mass flow rate (kg/s, lb_m/hr).
mmflz	ncells	limited	Z-direction mass flow rate (kg/s, lb_m/hr).
pan	ncells	limited	Cell noncondensable-gas partial pressures (Pa, psia).
pcore	1	limited	Reactor-core volume-averaged pressure (Pa, psia).
pdc	1	limited	Downcomer volume-averaged total pressure (Pa, psia).
phiL	ncells	full	Distance to phase separation interface (m, ft). [for 3D level tracking]

XTV Graphics

Table 3-24. VESSEL Component Graphics (Continued)

Variable	Dimension	Level	Description
plp	1	limited	Lower-plenum volume-averaged total pressure (Pa, psia).
pn	ncells	limited	Cell total pressures (Pa, psia).
pup	1	limited	Upper-plenum volume-averaged total pressure (Pa, psia).
qhstot	1	limited	Total HTSTR-component heat transfer (W, Btu/hr) to the fluid of the VESSEL component.
qsl	ncells	full	HTSTR-component heat transfer (W, Btu/hr) to the fluid in each VESSEL cell.
roan	ncells	limited	Cell noncondensable-gas densities (kg/m^3, lb$_m$/ft^3).
roln	ncells	limited	Cell liquid densities (kg/m^3, lb$_m$/ft^3).
rom	ncells	limited	Cell mixture densities (kg/m^3, lb$_m$/ft^3).
rovn	ncells	limited	Cell gas densities (kg/m^3, lb$_m$/ft^3).
sn	ncells	limited	Cell plated-solute mass/fluid volume (kg/m^3, lb$_m$/ft^3).
tcilmf	1	limited	Time-integrated reactor-core inlet liquid mass flow (kg, lb$_m$).
tcivmf	1	limited	Time integrated reactor-core inlet gas mass flow (kg, lb$_m$).
tcolmf	1	limited	Time integrated reactor-core outlet liquid mass flow (kg, lb$_m$).
tcore	1	limited	Reactor-core mass-averaged liquid temperature (K, °F).
tcovmf	1	limited	Time integrated reactor-core outlet gas mass flow (kg, lb$_m$).
tdc	1	limited	Downcomer mass-averaged liquid temperature (K, °F).
tln	ncells	limited	Cell liquid temperatures (K, °F).
tlp	1	limited	Lower-plenum mass-averaged liquid temperature (K, °F).
tscore	1	limited	Reactor-core average saturation temperature (K, °F) based on the reactor-core volume-averaged total pressure.

Table 3-24. VESSEL Component Graphics (Continued)

Variable	Dimension	Level	Description
tsdc	1	limited	Downcomer average saturation temperature (K, °F) based on the downcomer volume-averaged total pressure.
tslp	1	limited	Lower-plenum average saturation temperature (K, °F) based on the lower-plenum volume-averaged total pressure.
tsn	ncells	limited	Saturation temperatures (K, °F).
tsup	1	limited	Upper-plenum average saturation temperature (K, °F) based on the upper-plenum volume-averaged total pressure.
tup	1	limited	Upper-plenum mass-averaged liquid temperature (K, °F).
tvn	ncells	limited	Cell gas temperatures (K, °F).
tw	ncells		Effective wall temperature (K, °F).
vcore	1	limited	Reactor-core liquid mass (kg, lb_m).
vdclq	1	limited	Downcomer liquid mass (kg, lb_m).
vLev	ncells		Level velocity (m/s, ft/s). [for 3D level tracking]
vlnxr	xrfaces	limited	Liquid radial or x-direction velocities (m/s, ft/s).
vlnyt	ytfaces	limited	Liquid azimuthal or y-direction velocities (m/s, ft/s).
vlnz	zfaces	limited	Liquid axial velocities (m/s, ft/s).
vlpliq	1	limited	Lower-plenum liquid volume fraction.
vlplm	1	limited	Lower-plenum liquid mass (kg, lb_m).
vlplq	1	limited	Liquid mass below downcomer (kg, lb_m).
vlqmss	1	limited	VESSEL-component liquid mass (kg, lb_m).
vmfrl	ncells	limited	Liquid mass flows (kg/s, lb_m/hr) [NAMELIST variable IMFR = 1].
vmfrlxr	ncells	limited	Liquid mass flows in the radial or x-direction (kg/s, lb_m/hr).
vmfrlyt	ncells	limited	Liquid mass flows in the theta or y-direction (kg/s, lb_m/hr).
vmfrlz	zfaces	limited	Liquid mass flows in the axial or z-direction (kg/s, lb_m/hr) [NAMELIST variable IMFR = 3].
vmfrv	ncells	limited	Gas mass flows (kg/s, lb_m/hr) [NAMELIST variable IMFR = 1].

XTV Graphics

Table 3-24. VESSEL Component Graphics (Continued)

Variable	Dimension	Level	Description
vmfrvxr	ncells	limited	Gas mass flows in the radial or x-direction (kg/s, lb_m/hr).
vmfrvyt	ncells	limited	Gas mass flows in the theta or y-direction (kg/s, lb_m/hr).
vmfrvz	zfaces	limited	Gas mass flows in the axial or z-direction (kg/s, lb_m/hr) [NAMELIST variable IMFR = 3].
vol	ncells	limited	Cell fluid volumes (m^3, ft^3).
volM	ncells	full	Volume of sub-region between the interface and the lower bound cell boundary (m^3, ft^3). [for 3D level tracking]
volP	ncells	full	Volume of sub-region between the interface and the upper bound cell boundary (m^3, ft^3). [for 3D level tracking]
vsflow	1	limited	Fluid mass flow (kg/s, lb_m/hr) summed over all VESSEL-component source-connection junctions.
vupliq	1	limited	Upper-plenum liquid volume fraction.
vuplm	1	limited	Upper-plenum liquid mass (kg, lb_m).
vvnxr	xrfaces	limited	Gas radial or x-direction velocities (m/s, ft/s).
vvnyt	ytfaces	limited	Gas azimuthal or y-direction velocities (m/s, ft/s).
vvnz	zfaces	limited	Gas axial velocities (m/s, ft/s).
xg<name>	ncells	limited	Mass fraction for gas trace species "name" (-).
xl<name>	ncells	limited	Mass fraction for liquid trace species "name" (-).

Heat Structure, Power and Radiation Component Graphics

The following subsections describe the XTV graphics variables for the Heat Structure (HTSTR), Power (POWER and FLPOWER), and radiation (RADENC) components.

HTSTR Component Graphics

The XTV graphics variables that are output for all HTSTR (heat structure) components are listed below in two tables. **Table 3-25** lists all variables associated with "HTSTR" component names, and **Table 3-26** lists all variables associated with "HTSTRC" component names. It is important to note that due to the existence of the fine mesh renodalization logic which can add and remove node rows each timestep, there is no guarantee for some graphics variables (any dimensioned as nzmax) that the axial elevations will remain constant. Unfortunately, this can make creating axial plots somewhat difficult. Axial plots of the temperature distribution along the inner and outer surfaces (the most commonly needed capability) can be obtained using the the tsurfi and tsurfo variables. Each node row corresponds to fixed elevations in the heat structure.

In cases where a 1D component is set to calculate wall heat transfer (i.e. NODES > 0), the code will internally spawn heat structures to represent the wall. These heat structures will manifest themselves with separate channel id's that conform to the following convention:

- htstr-cccccsss & htstrc-cccccsss - "ccccc" denotes the ID number of the parent 1D component for which the heat structure is spawned (leading 0's are stripped off). "sss" denotes the spawned heat structure number.

Another thing to remember is that, for a given heat structure, if the variable NHOT is greater than 0, the code will internally spawn NHOT separate heat structures to represent the supplemental heat structures. This will lead to more than one set of HTSTR & HTSTRC channels per HTSTR component. The naming scheme in this situation conforms to the following convention:

- htstr-ccccc & htstrc-ccccc - corresponds to the average heat structure. ccccc is the component number (leading 0's are stripped off)
- htstr-cccccsss & htstrc-cccccsss - corresponds to the supplemental heat structures. "ccccc" is the component number (leading 0's are stripped off). "sss" denotes the supplemental heat structure number.

For example, let's say you have a HTSTR component with an ID = 130 and NHOT = 2. When browsing the channel ID's in ACGrace (see **Figure 3-1**), you will see 3 sets of channel id's for HTSTR 130. The channel id's that correspond to this component will be

- htstr-130 - corresponds to information for the average heat structure
- htstr-130001 - corresponds to information for the first supplemental rod
- htstr-130002 - corresponds to information for the second supplemental rod
- htstrc-130 - corresponds to information for the average heat structure
- htstrc-130001 - corresponds to information for the first supplemental heat structure
- htstrc-130002 - corresponds to information for the second supplemental heat structure

Table 3-25. HTSTR Component Graphics

Variable	Dimension	Level	Description
powli	nzhtstr	full	Inner-surface heat transfer to the liquid (W, Btu/hr).

XTV Graphics

Table 3-25. HTSTR Component Graphics (Continued)

Variable	Dimension	Level	Description
powlo	nzhtstr	full	Outer-surface heat transfer to the liquid (W, Btu/hr).
powvi	nzhtstr	full	Inner-surface heat transfer to the gas (W, Btu/hr).
powvo	nzhtstr	full	Outer-surface heat transfer to the gas (W, Btu/hr).
qppi	nzhtstr	limited	Inner-surface wall heat flux (W/m^2, $Btu/(ft^2$ hr)).
qppo	nzhtstr	limited	Outer-surface wall heat flux (W/m^2, $Btu/(ft^2$ hr)).
qradi	nzhtstr	full	Inner-surface radiation flux (W/m^2, $Btu/(ft^2$ hr)).
qrado	nzhtstr	full	Outer-surface radiation flux (W/m^2, $Btu/(ft^2$ hr)).
rdzN	nzhtstr	full	Node row heights for coarse mesh nodes (m, ft). Coarse mesh nodes are those that were input by the user (as opposed to those added by the fine mesh rezoning model)
rdznPerm	nzPermFM	limited	Node row heights that correspond to the permanent fine mesh heat structure nodes (m,ft)
tpowi	1	limited	Total power across the inner surface of the heat-structure component. (W, Btu/hr).
tpowo	1	limited	Total power across the outer surface of the heat-structure component. (W, Btu/hr).
tramax	1	limited	Maximum temperature (K, °F) of the average powered heat structures
trhmax	1	limited	Maximum temperature (K, °F) of the supplemental heat structures
tsurfi	nzPermFM	limited	Inner surface temperature of all coarse and permanent fine mesh nodes (when the fine mesh option is selected). This becomes the centerline temperature in a rod. The uppermost and lowermost values correspond to the top and bottom edge of the heat structure
tsurfo	nzPermFM	limited	Outer surface temperature of all coarse and permanent fine mesh nodes (when the fine mesh option is selected). The uppermost and lowermost values correspond to the top and bottom edge of the heat structure
bottomQF	1	limited	Lower quench front location (m, ft)

Table 3-25. HTSTR Component Graphics (Continued)

Variable	Dimension	Level	Description
topQF	1	limited	Upper quench front location (m, ft)

$$nzPermFM = \sum_{i=1}^{nzhtstr} NFAX_i + 2$$

where $NFAX_i = NFAX_i + 1$ if $NFAX_i$ is an even-valued integer.

Table 3-26. HTSTRC Component Graphics

Variable	Dimension	Level	Description
cepwni	1	full	Inner-surface heat-transfer difference (W, Btu/hr).
cepwno	1	full	Outer-surface heat-transfer difference (W, Btu/hr).
hrfli	nzmax	full	Liquid heat-transfer coefficient (W/(m^2 K), Btu/(ft^2 °F hr)) for the inner surface of the heat structure.
hrflo	nzmax	full	Liquid heat-transfer coefficient (W/(m^2 K), Btu/(ft^2 °F hr)) for the outer surface of the heat structure.
hrfvi	nzmax	full	Gas heat-transfer coefficient (W/(m^2 K), Btu/(ft^2 °F hr)) for the inner surface of the heat structure.
hrfvo	nzmax	full	Gas heat-transfer coefficient (W/(m^2 K), Btu/(ft^2 °F hr)) for the outer surface of the heat structure.
ihtfi	nzmax	full	Heat-transfer regime numbers for the inner surface of the heat structure.
ihtfo	nzmax	full	Heat-transfer regime numbers for the outer surface of the heat structure.
rftn	nodes* nzmax	full	heat structure fine mesh node temperatures (K, °F). If the fine mesh option is engaged, then axial elevations of all node rows is not guaranteed to be a constant.
tcefni	1	limited	Inner-surface total heat transfer to the fluid (J, Btu).
tcefno	1	limited	Outer-surface total heat transfer to the fluid (J, Btu).
twani	1	full	Inner-surface absolute error in the heat transfer to the fluid (J, Btu).

Table 3-26. HTSTRC Component Graphics (Continued)

Variable	Dimension	Level	Description
twano	1	full	Outer-surface absolute error in the heat transfer to the fluid (J, Btu).
tweni	1	full	Inner-surface effective error in the heat transfer to the fluid (J, Btu).
tweno	1	full	Outer-surface effective error in the heat transfer to the fluid (J, Btu).
zht	nzmax	full	Axial positions (m, ft) of the rows of nodes in the heat structure. Due to the possibility of the moving fine mesh renodalization logic being engaged, the values in this channel may change from timestep to timestep.

POWER Component Graphics

Table 3-27 lists the XTV graphics variables that are output for all POWER components.

Table 3-27. POWER Component Graphics

Variable	Dimension	Level	Description
aldelk	1	limited	Gas volume-fraction delta K_{eff} (–)
alreac	1	limited	Gas volume-fraction reactivity (–).
dbdelk	1	limited	Solute based delta K_{eff} (–)
dbreac	1	limited	Dissolved- and plated-solute reactivity (–).
mcprc	1	limited	Minimum critical power ratio (–).
powModerChan	1	limited	Direct heating power to the CHAN coolant (W, Btu/hr).
powModerTot	1	limited	Total direct heating power to the moderator (W, Btu/hr).
powModerVess	1	limited	Direct heating power to the VESSEL bypass (W, Btu/hr).
powWaterRod	1	limited	Direct heating power to the ABWR water rods (W, Btu/hr).
pgdelk	1	limited	Programmed delta Keff (–)
pgreac	1	limited	Programmed reactivity (–).
rmckn	1	limited	Reactor multiplication constant Keff (–).
rpower	1	limited	Reactor power (W, Btu/hr).

Table 3-27. POWER Component Graphics (Continued)

Variable	Dimension	Level	Description
tcdelk	1	limited	Coolant-temperature delta Keff (–)
tcreac	1	limited	Coolant-temperature reactivity (–).
tfdelk	1	limited	Fuel temperature delta Keff (–).
tfreac	1	limited	Fuel-temperature reactivity (–).
tramax	1	limited	Maximum temperature (K, °F) of the average power ROD or SLAB elements.
trhmax	1	limited	Maximum temperature (K, °F) of the supplemental ROD or SLAB elements.

FLPOWER Component Graphics

Table 3-28 lists the XTV graphics variables that are output for all FLPOWER (fluid power) components.

Table 3-28. FLPOWER Component Graphics

Variable	Dimension	Level	Description
powb	1	limited	Beam fluid power (W, Btu/hr).
powd	1	limited	Decay fluid power (W, Btu/hr).

RADENC Component Graphics

Table 3-29 lists the XTV graphics variables that are output for all RADENC (radiation enclosure) components.

Table 3-29. RADENC Component Graphics

Variable	Dimension	Level	Description
qrad	nzLevel*nHSS	limited	Radiation heat transfer enclosure heat flux (W/m^2, Btu/(ft^2 hr)).

4

Troubleshooting Input Models

The purpose of this section is to introduce you to various features and techniques for debugging an input model. In other words, this chapter describes what to do if TRACE aborts the calculation through some sort of execution error.

As discussed in **Chapter 1,** *General Concepts*, there are three main phases in a TRACE calculation that a user must be aware of - input processing, initialization, and the simulation itself. This is an important detail because the errors produced in each phase each require a different troubleshooting approach.

Error messages are generally reported in three places: the terminal (or if you are running TRACE from SNAP, the SNAP console window), the message file, and the output file. There are some exceptions to this rule, especially in terms of reporting programming errors. The user should know that, at this point, TRACE's error reporting is still crude in the sense that many of the error messages generated can be quite cryptic, or even non-existent. The TRACE development does have plans to work on this aspect of the code.

Dealing with Input Processing Errors

In general, input model development with TRACE is an iterative process. You may need to run the code several times with your input model (correcting errors as you go) before TRACE is able to successfully read your entire input model. This is especially true if you are creating an input model from scratch or are making large-scale changes to an existing model. TRACE checks the input data as it is being read in and tries to catch as many errors as possible in each pass, reporting them to you all at once.

There are both benefits and drawbacks to this approach. On the one hand, by reporting as many errors as it can all at once, TRACE allows the user to identify and fix multiple errors at once, eliminating unnecessary iteration with respect to running the code. Historically, this was extremely important because computational time was expensive and the turnaround time for a single calculation (even those that might fail during input processing) was on the order of days. Imagine the cost and length of time involved in creating an input model if the code were only to report one error at a time!

The drawback is that some of the messages that get reported can be very misleading, especially if you happen to be a novice user. What can happen is that the first error identified in an input model may actually cause the code to diagnose data that is further down as being erroneous, when, in fact, it is not. It is simply inconsistent with respect to the data that is first reported as being erroneous. Well, in many cases, the first error message that you usually see is actually the very last error reported. This inevitably leads to a great deal of confusion and wasted time as you try to understand and fix a problem that does not really exist.

For this reason, we recommend, especially for beginners, that you focus only on the first error message that TRACE produces and forget about all the rest. Once you have fixed that error, rerun the code and see what new errors are produced. As you gain more experience, you will inevitably learn which errors are the result of prior erroroneous input and which errors are real flaws, allowing you to iterate to an an error free model more quickly. Locating the first error message from a run involves searching forward from the start of the output or message file for one of the two following strings: ’warning’ or ’fatal’.

Insofar as the internals of TRACE are concerned, input processing is a two-stage process. First, the input file passes through a "pre-input" step, at which point a new version of the input deck called the input echo file (see **Chapter 2** for a complete description) is created. The data checking functions performed during this phase are designed to catch errors like typos (like an "o" instead of zero, or "l" instead of one), the presence of invalid characters (like tabs), missing characters, numbers that are too long, and other general formatting issues — in other words, errors that involve the mechanics of specifying text or numbers, not those having to do with the correctness of the value itself or whether its presence is consistent given the values on other cards in the file. If you see error messages that begin with the string " *PreInp* ", then you know that TRACE is currently in this phase of input processing. A real easy way to figure out what is going wrong is to open up the input echo file. It will normally point you directly to the character that is causing TRACE to have problems reading your model. Just search forward from the top of the file for the string “*ERROR” (starting in column 75) to identify the offending line. Currently, the writing of warning messages stops after 50 cards have been detected to be in error, although input processing does continue.

Once the model has passed the pre-input stage, the code moves on to the second stage of input processing. At this point, the newly created input echo file is opened up and all the data values are actually read in and loaded into memory. Throughout this process, the input deck is checked to make sure all the required cards and variables are present and that their values are correctly specified (at least, insofar as TRACE is able to determine "correctness"). When handling these types of errors, TRACE will generally identify the line number where the error occurs. The exception to this is when an error is discovered on an array data card (i.e. those lines that use the LOAD format (see **Chapter 5** for an explanation of what this means). In that case, TRACE identifies the card number of the array data being processed rather than the actual line number. Determining the array and its component requires searching the output file for the word "warning". If the output file shows the code stopped while processing data input in 'LOAD' format, look for errors on the input line below the last 'good' line printed before the stop occurred. An example list of common input errors with their corresponding TRACE message and an explanation is presented in **Appendix B**.

One error to watch out for when specifying NAMELIST data is the presence of a NAMELIST option that TRACE does not understand. If you specify a NAMELIST variable that TRACE is not able (or no longer able) to read, the code will ignore all other NAMELIST variables that come after it. In some cases, the code might run just fine even without the NAMELIST options you think you specified, making you think everything is well, when, in fact, it is not. In other cases, the fact that some NAMELIST options are missing will cause the code to fail outright. These failures will be very difficult to fix because it will seem as though all the needed data has been provided correctly, but, in fact, as far as TRACE is concerned, it hasn't. This can be a source of severe frustration for users.

In situations where there are no errors detected but input-processing difficulties are suspected, it is suggested that the user inspect the input echo file where faulty records may be apparent. Another highly recommended technique if you have an error that you just cannot seem to locate or fix, is to try importing the input file into SNAP. In general, SNAP has its own input diagnostics that are, in many cases, superior to TRACE's own diagnostics.

Dealing with Initialization Errors

Errors produced during the initialization phase of a code run are usually the result of fundamental inconsistencies in the boundary conditions. If an initialization error occurs, you can generally assume that the formatting of the input file is correct and the data is complete (because it got through input processing), but some data is not consistent with other data elsewhere in the model.

If a data inconsistency is found, TRACE will write out a message identifying the inconsistency. For example, providing different flow areas (outside a very small tolerance) at the same interface junction between two hydraulic components will lead to an error message of the type just described. An example list of common initialization errors with their corresponding TRACE message and an explanation is presented in **Appendix B**. Before one of these abbreviated messages is written out, TRACE generally outputs more detailed information with values of the variables that were tested and found at fault. Generally, this information along with the explanation of the abbreviated-description message is very useful in determining the cause of the error. For example the error message:

chbd Junction boundary error detected

tells the user there is a problem with junction input boundary conditions and the error was detected in subroutine **chbd**[1].

Dealing with Simulation Run-time Errors

Run-time errors are those that occur after the input deck has been read in and the calculation has been initialized. They are among the hardest and most difficult to track down because they may require a full understanding of the phenomenology inherent to the transient being simulated as well as a good working knowledge of understanding in such areas as reactor thermal-hydraulics, fluid dynamics, two-phase flow and heat transfer, and/or reactor kinetics.

Run-time errors generally manifest themselves as numerical solution difficulties. Errors in this class may include iteration convergence failures, repeated reductions in the timestep until it cannot be reduced anymore, waterpacking failures, choked flow errors, etc. They may not actually cause the calculation to abort, but instead will cause the calculation to grind down to a very small timestep, taking a very large amount of CPU time to complete and generating large message and output files as numerous error messages are repeatedly written each timestep. In extreme instances, the code will abort.

In many instances, the occurance of numerical solution difficulties is an indication that you have provided initial or boundary conditions that are not physical or are chainging too rapidly or that your geometric model is incorrect. As such, an appropriate change in the model may eliminate the numerical difficulty in a repeat calculation. For example, closing a valve in 0.2 s, rather than a more realistic 2.0 s, can cause numerical solution difficulties while a slower closing rate does not.

In some cases, the messages may indicate problems with the code itself, especially if the model is attempting to predict behavior outside the code's assessed range of applicability. When that happens, the best you can do is 1) report the problem to the code development team, 2) determine exactly what phenomenology is most important to simulate accurately, 3) decide whether the code is able to adequately reproduce that phenomena even in the face of other predictive weaknesses, and 4) if it is, live with the results.

The sections below will attempt to discuss various specific techniques you can use in an effort to understand what is going wrong with your model.

Check your model

We begin by emphasizing the first step - check your model! You need ensure that the values TRACE uses are the values you intended. There is a straightforward way to accomplish this. You can provide TRACE with a calculation end time of TEND = 0.0 s temporarily (see the timestep

1. The TRACE development team recognizes that the practice of providing the subroutine name in error messages that are meant to be read and understood by the code user is not really all that helpful, and can, in fact, impede your understanding of what is going wrong. We hope to eliminate this practice from the code in the future and improve the overall level of understandability of all error messages produced by the code. The only time we feel this practice is OK is when programming errors are produced because those are really only meant to be understood by actual programmers.

data description). TRACE will read and process your input model and provide an output echo of the input data to the output file before ending the calculation. Carefully checking the echoed output against your input data will eliminate the possibility that TRACE is reading different values from what you intended, ultimately reducing the time and effort required to obtain a successful calculation. Making the comparison with values from your working notes as well as the input file also will catch errors in going from your working notes to the typed input data in your input file.

Reviewing Error Messages

If you have checked the veracity of your data, and all seems to be OK and error messages are still being generated, you will need to read them and try to understand their cause. Even if they don't abort the calculation, they may indicate the need for a modeling change or for more restrictive timestep data. If they do cause the calculation to abort, you will have no choice but to resolve the error causing the abort. We are aware that the error messages are brief, but TRACE usually outputs more information to the message file in the form of actual values of various parameters that will be useful in diagnosing the error.

Generally speaking, TRACE will report, not only, the type of error, but also the location. The type of message and the output values of the affected parameters define the condition. The location of the difficulty may tell you something about the model at that location that causes the numerical solution to have such difficulty. These messages are written to both the message file and the terminal.

Reviewing the Message File

We cannot overemphasize the importance of carefully reviewing the message file. This file contains a summary of the behavior of the numerical solution and diagnostic information generated when TRACE encounters calculation difficulties. In some cases, a review of the message file will provide all the information needed to identify the difficulty. In other cases, you may need to review the thermal-hydraulic solution details in the output file and use your understanding of the calculated physical phenomena to provide the information you'll need for the debugging process.

The primary function of the message file is to provide condensed output on the behavior of the numerical calculation and to provide warning messages produced by various computational modules within TRACE. This documents the progress of the calculation and any numerical difficulties that were encountered. If TRACE terminates because of some numerical difficulty, the message file will have output information that describes that difficulty. Although the message file only contains numerical-status information and warning messages, it can grow to be very large if TRACE happens to encounter numerical-solution difficulty over an extended period of time. Usually the first few hundred lines of warning messages provide useful information as to the cause of any numerical difficulty. Solution results are always in SI units.

Understanding a calculation and diagnosing its warning error messages requires both a micro and macro examination process. In other words, you need to be cognizant not only of the local phenomena happening near the region where the message file is reporting problems, but you must also be aware of the specific features of your plant or facility model and the phenomena that TRACE is calculating in a much more broad sense. Even knowing all this, the information in the message file can be difficult to interpret. The diagnostic messages that appear in the message file were originally developed to provide guidance to advanced TRACE users. Although some effort has been expended to make the diagnostic messages more easily understood by the beginning or intermediate user, the development team recognizes that the learning curve is still high in this area. Future improvements to TRACE will involve providing more and better information about numerical difficulties and in plainer english.

If you are to understand the diagnostic messages appearing in the message file, you must be aware of the concept of "phantom cells" in TEE-based components (i.e. those that have a main-tube and a side-tube). TRACE evaluates and stores information at both the cell-center and the cell-edge. For simple 1D components like a PIPE, if you count the number of cells and edges, there will always be one more edge than cell (excluding any side junctions - they don't count for this analysis). For TEE-based components2, however, if you count the number of cells and edges, you quickly realize that there are actually two more edges than cells. Well, during the original development of TRAC-P many years ago, this seeming inconsistency posed a problem for the code development team in terms of how they stored data in the computer's memory that could be generally applicable to all component types in the code. They introduced the concept of a "ghost cell" or "phantom cell" into the way information for TEE-based components is stored inside the computer. By artificially adding a some extra memory storage for a phantom cell, they were able to make the computer memory layout for TEE-based components look exactly like the memory layout for components with only one mesh segment. This phantom cell is sandwiched between the last cell of the main-tube and the first cell of the side-tube.

The net effect of all this is that diagnostic messages that refer to a specific cell or interface in a TEE-based component do not take the phantom cell into account. It is left up to the user to do the translation. For example, consider a TEE with five cells in the main tube and four cells in the side tube. A diagnostic error message referring to cell 7 of a cell-centered variable such as pressure is referring to the first cell in the side-tube (cell 7 – 5 main-tube cells – 1 phantom cell = side-tube cell 1). A diagnostic error message referring to cell-edge 7 of some variable (like velocity) is referring to the edge that joins the side-tube to the main-tube (cell-edge 7 – 6 main-tube cell edges = side-tube cell-edge 1).

Right about now, you are probably thinking "What do I care about how the computer stores data in memory? I am a user, not a developer. I shouldn't have to worry about such things." Yes, you are correct. The original developers were simply not considering the effect this might have on new users 30 years into the future. The current development team has simply not yet had the chance to remove this artifact of the past.

Reviewing the Output file

The primary purpose of the output file is to provide a detailed record of the calculation results. Using the timestep data cards (see **Chapter 6,** *Timestep Data*), the user is able to control the frequencies with which short and large edits are generated, respectively.

A short edit is a half-page display. The initial line outputs the current problem time, timestep size, and timestep number and the number of iterations required to converge the last outer iteration. This is followed by the maximum convective power difference, the mesh location (component and cell/edge #) limiting the current timestep size, the minimum, average, and maximum number of outer iterations since the last short edit, the number of timesteps that each component was the last to converge its outer-iteration solution, and the current-calculation and accumulated-calculation's CPU execution times. This information conveys how well the numerical solution is doing and where in the model the solution convergence is most limited and the timestep size controlled.

Each large edit provides a "snapshot" of the modeled system's thermal-hydraulic solution at a given point in time. For even modestly sized systems with less than a dozen large edits, the output file can be large. You are cautioned to be judicious in your selection of the large-edit time-interval frequency. The large-edit output is useful because each snapshot can be analyzed for the detailed spatial behavior of the solution and for diagnostic purposes. However, we have found that transient phenomena are best captured and understood by plotting the solution data vs. problem time obtained from the graphics file.

The solution results written to the output file can be in either SI or English units depending upon the value specified for the NAMELIST variable IOOUT (**Main-Data Card 4**).

Diagnostic Checklist Assistance

Diagnostic information can be generated by setting selected NAMELIST (refer to **Main-Data Card 4**) variable parameters in the input data. The parameters are listed below with a brief description of their reset values.

IDIAG = 2, 3, or 4 requests that detailed diagnostic output be pr2ovided (2 gives flow reversal diagnostics; 3 gives flow reversal and steam and gas volume fraction temporal change diagnostics; 4 gives flow reversal, steam volume fraction temporal change, and out-of-bounds steam and gas volume fraction reiteration diagnostics). If the error messages relate to two-phase conditions, use options 3 or 4; otherwise, use option 2.

NSPL = beginning timestep number at which a large edit is written to the output file every timestep.

NSPU = ending timestep number at which a large edit is written to the output file every timestep.

NSDL = beginning timestep number at which short edit and pressure change to total pressure and the difference between basic and stabilizer macroscopic densities diagnostics are written to the output file and steam and gas volume fraction temporal change diagnostic (when IDIAG = 3 or 4) are output to the message file each timestep.

NSDU = ending timestep number at which short edit and pressure change to total pressure and the difference between basic and stabilizer macroscopic densities diagnostic are written to the output file and steam and gas volume fraction temporal change diagnostic (when IDIAG = 3 or 4) are output to the message file each timestep.

NSEND = timestep number at which the TRACE calculation ends.

Note that the timestep numbers referred to above correspond to the timestep numbers in the error messages written to the message file. The timestep number is incremented at the completion of each timestep calculation just before the newly calculated solution state is written to the output file. You are urged to use the additional IDIAG > 2 diagnostic printouts only as a last resort. You are given control over the beginning and ending timesteps because the output generated can be extremely large. You determine the timesteps to specify by reviewing the message file from the previous run to determine the timestep number at which the difficulty first occurred. Usually only a few timesteps of diagnostic information is useful for debugging.

Timestep Control

The TRACE development team has attempted to provide a sophisticated internally-evaluated timestep-size control algorithm. However, it is likely that TRACE will experience numerical-solution difficulties when the minimum or maximum timestep size specified by the user is too large, a rapid-transient event occurs at such a timestep size, the numerical solution fails to converge, and TRACE fails to recover by reducing the timestep size before the maximum user-specified iteration-limit number is reached. This difficulty usually is experienced during transient calculations when a rapid transient event (component action, phenomena, etc.) is initiated, but it can also occur at the start of a steady-state calculation when the timestep size is too large for a poor initial solution estimate. If you specify a large minimum or maximum timestep size and the code aborts on a maximum-number-of-iterations failure, make the minimum timestep size (DTMIN) or maximum timestep size (DTMAX) smaller (by a factor of 0.1 to 0.01) and repeat the calculation (using a recent data-dump restart if a significant calculative effort has already been spent). In general, on any initial run, you should always plot the timestep size (DELT graphics variable) vs. time. In regions where the time step size is jumping up and down, pick a time step size that represents the mean step size (a line up the middle of the fluctuations), and use that as the maximum time step size.

You should also watch out to make sure that the maximum timestep for one set of timestep cards is not smaller than the minimum timestep for a subsequent set of cards. Otherwise, the code will have no way to reduce the timestep any further as it transitions from using the first set of timestep cards to using the second, resulting in an immediate code failure.

To provide for continued improvement of TRACE, all developers and users need to report poor performance in the code beyond failures to match test data. You should watch for and report any of the following:

- Time steps below 1.0e-5 seconds
- Prolonged use of time steps below 1.0e-4 seconds
- Excessive failure messages in the message file
- Unexpectedly long execution times
- Any halt in code execution due to an error condition

When reporting the problem, please provide the following:

- The message file and the last time step edit in trcout before the problem
- All input files used to get to the point of the performance degradation or failure
- A restart dump two time steps before the difficulty with an input that picks up that dump and reproduces the problem.

If you cannot reproduce the execution problem from a restart, report that also because the code should provide exact restarts. If it isn't, the development team needs to know about it.

Dealing with Programming Errors

Programming errors are errors that occur because the programmer made a mistake. While the development team tries to write bug-free code, if you use TRACE long enough, you will inevitably encounter errors of this nature. The fact that you experience an error of this type means there is an outright bug in the code and as such, it needs to be reported as soon as possible. We never expect that you should have to fix an error like this on your own. In the final analysis, it may happen that an error of this type is, in fact, triggered by an error in the input model, but even under those circumstances, the code should generate an input processing error, not a programming error. Either way, the code needs to be fixed.

A programming error may manifest itself in one of two ways - either as a code abort generated directly by TRACE, or as a code abort generated by the compiler or operating system. Either way, the messages that get generated are only sent to the screen - not to the message or output files.

Errors that fall into the first category are produced in situations where the TRACE programmer took specific steps to guard against unknown situations or prevent invalid operations from taking place. An example might be an error message that gets generated to protect the code from dividing by zero or looping past the end of some array. They generally look like this:

```
** <subroutine_name> Programming Error ** - some string of text
```

where <subroutine_name> refers to the Fortran subroutine where the error was generated. This detail can be disregarded by the user. The important thing to note is that when errors of this nature occur, they should be immediately reported to the TRACE code development team since they are indicative of something happening that the programmers did not expect.

Errors that fall into the second category generally include segmentation faults, array bounds errors, access violations, math errors, uninitialized variables, floating point overflow and/or underflow, core dumps and bus errors. They usually occur because some computer memory becomes corrupted as a result of sloppy programming or an invalid mathematical operation takes place (like division by zero or infinity). The specific error messages written in these situations are very much dependent on the specific Fortran compiler and platform used to build TRACE. In many cases, specific compiler options need to be built into the TRACE executable in order for meaningful messages to be produced when one of these types of errors occurs.

Using Interactive Debugging Tools

For completeness, it is worth discussing the use of interactive debuggers as a tool for debugging input models. Given that debuggers are normally software programs used by programmers, we need to stress that we do not expect that users should have to go to such lengths to debug an input model. However, we do want to make the user aware that such tools do exist and can actually be very useful in tracking down problems for which there seems to be no logical explanation.

Two such tools are the Compaq Visual Fortran (CVF) debugger for Windows, and DBX, a source level symbolic debugging tool under UNIX, that can be used either during TRACE execution or after a TRACE error abort. When using any debugger to execute TRACE, you may stop TRACE at any location during its execution, examine the contents of computer memory and the values of parameters, and change the coding or parameter values. UNIX debuggers like DBX are specific to the computer being used.

5

Input File Format

This chapter describes the various formats and the methodologies used for specifying data values in your input file. In terms of nomenclature, you will see references throughout this chapter — and indeed, this entire manual — to the term "card". It is normally meant to refer to a group of input parameters that comprise one or more lines of actual data in your input deck. From a historical perspective, the term is derived from the usage of punch cards as a means of creating and storing an input model, before the advent of modern computer terminals and disk-based storage.

Generally speaking, input data can be specified either in a fixed-format way or a free-format way. The term fixed-format implies that numerical values must lie in specific columns. Free-format input, on the other hand, does not have these restrictions. You have much more flexibility in terms of where, on any given line, a data value can be placed. In addition to the obvious convenience of not having to count columns, free-format input also allows you greater flexibility in using comments to document your input data. TRACE also provides better error-checking capabilities with this scheme of input. The use of free- or fixed-format input is controlled by the first line of the input file (see **Main-Data Card 1** in **Chapter 6**).

The fixed-format method for entering input data is very old and practically speaking, is never used in modern TRACE input files. The only time you might see this style of formatting used would be in old TRAC-P input models dating back to the late 1970's or early 1980's. For this reason, rules and conventions regarding the use of fixed-format input will not be presented here. Users interested in reading more about this method of data entry should consult an old TRAC-P input manual.

There are typically five types of data that you will encounter in a TRACE input file: comment cards, title cards, NAMELIST data, scalar variables, and array variables. Each of these categories has its own specific rules regarding how the data is formatted in an input file.

The term "scalar variable" refers to single-valued parameters that typically are used to control global aspects of a specific component or the entire model. They may be integers, strings, or real-valued numbers. For example, the input which specifies that the number of cells (NCELLS) for a PIPE component is a scalar entry. Scalar variables are normally grouped into card sets with five parameters per card (although this need not always be the case). The presence of specific card sets in an input deck is governed by the rules established in **Chapter 6**.

The rules that govern the formatting of scalar variables are pretty simple. All data values must be delimited by, at least, one blank space and all data values are limited to a maximum width of 14 characters. If the code is expecting to read an integer value, then that value should be an integer. If the code is expecting to read a real number, then that value should be a real-number.

The term "array variable" refers to lists of numbers used to provide boundary conditions, initial conditions, or other state information on a cell-by-cell (or edge-by-edge) basis. It may also refer to such information as table-value pairs, lists of component identifiers, and any other data that must be input as a list of values. Array cards are specified using the LOAD formating convention. The rules that govern this formatting scheme are provided in the section **LOAD Format** later in this chapter. An example of array data would the input which provides the lengths (DX) for the cells in a PIPE.

In general, the following rules are established regarding how an input file is formatted:

- All cards (and variables on those cards) must be kept in the same order as specified in **Chapter 6**.
- Data may start in column 1 except for NAMELIST data, which starts in column 2.
- Lines of input may be up to 80 columns long.
- Input cards are limited to a maximum of five data fields per line.
- A LOAD-formatted data value must be 11 characters or less. A non-LOAD formatted data value must be 14 characters or less.
- All data that are not read in according to the LOAD format must be delimited by at least one blank space. Data in LOAD format may be blank delimited; delimited by any of the LOAD control characters **e**, **f**, **i**, **m**, **r**, **s**; or delimited by the two-digit repeat count.
- Integer 0 or real 0.0 should be entered explicitly. Strictly speaking, this is only true if a data value on some card of interest is to be followed by a non-zero value. If the last value (or several values) on a particular card are all zero, you can technically leave it blank - TRACE will fill it with 0 or 0.0). However, we highly recommended that you always specify a value for each and every variable that is required.
- Tab characters anywhere in an input file are forbidden

Comments

Input files may be annotated with user comments. These comments must be delimited by asterisks (*s) in unbroken strings of any length. The first line of the input file is an exception to this requirement - it cannot be a comment. Comments and their delimiters are equivalent to blank columns in a data field. When an input record has an odd number of comment delimiters (where *, **, ***, ****, etc., are all considered to be a single delimiter), everything on the record to the right of the last delimiter is considered a comment. The code will attempt to read input data after even-numbered comment delimiters and before odd-numbered comment delimiters. Entire records may be comments, for example, by making the first nonblank character an asterisk and not inserting any more comment delimiters on the line. Comments may appear anywhere in the input-data file except:

- before **Main-Data Card 1**,
- after **Main-Data Card 2** and before the problem title cards,
- within the NAMELIST variable defining records (see additional comments on NAMELIST input below).

Title Cards

The problem title cards immediately following **Main-Data Card 2** are written to the input echo file exactly as they are read: asterisks, blank cards, and all. Blank and comment cards may appear between the first two main-data cards and immediately after the problem title cards but not within the problem title cards following **Main-Data Card 2** without their being considered title cards.

Component descriptions of individual components (the CTITLE information) are written to the input echo file, left justified, starting in column 43. Asterisk strings in component descriptions are treated as comment delimiters.

Namelist Format

The NAMELIST capability is an extremely useful feature of Fortran that can be used to load values directly into variables named within the program. TRACE uses this feature as a means of setting global parameters and flags that govern overall behavior of the code during the run. The exact global parameters and flags that are controlled by NAMELIST variable input are described in **Chapter 6**.

At present, all NAMELIST input must adhere to the following rules:

- hollerith constants are not allowed. If you don't know what a hollerith constant is, then you don't need to worry about it.
- the first column of all physical records is ignored (the terminating dollar "`$`" or ampersand "`&`" sign can appear in any column except the first column).
- there must be no embedded blanks in the string `$INOPTS` or `&INOPTS` where INOPTS is the NAMELIST group name, the initial "`$`" or "`&`" must appear in column 2, and there must be at least one trailing blank after `$INOPTS` or `&INOPTS`.
- asterisk-delimited user comments are not allowed to be interspersed among NAMELIST data cards, although blank lines are allowed.

For example, the following five cards might be used to input data for the TRACE NAMELIST group INOPTS (described in **Chapter 6**).

Input File Format

```
         1         2         3         4         5
12345678901234567890123435678901234567890123456789012345 . . .


^$INOPTS^IELV=1,^^IKFAC^=^1,
^^^ISTOPT=2,
^ALP=0.,VL=0.,VV=0.,TL=550.,TV=550.0,
^^P=1.55E+07,PA=0.0,QPPP=0.,TW=5.5E2,HSTN=550.,
^$END
```

LOAD Format

TRACE uses a special user-friendly format called LOAD to read most array variables. The arrays may be read in floating point or integer format with up to five values per line. Array input is aided by the use of symbols: **f**, **i**, **m**, **r**, **s**, and **e**. They are described in **Table 5-1**. The first four symbols aid in repeating input data. **f**, **i**, **m**, and **r** are followed by two digits which specify the repeat count. The **s** symbol is used at the end of the line to indicate "skip" to the next line to finish array input. The **e** symbol must be used to terminate array input. Comments can be added to the line after the **e** or **s** symbol starting with an asterisk followed by text (for example; **s** * comment). In free-format input-data files, cards with an asterisk in column 1 are ignored and may be used for spacers or for comments. On data cards, the "* comment *" method may be used to embed comments among the variables.

Table 5-1. Operation symbol description.

Operation Symbol	Description
	An empty space: i.e.; **r** 2 is the same as **r**2 or **r**02.
e	End of the data array (must be followed by at least one blank column).
f	Fill the array starting at current element index with the data constant.
i	Interpolate between the following data constant and the succeeding data constant with nn intervening values with the same difference[a].
m	Multiple repeat. Repeat the data constant 10 × nn times.
r	Repeat the data constant nn times.
s	Skip to the next card (line).

a. nn denotes the one or two digit integer that follows the operation symbol.

Some restrictions in the use of the LOAD format are:

- the end of data for an array must be signaled by an "**e**",
- over filling or partial filling of an array is not allowed,
- integer interpolation is not allowed,

- the control characters are case-sensitive (i.e. you can't use E),
- data is restricted to five values per card, and
- data for different arrays must be on different card records (i.e. different lines)
- All numeric input data are limited to a maximum of 11 characters (that includes the decimal point and any exponential notation).

The following are examples of the use of the operations listed above to fill an array of dimension 11 with data.

EXAMPLE 1. Fill an integer array with a value of 61.

```
f 61 e
```

EXAMPLE 2. Use of the repeat operation to fill an array eleven long with a value of 1.2345.

```
r11  1.2345 e
```

EXAMPLE 3. Use of the skip operation to fill an array eleven long.

```
r 2  15   16 s

r05  17   18   19   20 e
```

EXAMPLE 4. Use of the multiple repeat operation to fill an array eleven long.

```
m01  1.556e-2 0.0156 e
```

EXAMPLE 5. Use of the interpolation operation to get the values 1.0, 2.0, 3.0, …, 11.0.

```
i 9  1.0   11.0 e
```

6

Input File Specification

This chapter describes how to actually construct an input file for TRACE.

Input Data Organization

The data in an input file is divided into eleven major sections which must appear in the following order:

1) Main Data,
2) Countercurrent Flow Limitation Data,
3) Material Properties Data,
4) Hydraulic-Path, Steady-State Initialization Data,
5) Constrained Steady-State (CSS) Controller Data,
6) Signal Variable Data,
7) Control Block Data,
8) Trip Data,
9) General Table Data
10) Component Data,
11) Timestep Data.

Main Data

The main-data information block contains general parameters that control global aspects of a simulation. This includes such information as title cards (for problem identification and QA purposes) NAMELIST variables, dump-restart flags, transient/steady-state flags, problem-size, problem-convergence criteria, and component identification numbers. This data block must always present in an input file. It is generally considered good practice to provide title cards

(**Main-Data Card 3**) that identify the plant or facility, the data base used to prepare the input-data model, any important limitations or assumptions inherent to the model, and in the case of follow-on analyses, what changes have been made to the input-data and the reason for making them. While the NAMELIST data cards (**Main-Data Card 4**) are considered optional, they generally appear in most input files where a few of the NAMELIST variables are defined with values that differ from their default values (for example, the choked-flow model option variable ICFLOW could be input with the value 2 to change its default value of 1).

Countercurrent Flow Limitation Data

A special model exists in TRACE to allow the user to apply correlations for countercurrent flow limitation (CCFL) at specific locations. The user supplies the correlation constants and the locations where the CCFL model is to be evaluated. The correlation data along with the CCFL option flag array must be present in the input file for calculations where countercurrent flow limitations are applied. The CCFL array, containing the locations where the CCFL calculation is applied in a hydraulic component, is saved in the restart dump file; therefore, those components do not need to be included in the input file for a restart calculation.

Generally, this data block is not input unless the TRACE user expects countercurrent flow (liquid flow down and gas flow up) in a vertical flow channel and has a data correlation that defines that flow relationship. This correlation model constrains the phasic flow relationship accordingly at user-selected mesh-cell interfaces rather than having TRACE evaluate this flow condition directly based on a detailed flow-geometry model. This input-data block is specified when NCCFL > 0 (Word 5 on **Main-Data Card 9**).

Material Property Data

By default, TRACE has its own set of built-in material properties that you may use as you build an input model. These built-in material types are listed in **Table 6-1**. They should be appropriate for most applications. If all you do is rely on these built-in properties, then you do not need to include this data block in your input file. However, if you think that the built-in material properties are inadequate for the modelling task at hand, this data block gives you the option of supplying your own. To do that you must set the NMAT > 0 (Word 4 on **Main-Data Card 2**) and include this data block in your input file. All new material ID numbers must be > 50. If you do decide to include your own material property data, then please be aware that these properties must be included in the input file for all restarts because they are not written to the dump file.

Hydraulic-Path, Steady-State (HPSS) Initialization Data

Hydraulic-path, steady-state initialization data provide the user with a convenient way to input phasic temperature and velocity distribution solution estimates for a steady-state calculation. The known or estimated thermal-hydraulic condition and a major heat source or sink are specified at a location in each 1D flow-channel hydraulic path of the hydraulic-system model. At the beginning of the initialization stage of the calculation, TRACE uses this information to initialize the phasic temperatures and velocities throughout the system model in all hydraulic components for both single- and two-phase conditions. This data block is input for steady-state calculations when the TRACE user desires a better initial solution estimate for the phasic temperatures and velocities throughout the modeled system than are defined by the component data. This better initial solution estimate generally halves the calculative effort to converge to the steady-state solution. This input-data block is specified when STDYST = 3 or 4 (Word 1 on **Main-Data Card 7**).

Constrained Steady-State Controller Data

When STDYST = 2 or 4 (Word 1 on **Main-Data Card 7**), a CSS calculation is performed using NCONTR ≥ 1 (Word 4 on **Main-Data Card 9**) controllers that are specified by CSS controller data. These controllers are internally programmed proportional-integral (PI) controllers that adjust specific adjustable component parameters to achieve desired steady-state values for specific monitored parameters. Transient-calculation control procedures for some of these component actions are specified in the component input data; however, these CSS controllers override those procedures and control their parameter actions during the CSS calculation.

Control System Data

This data specifies modeled-system parameters and logic procedures used to control the simulated operation of the system model. The control procedure is modeled by signal variables NTSV > 0, control blocks NTCB > 0, and/or trips NTRP > 0 (Word 1, Word 2 and Word 4 on **Main-Data Card 10**). Almost all TRACE input-data models use one or more of these control parameters. To simulate a control procedure effectively, you will need to know how to use signal variables, control blocks, and trips. We emphasize that you will need a detailed knowledge of how the plant operates to model its control procedure. You also will need to understand how to translate this operational behavior into a control model defined by signal variables, control blocks, and trips and their associated evaluation procedure.

Signal Variable Data

Signal variables, which access the values of parameters in the modeled system, are needed by most TRACE control procedures. They are the input signals to the control system's control blocks, trips, and component actions. In other words, they provide feedback from the thermal-hydraulic system model to the control procedure. Further information about the definition and usage of signal variables is provided in **Signal Variable Data**.

Control Block Data

Control blocks, which evaluate functions operating on input signals to determine an output signal (for example, the ADD function adds two input signals to define the sum output signal), are used

Input File Specification

in many but not all TRACE calculations. This is a very useful feature because the user can model through input data a network of coupled control blocks that simulate the logic of a control system of any complexity. Because of this capability, TRACE can be used solely to evaluate a network of coupled control blocks that simulate a control system with no interest in a simple hydraulic-component system model that must be input. Further information about the usage of control blocks is provided in **Control Block Data**.

Trip Data

Trips, which are ON/OFF switch controllers for the signal logic of control blocks and for when component actions are evaluated, are used in many but not all TRACE calculations. Trips are generally the most direct way of initiating component, operator, and abnormal actions. The trip's ON/OFF set status is defined based on the value of the trip signal lying within a subrange labeled with a set status. Setpoint values define the boundary limits of those subranges so that when the trip signal crosses a setpoint value, the trip's set status, after a user-specified delay time, changes to the set status of the new subrange where in the trip signal now lies. There are three types of trips based on how their trip signal is defined: by a signal variable or control block, by a trip-signal-expression, or by a trip-controlled-trip. The most common is a trip signal defined by a signal variable or control block. A trip-signal-expression trip signal is a simple arithmetic expression based on one or more signal-variable or control-block input signals (the equivalent of a simple control-block network). A trip-controlled-trip trip signal is the combined set status values of two or more trips (where OFF has a 0.0 value and ON has a –1.0 value for $ON_{reverse}$ and +1.0 value for $ON_{forward}$). The combining operator is addition for a coincidence trip (where the trip is set ON or OFF when the set status of M of N trips are ON) and is multiplication for a blocking trip (where the trip is set ON or OFF when all N trips are ON or any one trip is OFF). Trip setpoints are constant or vary if set-point-factor-table cards are input. Generally, setpoints are constant in value. Trip-initiated restart-dump and problem-termination cards can be used to generate data dumps when any one of a number of trips is set ON and, if desired, can terminate the calculation as well. Trip-initiated timestep data cards let the user apply a set of special timestep data for a problem time interval after one of the controlling trips is set ON. Guidelines and examples of trip-modeling techniques are provided in **Volume 2**.

General Table Data

This data block must be input if the NAMELIST input NUMGENTBL is greater than 0. A general table consists of a number of x-y data points. For each general table a control block/signal variable id is defined that will provide the x independent value that will be used to evaluate the table. Given an x independent value a general table will return a y dependent result that can be used during the TRACE calculation. Available general tables are:

- Power vs Time
- Heat Flux vs Time
- Heat Transfer Coefficient (HTC) vs Time

- HTC vs Surface Temperature
- Temperature vs Time
- Reactivity vs Time
- Normalized Area vs Stem Position
- Signal Variable/Control Block vs Temperature
- Signal Variable/Control block vs HTC
- Signal Variable/Control Block vs Heat Flux.

Component Data

The component-data block is the main body of the input-data file. This block contains a detailed description of every hydraulic and heat-transfer component in the system model unless the calculation is reinitiated from a restart-data dump. For restart calculations, this block contains only additional or modified components. The remainder of the component data are obtained from the restart input file. There is a component-data block in every unless all the component data are to be obtained from the restart file and only an "END" card is specified.

The components are assembled one following another in the component-data section of the input file. You will probably find it convenient to order your input-data blocks for each component in some logical fashion (usually in the order of increasing component numbers so that a component can be found easily). TRACE will arrange the components in another order for computational and output purposes. That order will depend on the order in which thermal-hydraulic loops are processed by TRACE. The component order you choose is for your convenience in finding component data in the input file.

NCOMP (Word 3 on **Main-Data Card 7**) or fewer sets of component-data cards are input. The sets may be input in any order. The component input is concluded with an "END" card. If fewer than NCOMP sets are input, TRACE will make the assumption that it should read the remaining components from the restart dump file. If the run is not actually a restart run, if the dump file cannot be found, or if the missing components cannot be located, then an error will be produced.

The format of each set depends on the component type. All velocities are positive in the direction of ascending cell number. Most of the array data variables should be input using the LOAD format described in **Chapter 5**. All tables that are entered as pairs of numbers (x,y) must be supplied in ascending order of the x independent variable.

Each hydrodynamic component requires a junction number for each of its connecting points. A junction is the connection point between two components. A PIPE requires two junction numbers, one for each end. A unique junction number must be assigned to each connecting point (unless a dead-end has been specified, in which case the junction ID is set to 0) and referenced by both components to be connected. For example, if two PIPEs are joined, then the junction numbers of the connecting end of each pipe must be the same. No component may "wrap around" and connect to itself and no junction may have only one component connected to it, unless the junction number is specified as zero (indicating a dead-end). Boundary-conditions can be applied to any given string of connected mesh segments (that are not in a loop) using the BREAK or FILL components. In the input description, the asterisk (*) indicates units of the defined variable and the hyphen (–) indicates a dimensionless quantity.

Timestep Data

The timestep-data block specifies maximum and minimum timestep sizes, edit frequencies, and the end of the problem for specified time intervals. There is also a parameter to control the timestep size to conserve convection heat-transfer energy between heat structures and hydraulic components. This data block is always present in the **tracin** file.

Main Data

The main-data parameters are listed below in the order in which they are entered. This data block always must be supplied at the start of the **tracin** file.

Main-Data Card 1. (Free format)

Note: The first card of the **tracin** file serves as the FREE-format ON-OFF switch, indicating whether the cards that follow are in FREE format. It must be included and must contain the string FREE if all of the input variables are not placed correctly in fields 14 spaces wide. This card is in free format; up to 80 columns may be used; the control string/s and documentation may appear anywhere on the card.

Description
FREE format

Main-Data Card 2. (Format 5I14) **NUMTCR, IEOS, INOPT, NMAT, ID2O**

Variable	Description
NUMTCR	Number of title cards to be read (NUMTCR ≥ 1).
IEOS	Steam/noncondensable gas option. 0 = gas phase treated as a steam and noncondensable gas mixture throughout the modeled system (the default); 1 = gas phase treated as noncondensable gas throughout the modeled system. Evaporation and condensation are inhibited. This is a legacy option used in older code versions to assist in testing and verifying the code numerics. Its use is no longer encouraged and, in fact, can cause problems in some circumstances.
INOPT	Specification for including or excluding NAMELIST group INOPTS input data after the title cards. 0 = NAMELIST group INOPTS input data omitted after the title cards (the default); 1 = NAMELIST group INOPTS input data inserted after the title cards (see **Main-Data Card 4**). -1 = NAMELIST group INOPTS input data is obtained from the restart file

Main-Data Card 2. (Format 5I14) **NUMTCR, IEOS, INOPT, NMAT, ID2O** (Continued)

Variable	Description
NMAT	Number of new different materials identified by user (not built-in materials in TRACE) for which material properties will be input. The default value is 0. If this parameter is set to -1 during a restart, then the material properties will be read in from the dump file. A value of -1 during a non-restart will produce an error.
ID2O	Heavy water flag. 0 = H_2O (the default); 1 = D_2O.

Main-Data Card 3. (Format 20A4) **ACH**

Variable	Description
Note:	**NUMTCR** (Word 1 on Main-Data **Main-Data Card 2**) Cards are input. A minimum of one card is required.
ACH	Problem title information.

Main-Data Card 4 lists the available NAMELIST variables if the variable INOPT = 1 (Word 3 on **Main-Data Card 2**). In this case, one or more of the NAMELIST variables described below may be specified with their **variable name = value**. The format of these data is not checked during preprocessing of FREE format data. Therefore, its data should be entered carefully to avoid fatal input errors. The data are entered in **columns 2–80** on one or more cards, beginning with **$INOPTS** in **columns 2 to 8**, and are terminated with a "**$END**" or "**$end**" string. The "**$**" may be replaced by an "**&**". A more detailed description of the format for NAMELIST input data is provided in **Chapter 5** and in a FORTRAN manual. The following variables are included in the NAMELIST group INOPTS, and one or more of them are included in the NAMELIST data when INOPT = 1 (Word 2 on **Main-Data Card 2**). Variables omitted from the specified data retain their default value

Main-Data Card 4. **NAMELIST** Data Cards for Group INOPTS (NAMELIST format.).

Variable	Value Range	Description	Default Value
Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).			
ALP	0.0 To 1.0	Default value for gas volume fractions (-) (real format). Used when ISTOPT = 1 or 2.	10^{20}

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
Note: C1RC1 and C2RC1 are not under user control and have hardwired values of 2.0 and 1.0 respectively they are relaxation constants in the equation: $relaxation = e^{C2RC \times \log(C1RC)}$			
C1RC2	> 0.0	Choking relaxation constant 1 for set 2.	2.0
C2RC2	> 0.0	Choking relaxation constant 2 for set 2.	1.0
C1RC3	> 0.0	Choking relaxation constant 1 for set 3.	2.0
C2RC3	> 0.0	Choking relaxation constant 2 for set 3.	1.0
C1RC4	> 0.0	Choking relaxation constant 1 for set 4.	2.0
C2RC4	> 0.0	Choking relaxation constant 2 for set 4.	1.0
C1RC5	> 0.0	Choking relaxation constant 1 for set 5.	2.0
C2RC5	> 0.0	Choking relaxation constant 2 for set 5.	1.0
CCIF	>0.0 kg/m^4 (>0.0 lb_m/ft^4)	Constant two-phase flow interfacial drag coefficient (kg/m^4, lb_m/ft^4) if NIFSH = 1 (real format).	10^4 kg/m^4 (1.90×10^2 lb_m/ft^4)
CFZ3	> 0.0	Default value for 3D loss coefficients (real format). Used when ISTOPT = 1 or 2.	10^{20}
CHFMULT	> 0.0	Multiplier to CHF (real format). By default, this value is 1.0.. This option should only be used by developers. It is intended to provide a means to lock the deyout point for some assessments in order to be able to assess the post-CHF heat transfer regime.	1.0
Note: CHM11 and CHM21 are not under user control and have hardwired values of 1.0.			

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
CHM12, CHM22	> 0.0	Subcooled and two-phase multipliers, respectively, for choked-flow multiplier set 2 (real format).	1.0
CHM13, CHM23	> 0.0	Subcooled and two-phase multipliers, respectively, for choked-flow multiplier set 3 (real format).	1.0
CHM14, CHM24	> 0.0	Subcooled and two-phase multipliers, respectively, for choked-flow multiplier set 4 (real format).	1.0
CHM15, CHM25	> 0.0	Subcooled and two-phase multipliers, respectively, for choked-flow multiplier set 5 (real format).	1.0
CPUFLG	0 or 1	Option for eliminating CPU times from being output to files **trcmsg**, **trcout**, and the terminal so that file comparisons of output files between different TRACE versions will not include the CPU-time differences that will inevitably occur.. 0 = no; 1 = yes.	0
DTSTRT	–1.0 or > 0.0 s	Initial timestep size/s (real format) when DTSTRT > 0.0.	-1.0
FDFHL	0.0 to 1.0	Multiplier used on the Forslund-Rohsenow film-boiling correlation in standard blowdown heat transfer. A value of 1.0 is fully on while 0.0 is fully off.	1.0

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
FLUIDS(8)	“He”, “he”, “Na”, “na”, “Air”, “air”, “PbBi”, “pbbi”, “H2O”, “h2o”, “D2O”, “d2o”, “STH2O”, or “sth2o”	List of working fluids that will appear in the TRACE model. If there is no input for the FLUIDS array, then the normal equation of state input selection logic for TRACE (in other words, use the ID2O NAMELIST option to control the working fluid) is used. If there is any input for the FLUIDS array, then ID2O input is ignored. If there is more than one input for the FLUIDS array, then additional input must be provided for each hydro component in the model specifying which EOS package will be used for that component. Such input is described in each hydro component’s input description	blank
GRAPHLEVEL	"minimal", "limited", "full"	This option allows a user to control the level of verbosity with which information is dumped to the XTV graphics file. "minimal" implies that only the control system parameters and a few global parameters are dumped. "limited" implies that only the most commonly used graphics variables or those thought to be genuinely useful during a typical analysis are written to the XTV file. For example, this level includes (but is not necessarilty limited to) such quantities as pressure, temperature, void fraction, mass flow rate, core-averaged quantities, etc. "full" implies that all possible graphics variables are written to the graphics file. See **Chapter 3** for a complete description of the variables in each category	"limited "
HD3	≥ 0.0 m (≥ 0.0 ft)	Default value for 3D hydraulic diameters (m, ft) (real format). Used when ISTOPT = 1 or 2.	10^{20} m (3.28×10^{20} ft)

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).			
Variable	**Value Range**	**Description**	**Default Value**
HSTN	> 0.0 K (> -4.5967 ×10^2 °F)	Default value for HTSTR temperatures (K, °F) (real format) in 3D components. Used when ISTOPT = 1 or 2.	10^{20} K, (1.8× 10^{20} °F)
HTCWL	> 0.0 W/(m^2 K) [>0.0 Btu/ (ft^2 °F hr)]	Constant wall to liquid heat-transfer coefficient [W/(m^2 K), Btu/(ft^2 °F hr)] (real format) if ICONHT = 1.	10.0 W/(m^2 K) [1.76 Btu/ (ft^2 °F hr)]
HTCWV	> 0.0 W/(m^2 K) [>0.0 Btu/ (ft^2 °F hr)]	Constant wall to vapor heat-transfer coefficient [W/(m^2 K), Btu/(ft^2 °F hr)] (real format) if ICONHT = 1.	10.0 W/(m^2 K) [1.76 Btu/ (ft^2 °F hr)]
IADDED	≥ 0	Option that adds a numerical-solution status-parameter message to the **trcmsg** and TTY files. The status parameters are written every IADDEDth timestep.	0
IAMBWR	FALSE or TRUE	This NAMELIST variable is to be used if a BWR-style reactor vessel is to be modeled using the VESSEL component. .FALSE.= do not set vessel area at the core inlet to zero .TRUE.= set vessel area to zero at the core inlet. (This NAMELIST variable is to be used if a vessel component is modeled).	.FALSE.

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
IBLAUS	0 or 1	Apply the Blasius interfacial drag correlation in the lower plenum and downcomer of VESSEL components. This option is no longer recommended for use and will be removed in a future code version. 0 = no; 1 = yes.	0
ICDELT	0 or 1	Option that overrides the evaluation of DELT at the beginning of an initial calculation by defining DELT = DTMIN when ICDELT = 0. ICDELT = 1 forces DELT to be evaluated.	0
ICFLOW	0,1 or 2	Choked-flow model option. 0 = model turned off; 1 = model using default multipliers is turned on only at component junctions connected to a BREAK; 2 = model using optional multipliers (NAMELIST variables CHM12, CHM22; CHM13, CHM23; CHM14, CHM24; and CHM15, CHM25) is turned on at cell-edges indicated in the component input. (Note that this option requires additional array data for all one-dimensional hydrodynamic components.)	1
ICONHT	0 or 1	Heat-transfer option. 0 = normal heat-transfer calculation; 1 = constant heat-transfer coefficients.	0

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
IDIAG	0,1,2,3 or 4	This option is intended to generate additional information primarily for the code developer rather than the analyst. 0 = standard output; 1 = additional variables, including the stabilizer velocities, are output as part of the large edits written to the **trcout** file; 2 = information from IDIAG = 1 plus diagnostics about reiterations due to flow reversals are output to the **trcmsg** file for every timestep; 3 = information from IDIAG = 1 and 2 plus diagnostics about the temporal changes in gas volume fraction are output to the **trcmsg** file. **Note:** The timestep interval during which additional information for this option (IDIAG = 3) is output is defined by NAMELIST variables NSDL and NSDU. 4 = information from IDIAG = 1, 2, and 3 plus diagnostics about reiterations due to out-of-bounds gas volume fraction predictions are output to the **trcmsg** file for every timestep. **Note:** The use of IDIAG > 0 will approximately double the size of the **trcout** file; the use of IDIAG > 1 will greatly increase the size of the **trcmsg** file.	0

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
IDIAGS	0 or 1	Option to select the additional variables written in a large edit to file **trcout** for 1D hydraulic components when NAMELIST variable IDIAG > 0. 0 = liquid and gas mass flows; 1 = ARLN and ARVN stabilizer-solution parameters replace the liquid and gas mass flows.	0
IELV	0 or 1	Option that determines whether gravity (GRAV) terms or cell-centered elevations (ELEV) in meters are to be input in the component data. When this option is selected, ELEV (dimensioned NCELLS) or cell-centered elevations should be input for GRAV array data cards in all components. In addition, a BREAK elevation BELV (BREAK component **Card Number 7**), a FILL elevation FELV (FILL component **Card Number 6**), and a Vessel elevation shift SHELV (VESSEL component **Card Number 7**) are required. 0 = gravity terms must be input (default); 1 = cell-centered elevations must be input. **Note:** The value of IELV must not be changed when performing a restart calculation.	0
IFLCOND	0 or 1	Fluid conduction flag. 0 = no fluid conduction in this model. 1 = fluid conduction model is on.	0

Main-Data Card 4. **NAMELIST** Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
IGAS	1, 2, 3, 4, 5, 6, 7, 12, 13, 14, 15, 16, or 17	Noncondensible-gas type option. 1 = air; 2 = hydrogen; 3 = helium (ideal gas); 4 = argon; 5 = nitrogen; 6 = xenon; 7 = kryton; 12 - 17 = a mixture of non-condensible-gases. If IGAS > 11, then the number of non-condensible gases in the mixture is determined by IGAS-10. In that case the NCGSPECIES namelist parameter must be provided to indicate what specific gases comprise the mixture. In addition, gas trace species mass fractions must be included for each hydro component in the model.	1
IGEOM3	0 or 1	Option that determines, for all 3D vessel components, whether the mesh-cell interface flow areas between the downcomer and the inside of the vessel are to be set to zero. 0 = areas to be set to zero; 1 = the user enters the values of the flow-area fractions used.	0
IH2SRC	≥ 0	Option that sets the hydrogen source flag. If this parameter is nonzero, the hydrogen source flags, IGAS = 2 and NOAIR = 0 are set internally by TRACE .	0
IHOR	0, 1, 2 or 3	Wall-drag form option. 0 = uses dispersed drag only; 1 = uses stratified drag in one dimension if conditions are met; 2 = always uses stratified drag; 3 = turns off head gradient force.	1

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
IKFAC	0 or 1	Option that defines whether additive loss coefficients (FRIC) or K factors are to be input in the component data. When this option is selected, K factors (dimensioned NCELLS+1) replace the FRIC array input cards in all components. To input K factors that depend on flow direction, include the NFRC1 or NFRC3 options. 0 = additive loss coefficients will be input; 1 = K factors will be input. **Note:** The value of IKFAC must not be changed when performing a restart calculation.	0
IMFR	1 or 3	Option that sends the VESSEL-component phasic mass flows to the **trcxtv** file. 1 = sends no phasic mass flows; 3 = sends the phasic mass flows in the theta, radial, and axial directions.	1
INLAB	0 or 3	Option that creates, during input-data processing, a new input-data file in free format named INLAB. All input-data values from file **tracin** are echoed to INLAB along with their variable names as comments contained between asterisks. 0 = file INLAB is not created; 3 = file INLAB is created.	0
INVAN	0 or 3	Option that selects either the T_{CHF} or T_{SAT} values for the inverted annular switch. 0 = T_{CHF} value is selected (all code assessment was performed with this option); 3 = T_{SAT} value is selected.	0

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).			
Variable	**Value Range**	**Description**	**Default Value**
IOFFTK	0 or 1	Option that selects TEE component offtake model. 0 = model off; 1 = model on.	0
IOGRF	-1, 0, 1	SI/English units flag for writing graphics data to file **trcxtv**. -1 = do not output graphics data; 0 = SI units; 1 = English units	0
IOINP	0 or 1	SI/English units flag for reading input data from file **tracin**. 0 = SI units; 1 = English units.	0
IOLAB	0 or 1	SI/English units flag for writing comment-labeled input data to file INLAB. 0 = SI units; 1 = English units.	0
IOOUT	0 or 1	SI/English units flag for echoing input and restart data, writing short and large edits to file **trcout**, and writing calculative information to file **trcmsg** and the terminal. 0 = SI units; 1 = English units.	0

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
IPOWR	–1, 0 or 1	Option that controls core-power initialization at its steady-state level during a steady-state calculation. See the Appendix on TRACE's control procedure in the TRACE Theory Manual for additional details. –1 = turn on the core steady-state power at time TPOWR; 0 = turn on the core steady-state power at time based on built-in logic or at time TPOWR, whichever occurs first (the built-in logic checks that the fractional change in the coolant velocity per second is ≤ 0.1 in all hydraulic cells at the bottom of the core that are coupled to powered heat structures; 1 = turn on the core steady-state power at the beginning of the steady-state calculation.	0
IRESET	0 or 1	Option to re-initialize the energy error to zero at the start of a restart calculation. 0 = no (allow the energy error to accumulate from the previous calculation); 1 = yes.	0

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).			
Variable	**Value Range**	**Description**	**Default Value**
ISOLCN	0 or 1	Solubility-parameters option. [Solubility parameters characterize the dissolved material that is followed by the solute tracker when ISOLUT = 1 (Word 3 on **Main-Data Card 9**).] 0 = use of default parameters for linear fit to solubility of orthoboric acid as a function of liquid temperature (default condition); 1 = input parameters for linear fit to solubility of solute as a function of liquid temperature. See Solubility-Parameters Card before Main-Data **Main-Data Card 5**. **Note:** No input solubility parameters are saved on the dump/restart file; thus, these parameters must be input for each restart.	0
ISSCVT	0 or 1	Option for evaluating the EPSS (Word 2 on **Main-Data Card 8**) steady-state convergence test in a TRANSI = 1 (Word 2 on **Main-Data Card 7**) transient calculation. 0 = no; 1 = yes.	0

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
ISTOPT	0, 1 or 2	Option that allows the user to input only once default values for certain parameters that are used to initialize data arrays for hydraulic components. The default parameter values also are input through the NAMELIST group INOPTS. The NAMELIST variables that can be assigned default values are ALP, CFZ3, HD3, HSTN, P, PA, QPPP,VL, VV, TL, TV, and TW. When ISTOPT= 1 or 2, the values of these variables are used to fill the corresponding arrays in all hydraulic components except PRIZERs and VALVEs. This option can be used for both steady-state and transient calculations. 0 = off; 1 = Those component arrays (excluding PRIZER and VALVE), for which default values are included in the NAMELIST data, are filled with the default value. All cards that would contain data for the defaulted arrays must be omitted from the input-data file; 2 = Those component arrays (excluding PRIZER and VALVE), for which default values are included in the NAMELIST data, are filled with the default value. Cards containing data for the defaulted arrays must remain in the input-data file but are overridden by the default value.	0

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Variable	Value Range	Description	Default Value
Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).			
ITDMR	0 or 1	Option for activating coupled neutronics/ TH code calculation. When ITDMR = 0 (default) the core heat source is calculated by TRACE point kinetics. When ITDMR = 1 the core heat source is calculated by the spatial kinetics code.	0
ITHD	0 or 1	Option for inputting heat-transfer diameters through variables HDRI and HDRO (Words 4 and 5 on Card Number 4) for HTSTR components. When ITHD = 0, the mesh-cell hydraulic diameters are used for the heat-transfer diameters. 0 = no; 1 = yes. HDRI and HDRO input as zero, will be estimated from the hydraulic diameters for the fluid components connected to the HS inner or outer surface, respectively. **Note:** The value of ITHD must not be changed when performing a restart calculation.	0
ITMRP	0 or 1	Option for activating additional diagnostics printing when TDMR is activated (ITDMR = 1). When ITMRP = 0 (default) the print option is off. When ITMRP = 1 the print option is on (only possible when ITDMR = 1).	0
ITRACE	0 or 1	Trace species in this problem 1=yes; 0=no.	0

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
IUNLAB	≥ 0 and ≤ 100	Option for inputting user-defined units-name labels required for defining the units of control block or trip-signal-expression parameters. 0 = no; >0 = yes. The magnitude of this parameter indicates the exact number of user-defined units labels the user intends to provide later on in the input deck **Note:** User-defined units-name label data is not written to the **trcdmp** file and not read from the **trcrst** file, so the user needs to input the user-defined units-name label data to the **tracin** file for all (initial and	0
IUNOUT	0 or 1	Option for writing SI/English units to file **trcout**. 0 = no; 1 = yes.	1

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Variable	Value Range	Description	Default Value
Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).			
LBDRAG	.TRUE. or .FALSE	Option for adjusting the interfacial drag model that gets used in VESSEL components. When LBDRAG is true, the code sets the interfacial drag coefficient, Ci, in the axial direction for vertically stratified flow to that for annular flow. This improves UPTF assessment calculations and should give a better prediction of ECCS bypass during PWR LBLOCAs. This option should not be used in SBLOCA calculations or other situations with slowly moving levels. When LBDRAG is FALSE (the default), interfacial drag in vertically stratified flow is kept artificially high to overcome numerically-driven oscillations caused by the way the V∆V term in the momentum equation is formulated. Users should note that this option is a temporary fix; the LBDRAG = .TRUE. drag will be the default when the underlying problem with the V∆V term is fixed in the future.	.FALSE.
MHTLI	0 or 1	Option for input specifying wall-to-liquid heat-transfer multiplicative design factors for the inner surface of all HTSTR components. 0 = no; 1 = yes.	0
MHTLO	0 or 1	Option for input specifying wall-to-liquid heat-transfer multiplicative design factors for the outer surface of all HTSTR components. 0 = no; 1 = yes.	0

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).			
Variable	**Value Range**	**Description**	**Default Value**
MHTVI	0 or 1	Option for input specifying wall-to-gas heat-transfer multiplicative design factors for the inner surface of all HTSTR components. 0 = no; 1 = yes.	0
MHTVO	0 or 1	Option for input specifying wall-to-gas heat-transfer multiplicative design factors for the outer surface of all HTSTR components. 0 = no; 1 = yes.	0
MWFL	0 or 1	Option for input specifying wall-to-liquid wall-friction multiplicative design factors. 0 = no; 1 = yes. **Note:** Additional array input is required by the PIPE, PRIZER, PUMP, SEPD, TEE, TURB, VALVE, and VESSEL components when MWFL = 1.	0
MWFV	0 or 1	Option for input specifying wall-to-gas wall-friction multiplicative design factors. 0 = no; 1 = yes. **Note:** Additional array input is required by the PIPE, PRIZER, PUMP, SEPD, TEE, TURB, VALVE, and VESSEL components when MWFV = 1.	0
NCGASSPECIES	"air", "h2", "he", "n2’, "ar", "xe", "kr"	This parameter specifies those gases that comprise the non-condensible gas field when the user has chosen it to be a mixture (IGAS > 11). In that case, IGAS-10 actual values are expected.	N/A
NCONTANT	0 or 1	0 = No containment calculation 1 = perform containment calculations using the CONTAN component.	0

Main-Data Card 4. **NAMELIST** Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
NDIA1	1 or 2	Option used to input the heat-transfer diameter as well as the hydraulic diameter (HD), for all 1D hydraulic components for the evaluation of the wall heat-transfer coefficient. When NDIA1 = 2, the dimension of the HD array is doubled to 2× (NCELLS+1). The HD-array data must be defined with NCELLS+1 values for the hydraulic diameter that end with an "e" followed by another record with NCELLS+1 values for the heat-transfer diameter that end with an "e". 1 = only hydraulic diameters are input; 2 = hydraulic and heat-transfer diameters are input. **Note:** The value of NDIA1 must not be changed when performing a restart calculation.	1
NENCLOSURE	≥ 0	Number of radiation heat transfer enclosures	0
NFLPOWER	> 0	Number of fluid power components in this model.	0

Main-Data Card 4. **NAMELIST** Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
NFRC1	1 or 2	This option can be used to require input of forward and reverse loss coefficients for all 1D components. When it is set to 2, the dimension of the FRIC array is doubled to 2 × (NCELLS + 1). The input data must be defined to provide two consecutive arrays of loss coefficients, each dimensioned NCELLS + 1. Each array is in LOAD format and must be terminated with an “E.” The first array provides loss coefficients that are used with positive velocities, and the second array provides loss coefficients that are used with negative velocities. To input these coefficients as K factors, use the IKFAC option. 1 = FRIC loss coefficients (default); 2 = FRIC and RFRIC two-way loss coefficients. **Note:** NFRC1 must not be changed when performing a restart calculation.	1
NFRC3	1 or 2	This option can be used to require input of forward and reverse loss coefficients for all 3D vessel components. When it is set to 2, input must be augmented to include the additional reverse loss coefficients. The variables CFZL-T, CFZL-Z, CFZL-R, CFZV-T, CFZV-Z and CFZV-R are input as before to provide forward (positive velocity) loss coefficients. This block of input is immediately followed by a corresponding block containing the reverse loss coefficients CFRL-T, CFRL-Z, CFRL-R, CFRV-T, CFRV-Z, and CFRL-R. To input these coefficients as standard K factors, use the IKFAC option. **Note:** NFRC3 must not be changed when performing a restart calculation.	1

Main Data

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
NIFSH	0 or 1	Interfacial shear option. 0 = normal interfacial-shear calculation; 1 = constant interfacial-shear coefficients.	0
NLT	≥1	Number of hydraulic-component loops.	10
NOAIR	0 or 1	Option that controls the calculation of noncondensable-gas partial pressure in hydraulic components. 0 = noncondensable-gas partial pressures solved for (this is less efficient when there is no noncondensable-gas in the system); 1 = noncondensable-gas partial pressures are not solved for (the noncondensable-gas partial-pressure array PA must be input with a value of 0.0 when NOAIR = 1). **Note:** TRACE sets PA to 0.0 when ALP is 0.0.	1
NOFAT	.TRUE. or .FALSE.	Suppresses JUN1 and JUN2 flow area matching test in fluid components.	.FALSE.

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
NOLT1D	1, 0 or -1	Option controlling use of the 1D level tracking model 1 = disable level tracking for all 1D components. 0 = allow level tracking to occur but requires the input of array ILEV for all 1D cells. Each value in the ILEV array for each component determines whether level tracking is turned on or off for specific cells. -1 = force level tracking to be used everywhere without requiring additional component input .	1
NOLT3D	1, 0 or -1	Option controlling use of the 1D level tracking model 1 = disable level tracking for all vessel components. 0 = require the input of array ILEV for all vessel cells. Values of ILEV array determine whether level tracking is turned on or off -1 = force level tracking to be used everywhere without requiring additional component input .	1
NOSETS	0 or 1	Flag for using either the SETS or Semi-Implict Numerical Methods to solve the two-phase flow equations 0 = use SETS 1 = use Semi-Implicit.	0

Main-Data Card 4. **NAMELIST** Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
NRSLV	0 or 1	Axial-direction conduction heat-transfer calculation numerics in all HTSTR/ CHAN components having IAXCND = 1. 0 = explicit numerics; 1 = implicit numerics.	0
NSDL	≥ –1	The first timestep number in the range NSDL to NSDU at which a short edit and additional diagnostics are printed to the **trcout** file and IDIAG = 3 diagnostics are printed to the **trcmsg** file for every timestep in the range NSDL to NSDU. –1 = no additional output edits; ≥0 = short edits and additional diagnostics at the selected timesteps NSDL to NSDU. **Note:** The diagnostics include information on what is controlling the timestep size, the value of the largest ratio of iterate pressure change to total pressure (VARERM), and the differences between the basic and stabilizer macroscopic densities.	–1
NSDU	≥ –1	The last timestep number in the range NSDL to NSDU at which a short edit and additional diagnostics are printed to the **trcout** file and IDIAG = 3 diagnostics are printed to the **trcmsg** files for every timestep in the range NSDL to NSDU. –1 = no additional output edits; ≥0 = short edits and additional diagnostics at the selected timesteps NSDL to NSDU.	–1
NSEND	≥ –1	Parameter used to stop the calculation at timestep NSEND. This parameter is useful for setting the boundaries for runs that might bog down with small timesteps. –1 = off; ≥0 = on.	–1

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
NSOLVER	0 or 1	Enables the use of the optional SuperLU direct sparse matrix solver (nsolver=1) for all linear systems associated with flow equations. With this available, it is possible to create decks with 1D flow loops connecting to different directions in a vessel (e.g. one end of a loop connected to a vessel axial face and the other to a radial face). In this instance a message is printed indicating that nsolver=1.	0
NSPL	≥ –1	The first timestep number in the range NSPL to NSPU at which a large edit is printed to the **trcout** file for every timestep in the range NSPL to NSPU. –1 = no additional large edits; ≥0 = large edits at the selected timesteps NSPL to NSPU. **Note:** Additional information may be included on all large edits if IDIAG > 0.	–1
NSPU	≥ –1	The last timestep number in the range NSPL to NSPU at which a large edit is printed to the **trcout** file for every timestep in the range NSPL to NSPU. –1 = no additional large edits; ≥0 = large edits at the selected timesteps NSPL to NSPU.	–1
NUMGENTBL	≥ 0	Number of general tables to be read from the TRACE input and/or restart files	0
NVGRAV	0 or 1	Option for user-specified orientation of 3D vessel components relative to the gravity-vector direction. 0 = gravity vector is in the negative z-direction of the vessel component; 1 = general orientation defined through input for each vessel component.	0

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
P	1.0 Pa to 4.5×10^{7} Pa (1.45×10^{-4} psia to 6.53×10^{3} psia)	Default value for the initial pressures (Pa, psia) (real format). Used when ISTOPT = 1 or 2.	10^{20} Pa (1.45×10^{16} psia)
PA	0.0 Pa to 4.5×10^{7} Pa (0.0 psia to 6.53×10^{3} psia)	Default value for the initial noncondensable-gas partial pressures (Pa, psia) (real format). PA > P is invalid. Used when ISTOPT = 1 or 2.	10^{20} Pa (1.45×10^{16} psia)
QPPP	≥ 0.0	Default value for the heat-source distribution (–) in the walls of 1D hydraulic components (real format). Used when ISTOPT = 1 or 2. If this array is filled with the same nonzero constant, a uniform heat-source distribution results.	10^{20}
R5DH	0 or 1	Use RELAP5 ANS 94 Decay Heat data when R5DH = 1.	0
R5FDBK	0 or 1	Use RELAP5 reactivity feedback when R5FDBK = 1.	0
TDMRRAMP	≥ 0	Use steady-state spatial kinetics code power ramp.	0
TIMDL	–1.0, ≥ 0.0 s	Time (s) to begin the debug printout over the time range TIMDL to TIMDU (real format). –1.0 = off; ≥0.0 s = on.	–1.0
TIMDU	–1.0, ≥ 0.0 s	Time (s) to end the debug printout over the time range TIMDL to TIMDU (real format). –1.0 = off; ≥0.0 s = on.	–1.0

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
TL	2.7315 $\times 10^2$ K to 7.1395 $\times 10^2$ K (32.0°F to 8.2544 $\times 10^{2}$°F)	Default value for the initial liquid temperatures (K, °F) (real format). Used when ISTOPT = 1 or 2.	10^{20} K (1.8$\times 10^{20}$ °F)
TPOWR	≥ 0.0 s	Time (s) at which the steady-state power is set on under the control of NAMELIST variable IPOWR (real format).	10^{30} s
TRACBOUT	0 or 1	For each BWR component, write some additional information (that TRAC-B provides in its own OUTPUT file) to **trcout**.	0
TRCDIF	0 or 1	Flag which specifies if a **trcdif** file should be generated. **trcdif** file contains information, used to determine if a code modification alters the numerical result. If 0 no file is created.	0
TSDLS	≥ 0	First timestep for timestep diagnostic and edits to be output to TRCMSG)	-1
TSDLT	≥ 0.0 s	Problem time to begin detailed timestep size diagnostic edits.	-1.0
TSDUS	> TSDLS	Last timestep for timestep diagnostic and edits to be output to TRCMSG)	-1
TSDUT	> TSDLT	Problem time to end detailed timestep size diagnostic edits.	-1.0
TV	2.7315 $\times 10^2$ K to 3.0000 $\times 10^3$ K (32.0 °F to 4.9403 $\times 10^3$ °F)	Default value for the initial vapor temperatures (K, °F) (real format). Used when ISTOPT = 1 or 2.	10^{20} K (1.8$\times 10^{20}$ °F)

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Variable	Value Range	Description	Default Value
		Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).	
TW	> 0.0 K (> -459.7 °F)	Default value for the initial wall temperatures (K, °F) (real format). Used when ISTOPT = 1 or 2.	10^{20} K (1.8×10^{20} °F)
USE_IAPWS_ST	.TRUE. or .FALSE.	Flag to indicate which steam table formulation should be used. .TRUE. = Use steam tables based on the IF97 standard from the International Association for the Properties of Water and Steam (IAPWS). This is essentially the same system as used by RELAP5. .FALSE. = Calculate water properties using legacy internal curve fits to water property data. This scheme may tend to be faster with some sacrifice in overall accuracy in some regions of the pressure-temperature phase diagram. This is the default option. When .TRUE., TRACE, by default, uses IAPWS-IF97 data that has been hardcoded into the executable. However, if the presence of an external steam table property file (called **tpfh2onew**, **trch2o**, or **<prefix>.h2o**) is detected in the working directory at the time the simulation is performed, TRACE will preferentially use the data from that file instead. See **Chapter 1** for the details regarding this feature.	.FALSE.

Main-Data Card 4. NAMELIST Data Cards for Group INOPTS (NAMELIST format.).

Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).

Variable	Value Range	Description	Default Value
USESJC	0, 1, 2 or 3	Single Junction Components (SJC) can be made by setting NCELLS = 0 in PIPES, VALVES, and PUMPS when USESJC > 0. 0 = Default value. No SJC. 1 = PIPE,VALVE and PUMP can be used as a SJC by setting NCELLS = 0; 2 = PIPE,VALVE and PUMP can have side junctions if NCELLS > 0. USESJC = 2 requires inputting NSIDES cards. Connects at 90^o. 3 = Same as 2 above except that USESJC = 3 requires additional side junction angle input.	0
VL	$\|VL\| < 10^4$ m/s, (3.28×10^4 ft/s)	Default value for the initial liquid velocities (m/s, ft/s) (real format). Used when ISTOPT = 1 or 2.	10^{20} m/s (3.28×10^{20} ft/s)
VV	$\|VV\| < 10^4$ m/s, (3.28×10^4 ft/s)	Default value for the initial vapor velocities (m/s, ft/s) (real format). Used when ISTOPT = 1 or 2.	10^{20} m/s (3.28×10^{20} ft/s)
XTVAPPEND	0, 1, or 2	Flag for appending graphics output to an old **trcxtv** file. 0 = create new file, 1 = append to old file overwriting duplicate timesteps, 2 = copy old **trcxtv** and append new values to end.	0

Main-Data Card 4. **NAMELIST** Data Cards for Group INOPTS (NAMELIST format.).

Variable	Value Range	Description	Default Value
Note: Input NAMELIST data cards if INOPT = 1 (Word 3 on **Main-Data Card 2**).			
XTVRES	4 or 8	This option controls the numerical precision of numbers in the graphics file. Lower precision will minimize the size of the graphics file, but may be insufficient for some off-normal uses. 4 = Graphics file output in single precision (appropriate for normal graphics file use). 8 = Graphics file output in double precision	4

Main-Data Card 5. (Format 4E14.4) Solubility-Parameters Card. **CNTLMN, CNMIN, CNTLM, CNMAX**

Variable	Description
Note: Input this card only when NAMELIST parameter ISOLCN = 1	
CNTLMN	Minimum liquid temperature (K, °F) to use linear fit.
CNMIN	Solubility concentration ratio (kg(solute)/kg (liquid), lb_m (solute)/lb_m (liquid) when liquid temperature is at or below CNTLMN.
CNTLMX	Maximum liquid temperature (K, °F) to use linear fit.
CNMAX	Solubility concentration ratio (kg(solute)/kg (liquid), lb_m (solute)/lb_m (liquid) when liquid temperature is at or above CNTLMX.

Main-Data Card 6. (Format I14,E14.4) **DSTEP, TIMET**

Variable	Description
DSTEP	Timestep number of the **trcdmp**-file data dump to be read from the **trcrst** file for a restart calculation. If DSTEP is less than zero, the last data dump found will be used. Input DSTEP = 0 for an initial calculation where all the input data is defined by the **tracin** file.
TIMET	Problem start time (s). If DSTEP or TIMET is less than zero, the time obtained from the retrieved data dump overrides the TIMET input value.

Main-Data Card 7. (Format 5I14) **STDYST, TRANSI, NCOMP, NJUN, IPAK**

Variable	Description
STDYST	Steady-state calculation indicator. 0 = no steady-state calculation; 1 = generalized steady-state (GSS) calculation; 2 = CSS calculation; 3 = GSS calculation with hydraulic-path steady-state initialization (HPSSI); 4 = CSS calculation with HPSSI; 5 = static-check steady-state (SSS) calculation (checks to see if zero flow can be achieved with the pumps turned off and no heat transfer).
TRANSI	Transient calculation indicator. 0 = no transient calculation; 1 = transient calculation.
NCOMP	Total number of hydraulic and HTSTR components.
NJUN	Total number of junctions between hydraulic components. Not used by the code.
IPAK	Water-packing option (suggested value = 1). 0 = off; 1 = on.

Main-Data Card 8. (Format 2E14.4) **EPSO, EPSS**

Variable	Description
EPSO	Convergence criterion for the outer-iteration pressure calculation (suggested value = 1.0×10^{-4}).
EPSS	Convergence criterion for the steady-state calculation (suggested value = 1.0×10^{-4}).

Main-Data Card 9. (Format 5I14) **OITMAX, SITMAX, ISOLUT, NCONTR, NCCFL**

Variable	Description
OITMAX	Maximum number of outer iterations for pressure calculation (suggested value = 10).

Main-Data Card 9. (Format 5I14) **OITMAX, SITMAX, ISOLUT, NCONTR, NCCFL**

Variable	Description
SITMAX	Maximum number of outer iterations for steady-state calculation (suggested value = 10).
ISOLUT	Solute-tracking option (for example, orthoboric acid solute in liquid coolant). ISOLUT must not be changed when performing a restart calculation. 0 = off; 1 = on. -1 = use the value of ISOLUT from the restart file
NCONTR	Number of CSS controllers (NCONTR $\geq$ 1 when STDYST = 2 or 4; NCONTR = 0 when STDYST $\neq$ 2 and $\neq$ 4).
NCCFL	Number of countercurrent flow-limitation parameter sets to be input.

Main-Data Card 10. (Format 5I14) **NTSV, NTCB, NTCF, NTRP, NTCP**

Variable	Description
NTSV	Number of signal variables from input and the restart file (NTSV $\geq$ 0) (used to dimension variable storage).
NTCB	Number of control blocks from input and the restart file (NTCB $\geq$ 0) (used to dimension variable storage).
NTCF	Total number of table entries for the tabular control blocks from input and the restart file (NTCF $\geq$ 0) (used to dimension variable storage).
NTRP	Number of trips from input and the restart file (NTRP $\geq$ 0) (used to dimension variable storage).
NTCP	Number of passes made each timestep through the control-parameter evaluation of signal variables, control blocks, and trips (NTCP $\geq$ 0) (two or more passes may be needed when the signal or set status of a trip is a signal-variable or control-block input parameter or when a control procedure contains an implicit control-block evaluation loop).

Main-Data Card 11. (Format 2I14) **NTRACEG, NTRACEL**

Note: If NAMELIST variable ITRACE > 0 read this card.

Variable	Description
NTRACEG	Number of gas trace species.

Main-Data Card 11. (Format 2I14) **NTRACEG, NTRACEL**

Note: If NAMELIST variable ITRACE > 0 read this card.	
Variable	**Description**
NTRACEL	Number of liquid trace species.

Main-Data Card 12. (Format 5(3X,I11)) **TRACEGPHASE Array** (TRACEGPHASE(I), I = 1, NTRACEG) Load Format.

Note: If NAMELIST variable ITRACE > 0, input this card.		
Variable	**Dimension**	**Description**
TRACEGPHASE	NTRACEG	For each TRACEGPHASE(I) array value, input 0 if trace species is in the gas phase and input a 1 if trace species is in the liquid phase.

Main-Data Card 13. (Format 5(3X,I11)) **TRACELPHASE Array**. (TRACELPHASE(I), I = 1, NTRACEL) Load Format

Note: If NAMELIST variable ITRACE > 0 input this card.		
Variable	**Dimension**	**Description**
TRACELPHASE	NTRACEL	For each TRACELPHASE(I) array value, input 0 if trace species is in the liquid phase and input a 1 if trace species is in the gas phase.

Main-Data Card 14. (Format 5(3X,I11)) **IORDER array** (IORDER(I), I = 1, **NCOMP**) Load Format.

Variable	**Dimension**	**Description**
IORDER	NCOMP	Component ID numbers. All component identification numbers (input variable NUM on card number 1 of each component input) are listed in LOAD format. The list can be in any order.

Countercurrent Flow Limitation Data

If NCCFL = 0 (Word 5 on **Main-Data Card 9**), do not input any of the CCFL data cards.

Card Set Number	Variable	Dimension	Description
Note: Use Load Format: (Format 5E14.4) **CBETA** (I), I = 1, NCCFL.			
1	**CBETA**	NCCFL	Bankoff interpolation constant for interpolating between Wallis characteristic length dimension to Kutateladze characteristic length dimension. CBETA is used in the following equation, OMEGA = $D^{(1.0-CBETA)} \times L^{CBETA}$, where OMEGA is the length scale used in the Bankoff nondimensional volumetric fluxes Hg * & Hf *, D is the hydraulic diameter which is the Wallis scaling parameter, and L is the Kutateladze scaling parameter. CBETA = 0.0 yields Wallis scaling; CBETA = 1.0 yields Kutateladze scaling; CBETA < 0.0 implies that the complete Bankoff correlation will be input to calculate CBETA as a function of geometry and thermodynamic properties.
Note: Use Load Format: (Format 5E14.4) **CCFLM**(I), I = 1, NCCFL.			
2	**CCFLM**	NCCFL	The slope for the CCFL correlation. Default is 1.07 if CBETA is < 0.0 and 1.0 if CBETA is ≥ 0. The general form of the correlation for CBETA ≥ 0 is: $\sqrt{Hg^*} + \mathbf{CCFLM} \times \sqrt{Hf^*} = \mathbf{CCFLC}$ The general form of the correlation for CBETA < 0.0 is: $\sqrt{Hg^*} + \sqrt{Hf^*} = \mathbf{CCFLM} + \mathbf{CCFLC} \times \mathrm{AMIN1}(\mathbf{BOND}, \mathbf{CTRANS})$
Note: Use Load Format: (Format 5E14.4) **CCFLC**(I), I = 1, NCCFL.			
3	**CCFLC**	NCCFL	The constant for the CCFL correlation. See the general form of the correlation given above. Default is 0.00433 if CBETA < 0.0 and 1.0 if CBETA ≥ 0.

Card Number 4. (Format I14,4E14.4) **NHOLES, TP, GAMMA, DIAH, CTRANS**

Note:	For each CBETA(I) < 0.0 (**Card Set 1**), the following input is required to calculate CBETA based on Bankoff's correlation.
Variable	**Description**
NHOLES	Number of holes in the perforated plate.
TP	Plate thickness (m, ft).
GAMMA	Ratio of open-plate flow area to total-plate flow area.
DIAH	Diameter of one hole (m, ft).
CTRANS	Bond number above which the CCFL constant is independent of the Bond number. See **Card Set 2** for the general formulation of the Bankoff's correlation (default is 200.0).

Material Property Data

A user may use existing materials (built-in) or may define new materials.

Built-in Materials

Some material properties are already built-in the TRACE code. These material properties with their identification numbers are listed in **Table 6-1**. The user identifies these material properties in appropriate cards.

Table 6-1. Built-in material types.

Material Type Number	Material Type
1	mixed oxide
2	zircaloy
3	fuel-clad gap gases
4	boron nitride insulation
5	constantan/Nichrome heater wire
6	stainless steel, type 304
7	stainless steel, type 316
8	stainless steel, type 347
9	carbon steel, type A508
10	inconel, type 718
11	zircaloy dioxide
12	inconel, type 600

User Defined Materials

If the built-in material properties are inappropriate, users may input their own data. Data for new material properties may be input by setting **NMAT** > 0 (Word 4 on **Main-Data Card 2**). For each new material, the user must provide:

- a unique material identifier (**MATB** > 50),

- the number of data-point sets provided for each material (**PTBLN**), and
- the data tables and/or functional fits that specify the material properties (ρ, cp, k, and ε) as a function of temperature (T).

If tabular fits are used, linear interpolation is employed to obtain property values for intermediate values of temperature. Extrapolation is not allowed (an error message results). The material-properties tables are not included in the dump file; therefore, it is up to the user to ensure that the tables are supplied in the input file during a restart run.

The material properties can be input as data tables or functional fits or a mixture of data tables and functional fits. The required input cards and the order of these input cards depends on the value of **PTBLN (**number of data-point sets). In other words, the number of data points is used as a flag to indicate which form will be used to provide the material properties:

- If **PTBLN** for a material is positive (**PLBLN(I) > 0**), this indicates that the material properties will be defined as temperature-dependent data tables. The material properties are entered using the **PRPTB** arrays (**Card Set 3**). The functional-fit input (**Card Number 4** through **Card Number 6**) are not used at all.
- If **PTBLN** for a material is zero (**PLBLN(I) = 0**), this indicates that functional fits will be used to define each material property. The **PRPTB** data-table array is not entered at all. Instead, the functional-fit input (**Card Number 4** through **Card Number 6**) are used to define the material properties.
- If **PTBLN** for a material is negative (**PLBLN(I) < 0**), this indicates that some of the properties of the material will be entered as data table arrays and others will be entered using functional fit input. The functional-fit **Card Number 4** is read in before the **PRPTB** array (**Card Set 3**). **Card Number 4** input defines the number of functional fits for each of the required material property types (density, specific heat, thermal conductivity, and emissivity). An input of zero for a functional fit indicates that the material property data is to be input using the PRPTB data tables. Following **Card Number 4**, the **PRPTB** data table (**Card Set 3**) is then read in for those material properties that have the number of functional fits set to zero. The size of the **PRPTB** data table is indicated by the absolute value of **PLBLN**(I). Following the PRPTB data tables (**Card Set 3**) the functional-fit data (**Card Number 5** and **Card Number 6**) is input for those material properties that have the number of functional fits set greater than zero. The order of the material properties in these two categories is: material density first, specific heat second, thermal conductivty third, and emissivity fourth. For example, if data tables are to be provided for material density and thermal conductivity and functional fits for specific heat and emissivity, then the material property tables for density and thermal conductivity are input first and then the functional fits for specific heat and emissivity.

Card Set Number	Variable	Dimension	Description
[Format 5(3X,I11)] [**MATB**(I), I = 1, NMAT]. Load Format			
1	**MATB**	NMAT	ID numbers, **MATB**(I) ≥ 50, I = (1, NMAT), of new materials. These are the material ID numbers used in the component input to reference the input material properties instead of the built-in properties.
[Format 5(3X,I11)] (**PTBLN**(I), I = 1, NMAT). Load Format			
2	**PTBLN**	NMAT	Number of data-point sets provided for each of **NMAT** materials; material **MATB**(I) consists of **PTBLN**(I) data-point sets. < 0 = Material properties are mixture of data tables and functional fits. 0 = Material properties are in form of functional fits. > 0 = Material properties are in form of tables. The actual number indicates the number of data-point pair sets to be provided for each of **NMAT** materials; material **MATB**(I) consists of **PTBLN**(I) data-point sets.

Temperature-Dependent Data Table Input

Card Set Number	Variable	Dimension	Description
Note: Input **NMAT** data tables, one for each material (**MATB**(I), I = 1, NMAT). **Note:** Use Load Format [Format 5(3X,E11.4)] [**PRPTB**(J), J = 1, 5 × **PTBLN**(I)].			

Card Set Number	Variable	Dimension	Description
3	PRPTB(I)	5*PTBLN(I)	The material-properties data for material **MATB**(I), each point of which consists of the two to five variables in order T, ρ, C_p, k, and ε [where T is the temperature (K, °F), ρ is the density (kg/m^3, lb$_m$/ft^3), C_p is the specific heat [J/(kg K), Btu/(lb$_m$ °F)], k is the thermal conductivity [W/(m^{-1} K), Btu/(ft °F hr)], and ε is the emissivity (–)]. Each card contains five material variables; i.e., T is the independent variable and ρ, C_p, k and ε are dependent variables. The following card contains again five variables corresponding to the next data-point pair. Each material **MATB**(I) consists of **PTBLN**(I) points with the values of T increasing monotonically. The table array appears as T_1, ρ_1, C_{p1}, k_1, ε_1, T_2, ρ_2, C_{p2}, k_2, ε_2, T_3,...., $T_{PTBLN(I)}$, $\rho_{PTBLN(I)}$, $C_{pPTBLN(I)}$, $k_{PTBLN(I)}$, $\varepsilon_{PTBLN(I)}$. For those material properties that will be input as functional fits, they are removed from this input array; however, the order of the array is maintained with the functional fit properties removed. A one point table results in a constant table. Extrapolation is not allowed.

Functional-Fit Data Input

Card Number 4. [Format 5114] **RHONUM, SPHTNUM, CONDNUM, EMISNUM**

Note: Input this card if PTBLN(I) ≤ 0.	
Variable	**Description**
RHONUM	Number of functional fit sets for the material density.
SPHTNUM	Number of functional fit sets for the material specific heat.
CONDNUM	Number of functional fit sets for the material thermal conductivity.
EMISNUM	Number of functional fit sets for the material emissivity.

There will be **RHONUM** sets of the functional fit **Card Number 5** and **Card Number 6**, followed by **SPHTNUM** sets of the functional fit **Card Number 5** and **Card Number 6**, followed by **CONDNUM** sets of the functional fit **Card Number 5** and **Card Number 6**, followed by **EMISNUM** sets of the functional fit **Card Number 5** and **Card Number 6**, when **PTBLN**(I) $\leq$ 0. If more than one functional set is input for a given material property, then the **TUPPER** for the previous set must equal the **TLOWER** for the current set. The temperature range from first lower temperature limit to the upper temperature limit defined by the last function fit set must be contiguous (i.e., no undefined gaps). A fatal error will occur if material property evaluation is attempted outside of the temperature ranged defined by the first lower temperature limit and the last upper temperature limit.

Note: Input RHONUM + SPHTNUM + CONDNUM + EMISNUM sets of **Card Number 5** and **Card Number 6**. The form of the functional fit is: Y = A0 + A1 * Z + A2 * Z^2+ A3 * Z^3 + A4 * Z^4 + A5 / Z: where Z = T - TOFFSET

Card Number 5. [Format 5(3XE11.4)] **TOFFSET, TLOWER, TUPPER, A0, A1**

Variable	Description
TOFFSET	Offset for the Z independent variable in the functional fit.
TLOWER	Lower temperature limit (T) for applying this functional fit.
TUPPER	Upper temperature limit (T) for applying this functional fit.
A0	Coefficient A0 in the functional fit.
A1	Coefficient A1 in the functional fit.

Card Number 6. [Format 4(3XE11.4)] **A2, A3, A4, A5**.

Note: Input RHNOM + SPHTNUM + CONDNUM + EMISNUM sets of **Card Number 5** and **Card Number 6**.

Variable	Description
A2	Coefficient A2 in the functional fit.
A3	Coefficient A3 in the functional fit.
A4	Coefficient A4 in the functional fit of the form.
A5	Coefficient A5 in the functional fit of the form.

The following is an input example for each of the material properties options. Note that for this example, **NMAT** on **Main-Data Card 2** is assumed to be 3.

```
****************************
* material-properties data            *
****************************
* Card Set 1 and Card Set 2
* matb  *              51   52  53e
* ptbln *               2    0  -1e
*
******input for matb 51 - ptbln(1) > 0, all properties as data tables
* Card Set 3
*     prptb(1,i)      prptb(2,i)        prptb(3,i)        prptb(4,i)
prptb(5,i)
*       temp            rho                cp               cond
emis
    2.0000e+01    1.0000e+00    1.0000e+00    2.0000e+00    1.0000e+00
    4.0000e+05    1.0000e+00    1.0000e+00    2.0000e+00    1.0000e+00e
*
******input for matb 52 - ptbln(2) = 0, all properties as functional fits
* Card Number 4
*       rhonum        sphtnum        condnum        emisnum
                 1                 2                   3                  1
*
*         rho function
*
* Card Number 5
*      toffset       tlower         tupper            a0            a1
           0.0            0.0     400000.0           1.0           0.0
* Card Number 6
*           a2            a3             a4            a5
           0.0           0.0            0.0           0.0
*
*         Cp function 1
*
* Card Number 5
*      toffset       tlower         tupper            a0            a1
           0.0           0.0          100.0           1.0           0.0
* Card Number 6
*           a2            a3             a4            a5
           0.0           0.0            0.0           0.0
*
*         Cp function 2
*
* Card Number 5
*      toffset       tlower         tupper            a0            a1
           0.0         100.0     400000.0           1.0           0.0
* Card Number 6
*           a2            a3             a4            a5
           0.0           0.0            0.0           0.0
*
*       Cond function 1
*
* Card Number 5
*      toffset       tlower         tupper            a0            a1
           0.0            0.0          100.0           2.0           0.0
* Card Number 6
*           a2            a3             a4            a5
           0.0           0.0            0.0           0.0
*
*       Cond function 2
*
```

```
* Card Number 5
*      toffset       tlower          tupper          a0            a1
           0.0        100.0          1000.0         2.0           0.0
* Card Number 6
*           a2           a3              a4          a5
           0.0          0.0             0.0         0.0
*
*       Cond function 3
*
* Card Number 5
*      toffset       tlower          tupper          a0            a1
            0.0      1000.0      400000.0         2.0           0.0
* Card Number 6
*           a2           a3              a4          a5
           0.0          0.0             0.0         0.0
*
*       Emis function 1
*
* Card Number 5
*      toffset       tlower          tupper          a0            a1
           0.0        200.0       400000.0         1.0           0.0
* Card Number 6
*           a2           a3              a4          a5
           0.0          0.0             0.0         0.0
*
******input for matb 53 - ptbln(3) < 0, both data tables and functional
fits
*                        are used to enter material properties
*
* Card Number 4
*       rhonum       sphtnum       condnum       emisnum
                 3                 0                  1                  0
*
*  Data table for cp and emis
*
* Card Set 3
*        temp                cp                   emis
    4.0000e+03    1.0000e+00    1.0000e+00 e
*
*  Functional fits input for rho
*
*       rho function 1
*
* Card Number 5
*      toffset       tlower          tupper          a0            a1
            0.0          0.0          100.0          2.0           0.0
* Card Number 6
*           a2           a3              a4          a5
           0.0          0.0             0.0         0.0
*
*       rho function 2
*
* Card Number 5
*      toffset       tlower          tupper          a0            a1
            0.0        100.0         1000.0         2.0           0.0
* Card Number 6
*           a2           a3              a4          a5
           0.0          0.0             0.0         0.0
*
*       rho function 3
*
* Card Number 5
*      toffset       tlower          tupper          a0            a1
            0.0      1000.0      400000.0         2.0           0.0
```

```
* Card Number 6
*          a2           a3             a4            a5
          0.0          0.0            0.0           0.0
*
*  Functional fits input for conductivity
*
*       cond function 1
*
* Card Number 5
*      toffset       tlower         tupper            a0            a1
           0.0        200.0     400000.0           1.0           0.0
* Card Number 6
*          a2           a3             a4            a5
          0.0          0.0            0.0           0.0
*
```

Hydraulic-Path Steady-State Initialization Data

Card Number 1. (Format 3I14) **NPATHS, NFPI, NTP**

Note: If STDYST = 3 or 4 (Word 1 on **Main-Data Card 7**), input this card and **NPATHS** of **Card Number 2** through **Card Number 4** (if NTPI = 0).

Variable	Description
NPATHS	Number of 1D hydraulic paths in the system model. The internal-junction interface between the main and side tubes of **SEPD** and **TEE** components defines the starting or ending interface of a 1D hydraulic path. The internal-junction interface of **SEPD** and **TEE** components and the junction interfaces of **PLENUM** and **VESSEL** components define the path end of a 1D hydraulic path. A user-defined hydraulic-path connection interface within a 1D hydraulic component or at a junction between two 1D hydraulic components provides a connection point for two hydraulic paths.
NFPI	**PMVL** and **PMVV** (Words 1 and 2 on **Card Number 3**) flow-parameter input option. 0 = liquid and vapor mass flows; 1 = liquid and vapor velocities.
NTPI	Total and noncondensable-gas pressure input option. 0 = specify pressures on **Card Number 4** and use these pressures to define the pressure for all mesh cells in the hydraulic path; 1 = get pressures from the donor cell of the thermal-hydraulic condition location **IDCLOC** (Word 3 on **Card Number 2**) in the component data and use these pressures to define the pressures for all mesh cells of the hydraulic path; 2 = get pressures from each mesh cell of the component data for the hydraulic path.

Note: Potential hydraulic paths that are appropriately defined by the component data do not need to be specified (for example, the emergency-coolant system side-leg channel with stagnant coolant).

Card Number 2. (Format 5I14) **IDCINF, IDCOUF, IDCLOC, IDCPWI, IDCPWO**

Variable	Description
IDCINF	Hydraulic path N inflow location number defined by the composite value (component ID number)* 1000 + interface number where its thermal-hydraulic condition is donor-cell convected through the mesh-cell interface (except for VESSEL-component source connections where the thermal-hydraulic condition is assumed donored from the 1D cell). Make the composite value negative if the location is on the side tube of a **SEPD** or **TEE** component and either **IDCINF** or **IDCOUF** must define the **SEPD** or **TEE** internal-junction interface number NCELL1+2. Each **PLENUM**-component junction interface must be defined by **IDCINF** or **IDCOUF** of a hydraulic path.
IDCOUF	Hydraulic path N outflow location number defined by the composite value (component ID number)* 1000 + interface number where its thermal-hydraulic condition is donor-cell convected through the mesh-cell interface (except for **VESSEL**-component source connections where the thermal-hydraulic condition is assumed donored from the 1D cell). Make the composite value negative if the location is on the side tube of a **SEPD** or **TEE** component and either **IDCINF** or **IDCOUF** must define the **SEPD** or **TEE** internal-junction interface number NCELL1+2. Each **PLENUM**-component junction interface must be defined by **IDCINF** or **IDCOUF** of a hydraulic path.
IDCLOC	Hydraulic path N thermal-hydraulic condition location number defined by the composite value (component ID number)*1000 + interface number where the defined thermal-hydraulic condition is donor-cell convected through the mesh-cell inter-face. Make the composite value negative if the location is on the side tube of a **SEPD** or **TEE** component. In this case, the interface location must be the **SEPD** or **TEE** internal-junction interface defined by **IDCINF** or **IDCOUF** while **IDCLOC** has a special defining form where instead its interface number is the **JCELL** cell number on the main tube of the **SEPD** or **TEE** component. **IDCLOC** must be defined the same as **IDCINF** or **IDCOUF** for a **PLENUM**-component junction interface. The donor cell's thermal-hydraulic parameters are defined on **Card Number 3** and **Card Number 4**. Don't define interface **IDCLOC** within the heat source or sink cell range from **IDCPWI** to **IDCPWO**.
IDCPWI	Hydraulic path N inflow location number defined by the composite value (component ID number)* 1000 + cell number for the first cell in the hydraulic-path flow direction having heat-transfer to or from it. Input 0 if there is no heat source or sink in the hydraulic path that needs to be considered.
IDCPWO	Hydraulic path N outflow location number defined by the composite value (component ID number)* 1000 + cell number for the last cell in the hydraulic-path flow direction having heat-transfer to or from it. Input 0 if there is no heat source or sink in the hydraulic path that needs to be considered.

Card Number 3. (Format 5E14.4) **PMVL, PMVV, PTL, PTV, PPOWER**

Variable	Description
PMVL	Initial liquid mass flow (kg/s or lb_m/hr) when NFPI = 0 (Word 2 on **Card Number 1**) or velocity (m/s or ft/s) when **NFPI** = 1 at the **IDCLOC** interface of hydraulic path N.
PMVV	Initial vapor mass flow (kg/s or lb_m/hr) when NFPI = 0 (Word 2 on **Card Number 1**) or velocity (m/s or ft/s) when **NFPI** = 1 at the **IDCLOC** interface of hydraulic path N.
PTL	Initial liquid temperature (K or °F) in the donor cell of the **IDCLOC** interface of hydraulic path N [input 0.0 K or –459.67°F to specify the saturation temperature based on the vapor pressure].
PTV	Initial vapor temperature (K or °F) in the donor cell of the **IDCLOC** interface of hydraulic path N (input 0.0 K or –459.67°F to specify the saturation temperature based on the vapor pressure).
PPOWER	Total heat-transfer power to [**PPOWER**(n) > 0.0] or from [**PPOWER**(n) < 0.0] all mesh cells between and including location numbers **IDCPWI** and **IDCPWO** (W or Btu/hr) (input 0.0 W or 0.0 Btu/hr if there is no heat source or sink in the hydraulic path such that **IDCPWI** = 0 and **IDCPWO** = 0).

Card Number 4. (Format 2E14.4) **PP, PPA**

Note: Input Path Card Number 3 if **NTPI** = 0 (Word 3 on **Card Number 1**)

Variable	Description
PP	Total pressure (Pa or psia) that is defined to be constant over all mesh cells of hydraulic path N.
PPA	Noncondensable-gas pressure (Pa or psia) that is defined to be constant over all mesh cells of hydraulic path N.

Steady-State Controller Data

When **STDYST** = 2 or 4 (Word 1 on **Main-Data Card 7**), a CSS calculation is performed using **NCONTR** ≥ 1 (Word 4 on **Main-Data Card 9**) controllers that are specified by CSS controller data. These controllers are internally programmed PI controllers that adjust specific parameter actions to achieve desired steady-state values for specific monitored parameters. Transient-calculation control procedures for some of these component actions are specified in the component input data; however, these CSS controllers override those procedures and control their parameter actions during the CSS calculation. Four types of controllers are available to the TRACE user:

- **Type 1 Controller:**

  A Type 1 controller adjusts a **PUMP** component's rotational speed (rad/s, rpm) to achieve a desired coolant mass flow (kg/s, lb_m/hr) through the **PUMP**. The desired coolant mass flow is specified initially in the **PUMP** component data at the **PUMP** interface by the input coolant mass flow (**NMPCSS** = -1) or velocity (**NMPCSS** = 0), which is summed over the liquid and vapor coolant (see the CSS Controller Card below).

- **Type 2 Controller:**

  A Type 2 controller adjusts a **VALVE** component's flow-area fraction to achieve a desired pressure (Pa, psia) in the mesh cell upstream of the **VALVE** interface (**NMPCSS** = 1) or a desired coolant mass flow (kg/s, lb_m/hr) through the **VALVE** (**NMPCSS** = 2) (see the CSS Controller Card below). The desired pressure is the input upstream-cell pressure or the input pressure in the lower-numbered cell adjacent to the **VALVE** interface if the initial velocity is zero. The desired mass flow, which is determined from the input velocity at the **VALVE** interface, is summed over the liquid and vapor coolant. These desired parameter values are specified initially in the **VALVE** component data.

- **Type 3 Controller:**

  A Type 3 controller adjusts: a **PUMP** component's rotational speed (rad/s, rpm) (**NAPCSS** = –1), a **VALVE** component's flow-area fraction (**NAPCSS** = 0), or a **FILL** component's mass flow (kg/s, lb_m/hr) with a direct-equality controller that defines mass flow out of (**NAPCSS** = 1) or into (**NAPCSS** = 2) the **FILL** (see the CSS Controller Card below). This achieves a desired coolant mass flow at the **FILL** junction that equals the coolant mass flow at interface location **NMPCSS** elsewhere in the modeled system. The monitored mass flow at location **NMPCSS**, specified initially by the velocity in its component data, can vary during the CSS calculation.

- **Type-4 Controller:**

  A Type-4 controller adjusts with a factor a **HTSTR** component's (a) inner or outer surface coupled hydraulic-channel pressure; (b) inner, outer, or both surface heat-transfer areas (heat-transfer coefficients); (c) inner, outer, or both surface nodes or all nodes of the entire wall thermal conductivities; or (d) both surface heat-transfer areas (heat-transfer coefficients) and all nodes of the entire wall thermal conductivities. This is done to achieve a desired single-phase coolant temperature (K,°F) or two-phase gas volume fraction at location **NMPCSS** defined (a) initially in the component data for **NMPCSS** > 1000, (b) by a signal variable with ID 0 < **NMPCSS** < 1000, or (c) by a control block with ID **NMPCSS** < 0 (see the CSS Controller Card below). If this controller adjusts a coupled hydraulic-channel pressure, a similar adjustment is applied to all the hydraulically coupled **VALVE**-component upstream pressures that are controlled by a Type 2 CSS controller and all break pressures.

The monitored-parameter location number **NMPCSS** at a component location for the last three controller types is a composite value that is defined by:

Location number **NMPCSS** = (component number) × 1000 + (cell or interface number).

The desired steady-state value for the monitored parameter is specified initially in input as part of the component data at the **PUMP** interface, **VALVE** interface, or **NMPCSS** location.

For a Type-4 controller, its signal-variable value is evaluated in the first timestep based on the input parameters of the modeled system, or its control-block value is specified in one of two ways: by the control-block input value of **CBCON2** ≠ 0 or by its evaluation in the first timestep based on the input parameters of the modeled system.

When restarting a CSS calculation, the CSS-Controller Cards need to be re-input in the **tracin** file. These cards must be input in the same order as in the original **tracin** file. If a composite number or a signal variable defines the monitored parameter **NMPCSS**, its desired value cannot be changed when performing the restart. Because of this limitation, the Type-4 controller also allows the user to specify the monitored parameter by a control block. The control block's desired value can be changed during a restart by re-inputting the control block that defines **NMPCSS** and defining its **CBCON2** with the new desired value.

Each of the **NCONTR** (Word 4 on **Main-Data Card 9**) controllers is specified by the TRACE user with four (controller Types 1 and 2) or five (controller Types 3 and 4) values on the following card.

CSS Controller Card

Card Number 1. (Format I14,2E14.4,2I14) **NUMCSS, AMNCSS, AMXCSS, NMPCSS, NACSS**

Variable	Description
NUMCSS	Component number whose parameter action is adjusted by the CSS controller.
AMNCSS	Minimum value to which the parameter action can be adjusted by the CSS controller (units based on **NMPCSS** and **NAPCSS** defining the controller type).
AMXCSS	Maximum value to which the parameter action can be adjusted by the CSS controller (units based on **NMPCSS** and **NAPCSS** defining the controller type).

Card Number 1. (Format I14,2E14.4,2I14) **NUMCSS, AMNCSS, AMXCSS, NMPCSS, NACSS**

Variable	Description
NMPCSS	Monitored-parameter number that is defined for each CSS controller type as follows: **Type 1:** the desired mass flow through the **PUMP** is defined by its input-specified initial liquid plus gas mass flow (**NMPCSS** = –1) or velocity (**NMPCSS** = 0) at the pump-impeller interface, **Type 2:** the desired upstream pressure (**NMPCSS** = 1) or liquid plus gas mass flow through the **VALVE** interface (**NMPCSS** = 2) is defined by its input-specified initial value, **Type 3:** the desired liquid plus gas mass flow is defined each timestep during the calculation at interface-location number **NMPCSS**, **Type 4:** the desired single-phase coolant temperature or two-phase coolant gas volume fraction is defined by its input-specified initial value at composite cell-location number **NMPCSS** ≥ 1000, by signal variable with ID number 0 < **NMPCSS** < 1000, or by control block with ID number **NMPCSS** < 0.
NAPCSS	Adjusted-parameter number that is defined for the last two controller types as follows: **Type 1: NAPCSS** is not used; **Type 2: NAPCSS** is not used; **Type 3:** adjusts the **PUMP's** impeller rotational speed (**NAPCSS** = –1), the **VALVE** flow-area fraction (**NAPCSS** = 0), the mass flow out of a **FILL** (**NAPCSS** = 1), or the mass flow into a **FILL** (**NAPCSS** = 2); **Type 4:** adjusts with a factor the **HTSTR** component's: inner-surface coupled hydraulic-channel pressure (**NAPCSS** = 5), outer-surface coupled hydraulic-channel pressure (**NAPCSS** = 6), inner-surface heat-transfer area (heat-transfer coefficient) (**NAPCSS** = 7), outer-surface heat-transfer area (heat-transfer coefficient) (**NAPCSS** = 8), both surface heat-transfer areas (heat-transfer coefficients) (**NAPCSS** = 9), inner-surface node thermal conductivity (**NAPCSS** = 10), outer-surface node thermal conductivity (**NAPCSS** = 11), both surface node thermal conductivities (**NAPCSS** = 12), all nodes of the entire wall thermal conductivities (**NAPCSS** = 13), or both surface heat-transfer areas (heat-transfer coefficients) and all nodes of the entire wall thermal conductivities (**NAPCSS** = 14).

Signal Variable Data

Signal-variable data are specified when **NTSV** > 0 (Word 1 on **Main-Data Card 10**). Signal variables define directly the input parameters for control blocks, the parameters for trip signals, the independent variable parameter for component-action tables, and the component action. Either **NTSV** or fewer signal variables are input. When fewer than **NTSV** signal variables are input, conclude the data with a card having parameter **IDSV** set to 0 (0 must be entered explicitly if the free-format option is used). The remaining signal variables (for a total of **NTSV**) are obtained from the restart file. They are the signal variables on the restart file whose **IDSV** ID numbers differ from those defined here on input. After all signal-variable data are read from input and obtained from the restart file, the signal variables are reordered with their ID numbers increasing monotonically. Each signal variable is defined by the following card.

Card Number 1. (Format 5I14) **IDSV, ISVN, ILCN, ICN1, ICN2**

Variable	Description
IDSV	Signal-variable ID number (1 ≤ **IDSV** ≤ 99000) (signal variables used to define a trip-signal expression require that 1 ≤ **IDSV** ≤ 399). All ID numbers in an input deck must be unique.
ISVN	Signal-variable parameter number. The possible values are -123 ≤ **ISVN** ≤ −57, -54 ≤ **ISVN** ≤ -16, **ISVN** = 0, 1, 2, and 8 ≤ **ISVN** ≤ 123. Refer to **Table 6-2** for a list of the signal-variable parameter numbers available for use and their parameter descriptions. The numerical sign of **ISVN** (for ISVN ≠ 0) specifies the behavior of the signal parameter. See the guidelines described in **Signal variable input guidelines**.
ILCN	The component number (18 ≤ |**ISVN**| ≤ 54 or 57 ≤ |**ISVN**| ≤ 123), control block number (**ISVN** = 2, 16), or the trip ID number (55 ≤ |**ISVN**| ≤ 56) of the signal-variable parameter. For **ISVN** = 0, **ILCN** = +1 previous timestep size, **ILCN** = -1 specifies the current timestep size, **ILCN** = 0 specifies the current time. See the guidelines described in **Signal variable input guidelines**.
ICN1	In general, the cell, interface, or node number of the first location in component **ILCN** where the signal-variable parameter is defined. If **ILCN** corresponds to a **TEE**, **VESSEL** or **HTSTR** component, **ICN1** must be specified in valid composite number format. See **Signal variable input guidelines** for a description of what “composite number format” means.

Signal Variable Data

Card Number 1. (Format 5I14) **IDSV, ISVN, ILCN, ICN1, ICN2**

Variable	Description
ICN2	In general, the cell, interface, or node number of the second location in component **ILCN** where the signal-variable parameter is defined. If **ILCN** corresponds to a **TEE**, **VESSEL** or **HTSTR** component, **ICN2** must be specified in valid composite number format. See **Signal variable input guidelines** for a description of what "composite number format" means.

Card Number 2. (Format A14). **VARREQSTRING**

Note: If **ISVN** is not equal to 3, do not input this card.

Variable	Description
VARREQSTRING	This parameter pertains only to the generic signal variable type (**ISVN** = 3). It is an ascii string denoting the TRACE internal parameter name the user wants to extract from the code each timestep. It must be prepended with the string "lu" in order to get through input processing. For example, a user requesting pressure (pn) would use "lupn".

Signal variable input guidelines

The most important thing to understand about the signal variable input is that there is no single set of rules that can be consistently applied to each and every signal variable type. By their very nature, signal variable parameters are unique entities which may or may not behave similarly with respect to other signal parameters. As a result, the user should keep in mind that depending upon the specific signal variable type of interest, the entity from which the signal is retrieved, and exactly which functional form he or she would like that signal to take on, the meaning and/or requirements of the input variables **IDSV**, **ISVN**, **ILCN**, **ICN1** and **ICN2** may change (see **Card Number 1** above).

The signal variable capability has been designed so that, in general, each signal parameter type can take on, at least, one of six different functional forms (depending upon how the input is structured). For every signal type, the user is able to retrieve an exact, singular value for that parameter each timestep (the Exact form). In addition certain signal types, but by no means all, lend themselves to taking on some subset of five other functional forms. For these signals, the user has at his or her disposal, the ability to take:

- the difference in some parameter between two different cells in a component (the CellDiff form, always implemented as the value in the low index cell minus the value in the high index cell, regardless of how these cell indicies are entered in ICN1 and ICN2),
- the difference in a parameter since the last timestep (the TimeDiff form),
- the minimum or maximum over some range of cells in a single component (the Min & Max forms),

- the volume average of a parameter over some range of cells in a single component (the VolAvg form)

Table 6-2 defines all the various functional forms that any given signal type may have.

A summary of the input rules for each input variable are as follows:

Concerning the **IDSV** variable:

- It must be less than 99000 (values greater than or equal to 99000 are reserved internally for CSS controllers to spawn
- It must be unique
- It must be positive

Concerning the **ISVN** variable:

- It must correspond to a valid signal parameter number (i.e. -123 ≤ **ISVN** ≤ -57, -54 ≤ **ISVN** ≤ -8, **ISVN** = 0, 1, 2, 3, and 8 ≤ **ISVN** ≤ 123)
- For positive **ISVN** values, the signal variable will take on the Min, Max, or Exact functional forms, depending upon how **ICN1** and **ICN2** are defined. Refer to Table 6-2 to determine exactly which specific functional forms are allowed for a given signal variable type (columns 7-12)
- For negative **ISVN** values, the signal variable will take on either the CellDiff, TimeDiff or VolAvg functional forms, depending upon how **ICN1** and **ICN2** are defined. Refer to Table 6-2 to determine exactly which specific functional forms are allowed for a given signal variable type (columns 7-12)
- It cannot be set to -55, -56, -1, -2, or -3 since the VolAvg, TimeDiff, and CellDiff forms make no sense in these cases.

Concerning the **ILCN** variable:

- For **ISVN** = 0:
  - **ILCN** can only be -1, 0 or +1. -1 corresponds to the previous timestep size, Δt_{old}; 0 corresponds to the current problem time (the internal etime variable); +1 corresponds to the current timestep size, Δt
- For **ISVN** = 1:
  - **ILCN** must equal 0
- For **ISVN** = 3:
  - If **ILCN is** greater than 0, it must correspond to a valid component number.
  - If **ILCN is** less than 0, it must correspond to a valid control block number.
  - **ILCN** can be equal to 0 if **VARREQSTRING** corresponds to a valid global parameter)

- For **ISVN** = 2, 16, 17:
  - **ILCN** must correspond to a valid control block number
- For |**ISVN**| = 18, 19, 44 through 54, 57, 58, or 108, 118:
  - **ILCN** must only correspond to a **POWER** component or a heat structure component that spawns a **POWER** component
- For |**ISVN**| = 25, 26, 58 through 60, 91, 92, or 123:
  - **ILCN** must only correspond to a HS component
- For |**ISVN**| = 20–23, 27–40, 65–87, 90, 95–101, 104, 105, or 121:
  - **ILCN** must only correspond to a 1D or 3D component
- For |**ISVN**| = 24, 93, or 94:
  - **ILCN** must only correspond to a 1D component
- For |**ISVN**| = 41, 61, 62, or 63:
  - **ILCN** must correspond to a pump component
- For |**ISVN**| = 42, 43, or 64:
  - **ILCN** must correspond to a valve component
- For **ISVN** = 55 or 56:
  - **ILCN** must correspond to a valid trip id number
- For |**ISVN**| = 88, 89, 102, 103:
  - **ILCN** must only correspond to a 1D or HS component
- For |**ISVN**| = 106:
  - **ILCN** must only correspond to a 3D component
- For |**ISVN**| = 107:
  - **ILCN** must correspond to a feedwater heater

Concerning the **ICN1** and/or **ICN2** variables:

- The numerical sign and/or magnitude of **ICN1** and **ICN2** are used to define the functional form of the signal variable.
- **ICN1** and **ICN2** must be specified in proper composite number format when **ILCN** corresponds to a **TEE**, **VESSEL**, or **HTSTR.** See below for a description of what “composite number format” means.
- In those instances where **ICN1** or **ICN2** correspond to a geometric location in a component, they must be within the allowable cell (or face, node, level, row, or rod) bounds for that component
- For |**ISVN**| = 0, 1, 2, 16, 17, 18, 19, 41–64, 102, 103, or 107:

- Both **ICN1** and **ICN2** must always be zero. There is no need to define a cell number for these signal parameters since they are unique for a given component/trip/control block.
- When **ISVN** is negative, the signal variable has the **TimeDiff** form
- When **ISVN** is positive, the signal variable has the **Exact** form.

• For **ISVN** = 3:

- **ICN2** must always be zero. A generic signal variable always only refers to a single location in the computational mesh
- In cases where **ILCN** refers to a **TEE** component, **ICN1** should NOT be entered in composite format. See below for a description of what "composite number format" means. Rather, the user must explicitly account for the fact that a ghost cell exists between the end of the primary cells and start of secondary cells. In other words, in a **TEE** with 3 primary cells and 1 secondary cell, cell number 4 is a phantom cell with cell 5 referring to the secondary cell. This means if a user attempts to set ICN1 = 4 (for this example), the data that is printed to the output file will be erroneous. This is only true for cell-centered parameters. Cell-edged numbering behaves normally; there are no phantom edges.

• For |**ISVN**| = 21–40, 65–101, 104, or 105:

- **ICN1** and **ICN2** may never both be zero at the same time
- When **ISVN** is positive,
  - The signal variable is the exact parameter value (Exact form) in cell |**ICN1**| when **ICN2** = 0 or in cell |**ICN2**| when **ICN1** = 0;
  - The signal variable is the maximum parameter value (Maximum form) between cells |**ICN1**| and |**ICN2**| when **ICN1** > 0 and **ICN2** > 0;
  - The signal variable is the minimum parameter value (Minimum form) between cells |**ICN1**| and |**ICN2**| when **ICN1** < 0 and **ICN2** < 0;
  - The signal variable is the volume-averaged parameter value (VolAvg form) between cells |**ICN1**| and |**ICN2**| when **ICN1** and **ICN2** are of opposite signs EXCEPT that volume averaging is not allowed for edge-based or surface-based signal variables
  - Volume averaging logic for signal variables 25 & 26 is currently not working correctly. Please do not attempt to use.
- When **ISVN** is negative
  - **ICN1** & **ICN2** must never be negative
  - The signal variable is the difference in the parameter value since the last time step (TimeDiff form) in location **ICN1** or **ICN2** when either **ICN1** or **ICN2** is 0.
  - The signal variable is the difference in the parameter value between locations **ICN1** and **ICN2** (CellDiff form) (that is, the parameter value in location corresponding to the smaller of **ICN1** and **ICN2** minus the parameter value in

location corresponding to the larger of **ICN1** and **ICN2**) when both **ICN1** and **ICN2** are non-zero.

- for |**ISVN**| = 106:
  - **ICN1** must be positive and **ICN2** must always be zero
  - **ICN1** corresponds to the azimuthal sector id of the outmost ring of the **VESSEL**. 'id' is between 1 and the total number of azimuthal sectors. This value does not conform to the normal VESSEL composite number scheme followed by other signal variables
- For |**ISVN**| = 121:
  - Both **ICN1** and **ICN2** must always be positive and non-zero
  - For 1D components, the user should just specify the two cells between which the two-phase level should be calculated. In 3D components, the values that the user provides for the cell number and level number (in composite format - see below for a description of what "composite number format" means), provide the code with a set of bounds to loop over when determining the location of the two-phase level. The user should take care to ensure that the cell number is identical both **ICN1** and **ICN2**, otherwise an error will be produced (this ensures that the level is determined over a single stack of vertical 3D cells).
  - The zero elevation is referenced to the bottom of the lower-most cell that you specify, not the bottom of the component. This means that if you set cell 2 as the bottom-most cell, you will need to add-in the height of cell 1 yourself if you are comparing to data that uses the bottom of the component as the zero elevation point.
  - At this point, the code will not allow the user to retrieve the two-phase level from components/cells that are, in any way, horizontal (not perfectly vertical). As such, the user should take special care to not specify a range of cells that includes GRAV terms not equal to plus or minus one.
  - **ICN1** and **ICN2** must both be contained in the same mesh segment (i.e they may not span a secondary cell and primary cell in a **TEE**-based component)
- For |**ISVN**| = 20:
  - Both **ICN1** and **ICN2** must always be positive and non-zero
  - For 1D components, the user should just specify the two cells between which the level should be calculated. In 3D components, the values that the user provides for the cell number and level number (in composite format - see below for a description of what "composite number format" means), provide the code with a set of bounds to loop over when calculating the collapsed level. For example, if the **VESSEL** being modeled has two rings and four theta cells per level (8 total cells), and if the user indicates cell 2 in **ICN1** (ring 1, theta sector 2) and cell 7 (ring 2, theta sector 3) in **ICN2**, then for each of the levels the user provides, the code will calculate the collapsed level for all the cells bounded by rings 1 and 2 and theta sectors 2 and 3 (cells 2, 3, 6 and 7).

- At this point, the code will not allow the user to retrieve the collapsed liquid level from components/cells that are, in any way, horizontal (not perfectly vertical). As such, the user should take special care to not specify a range of cells that includes GRAV terms not equal to plus or minus one.
- **ICN1** and **ICN2** must both be contained in the same mesh segment (i.e they may not span a secondary cell and primary cell in a **TEE**-based component)

• For |**ISVN**| = 88 & 89:
  - Follows the same guidelines as for **ISVN** = 21 – 40, plus the following:
    - The rod numbers must be specified as zero when **ILCN** corresponds to a heat structure
    - The node numbers must be specified at the surface of the rod
    - For rods with thermocouples (ittc = 1), the node numbers must be specified at the outer surface only

• For |**ISVN**| = 91 & 92:
  - Follows the same guidelines as for **ISVN** = 21 – 40, plus the following:
    - The node numbers must be specified at the surface of the rod
    - For rods with thermocouples (ittc = 1), the node numbers must be specified at the outer surface only

• For |**ISVN**| = 119 & 120:
  - ILCN, IOCMP, ICN2 = 0:
    - ICN1 is given in composite number format such that ICN1 = (1000000 * I) + (1000 * J) + K

Concerning the **VARREQSTRING** variable:

• This variable can only be input for signal variables with **ISVN** = 3

• It must be prepended with the string “lu” in order to be considered valid (akin to units input parameters)

Special Input Requirements

• For |**ISVN**| = 88, 89, 91, and 92:
  - The number of nodes in the associated component must be greater than one (otherwise indicates lumped parameter solution, hence no surface to couple the signal to.

• For **ISVN** = 3:
  - The code will check to see if units information is available for the parameter specified by **VARREQSTRING**. If it is, then the proper units label will be written to the output file. If not, then a warning will be given noting that units information is not

available and it will be up to the user to ensure the units are what they expect them to be.

- For |**ISVN**| = 15:
  - The **ITDMR** NAMELIST variable must be non-zero
- For |**ISVN**| = 18,19,44 through 54, 57, and 58:
  - The associated rod components must be powered
- For |**ISVN**| = 20:
  - The range of cells of interest must be perfectly vertical (grav array = +1 or -1)
- For |**ISVN**| = 24:
  - The number of nodes in the associated component must be greater than zero
- For |**ISVN**| = 25, 26, 88, and 89:
  - The reflood option in the associated rod component must be turned off
- For |**ISVN**| = 121:
  - The level tracking namelist options NOLT1D and NOLT3D should be 0 or -1, otherwise the calculated level location will most likely be 0.0 m (ft).

For the **VESSEL**, **TEE** (side tube), or **HTSTR** components, cells |**ICN1**| and |**ICN2**| are defined by a composite number format. For the **VESSEL**, the composite number is the horizontal-plane cell number times 1000 plus the axial level number; for the **TEE** side tube, it is the total number of primary-side cells plus the secondary-side cell number; for the **HTSTR**, it is the node number times 1000000 plus the **ROD** or **SLAB** element number times 1000 plus the axial node-row number. Refer to the TRACE Theory Manual for further information on defining cell and interface location composite numbers. It should be noted that in the case of the generic signal variable (**ISVN**=3), when **ILCN** refers to a **TEE**, **ICN1** is NOT input in composite format. Instead it is up to the user to explicity account for the ghost cell that occurs in **TEE** component.

There are some fundamental differences between **ISVN** = 20, **ISVN** = 106, and **ISVN** = 121 that the user should be aware of. In essence, **ISVN** = 20 is determined using a volume-weighted technique whereby the volume of liquid is summed for all the specified cells, and this quantity is used to repeatedly fill the specified cells from the lowest point to the highest point, until there is not enough liquid left to completely fill the next axial volume. At that point the remaining liquid volume is divided by the axial level volume and this ratio is multiplied by the cell height to determine the physical location of the level within that axial volume. Some traits of this signal type are:

- This signal type more truly represents a real “collapsed” height of liquid (over that of **ISVN** = 106) because it accounts for the fact that the volumes of the axial cells/volumes may not be constant.
- In a **VESSEL**, the level is smeared across all specified cells within each axial level. This smearing does not take into account the effects from flow restrictions in the radial and theta directions.

- It will not accurately determine the collapsed level height if the cell where the level resides has a non-uniform flow area.

Alternatively, **ISVN** = 106 is calculated simply by summing the volume fraction times the cell height for each cell in the specified range of a specified **VESSEL** theta column in the downcomer region. The traits of this signal type are:

- The level calculation is not the true collapsed level because it takes no account for differences in flow area or volume
- it only considers one theta column at a time from the bottom of the downcomer (as defined in the VESSEL input by the IDCL variable) to the very top of the VESSEL.
- it corresponds to how the water level is actually measured in a real reactor. As a result, it is recommended that this water level signal type always be used when creating level setpoints in models of actual reactor scenarios.

ISVN=121 corresponds to the location of the two-phase water level in some specified range of axial cells (either 1D or 3D), as calculated by the level tracking model. As such, this signal variable will only produce useful output if the 1D or 3D level tracking model is actually engaged in the component of interest (see the namelist options NOLT1D and/or NOLT3D). The user specifies a range of stacked axial cells over which to determine where the level exists. The code will loop over this range of cells, look at the values contained in the PHIL graphics variable to determine which cell contains the level and figure out the axial elevation from there. The traits of this signal variable type are

- The zero reference elevation is taken at the bottom of the specified range of cells, not the bottom of the component.
- In VESSEL components, the level is determined over a single column of theta cells whose range is specified by the user. Any attempt to specify a range of cells that includes more than one column of theta cells will generate an input error.
- No attempt is made to account for flow blockages that might exist in the axial direction (as might be the case in the outer ring of BWR vessel in which the flow area between the downcomer and lower plenum is blocked). The code simply locates the lowest predicted water level in the given range of cells and uses the bottom-most cell to establish the zero elevation reference point.
- Forgetting for a moment how unphysical it might actually be, if the conditions are such that the level tracking model predicts more than one water level in the range of specified cells (this could happen if the void fraction criteria used in the level tracking model are too loose), this signal variable will only identify the location of the bottom-most water level.
- The value for this signal variable will drop to zero if the level moves outside the range of specified cells (in either direction). This is due to a nuance of how the internal level tracking data structures operate and cannot be fixed without substantial changes to the level tracking model. This behavior can be rectified by filtering the signal variable output through a control system if it becomes a problem.

- You may, on occasion, notice minor discrepancies between the predicted maximum level location as compared to the expected value. In those cases, you should check the maximum timestep size and/or graphics edit interval to ensure there is enough resolution in those parameters to ensure the code is capturing a value with sufficient accuracy for your application.

Table 6-2 gives a summary of the input specifications for each signal variable. It can be used as a quick reference guide to decide whether a given set of input is valid, and whether a specific functional form is available to a given signal variable. Columns 3-6 denote the possible values that a given input parameter can take on. Columns 7-12 denote the specific functional forms available for each signal variable, given the input possibilities laid out in columns 3-6. For column three, a "+/-" indicates the user can specify **ISVN** as a positive or negative number. Column 4 indicates the types of entities a given signal variable can be associated with. Columns 5 and 6 indicate the range of possible values for **ICN1** and **ICN2** depending upon the sign of **ISVN**. In columns 7-12, a grayed out region indicates where the specific functional form is not allowed.

Note that the **POWER** component related signal variables (i.e. reactor power, reactivity, reactivity feedback, etc) must reference a **POWER** component either directly or indirectly. An indirect reference to a **POWER** component would be an **ILCN** that points to an **HTSTR** component that spawns a **POWER** component. A **HTSTR** component in the old **HTSTR** input format (i.e. rod/slab) with isFuelRod (formerly called nopowr) = 0, will result in a spawned **POWER** component. However, a **HTSTR** component in the new **HTSTR** input format cannot spawn a **POWER** component. Power for a **HTSTR** component in the new **HTSTR** input format must be provided by a **POWER** component input by the user rather than a spawned **POWER** component. In **Table 6-2** when **ILCN** values are given as **POWER** or **HTSTR**, it is implied that the **HTSTR** spawns a **POWER** component.

ISVN 119 and 120 are used when coupling TRACE to a 3D kinetics code.

Table 6-2. Summary of signal variable input specifications.

ISVN	Name & Units	sign of ISVN	ILCN	when ISVN is negative,	when ISVN is positive,	Fun		
				ICN1 & ICN2	ICN1 & ICN2	Exact	Cell Diff	Tim Di
0	Problem Time (s)	0	-1 = Δt_{old}; 0 = time; +1 = Δt	are always zero	are always zero	OK		
1	Null Signal Value	+ only	0	are always zero	are always zero	OK		
2	Generic Control Block Output	+ only	Valid cb	are always zero	are always zero	OK		
3	Generic Signal Variable	+ only	0, any component, any control block		icn2 must be zero, icn1 can be zero or correspond to any valid location in the computational mesh	OK		
8	Programmed Reactivity ($\Delta k/k$)	+/-	0	are always zero	are always zero	OK		
9	Pump Motor Torque (Pa-m3, lbf-ft)	+/-	Valid Pump	are always zero	are always zero	OK		OK
10	Energy from Turbine Torque (J, Btu)	+/-	Valid Turbine	are always zero	are always zero	OK		[redacted]
11	Turbine angular speed (rad/s)	+/-	Valid Turbine	are always zero	are always zero	OK		[redacted]
12	Core Average Boron Concentration (kg_{boron}/kg_{water})	+/-	0	are always zero	are always zero	OK		[redacted]
13	Dynamic Reactivity (1D/3D Kinetics) ($\Delta k/k$)	+/-	0	are always zero	are always zero	OK		OK
14	Global Eigen Value (1D/3D Kinetics) (k_{eff})	+/-	0	are always zero	are always zero	OK		OK
15	Total Reactor Power (0D/1D/3D Kinetics) (W, Btu/hr)	+/-	0	are always zero	are always zero	OK		OK
16	Control Rod Position (normalized)	+ only	Valid cb	Control rod bank ID#	are always zero	OK		
17	Control Rod Reactivity ($\Delta k/k$)	+ only	Valid cb	are always zero	are always zero	OK		
18	Core Power (W, Btu/hr)	+/-	POWER or HS	are always zero	are always zero	OK		OK
19	Heat Structure Reactor Power Period (s)	+/-	POWER or HS	are always zero	are always zero	OK		OK
20	Generalized Collapsed Level For Approximate Liquid Inventory Check (m, ft)	+/-	1D or 3D	always positive & non-zero	always positive & non-zero	OK		OK

Table 6-2. Summary of signal variable input specifications. (Continued)

ISVN	Name & Units	sign of ISVN	ILCN	when ISVN is negative,	when ISVN is positive,	Fun		
				ICN1 & ICN2	ICN1 & ICN2	Exact	Cell Diff	Tin Di
21	Pressure (Pa, psia)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
22	Cell Vapor Temperature (K, °F)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
23	Cell Liquid Temperature (K, °F)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
24	1D Inner SurFace Temperature (K, °F)	+/-	HS only	can never be negative	at least one must be non-zero	OK	OK	OI
25	Slab/Rod SurFace Temperature (K, °F)	+/-	HS only	can never be negative	at least one must be non-zero	OK	OK	OI
26	Slab/Rod Temperature (K, °F)	+/-	HS only	can never be negative	at least one must be non-zero	OK	OK	OI
27	Cell Vapor Volume Fraction	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
28	YT-Face Vapor Mass Flow (kg/s, lb_m/hr)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
29	Z-Face Vapor Mass Flow (kg/s, lb_m/hr)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
30	XR-Face Vapor Mass Flow (kg/s, lb_m/hr)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
31	YT-Face Liquid Mass Flow (kg/s, lb_m/hr)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
32	Z-Face Liquid Mass Flow (kg/s, lb_m/hr)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
33	XR-Face Liquid Mass Flow (kg/s, lb_m/hr)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
34	YT-Face Vapor Velocity (m/s, ft/s)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
35	Z-Face Vapor Velocity (m/s, ft/s)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
36	XR-Face Vapor Velocity (m/s, ft/s)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
37	YT-Face Liquid Velocity (m/s, ft/s)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
38	Z-Face Liquid Velocity (m/s, ft/s)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
39	XR-Face Liquid Velocity (m/s, ft/s)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI
40	Boron Concentration (kg_{Boron}/kg_{water})	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OI

Table 6-2. Summary of signal variable input specifications. (Continued)

ISVN	Name & Units	sign of ISVN	ILCN	when ISVN is negative,	when ISVN is positive,	Fun		
				ICN1 & ICN2	ICN1 & ICN2	Exact	Cell Diff	Tim Di
41	Pump Rotational Speed (rad/s, rpm)	+/-	Valid Pump	are always zero	are always zero	OK		OK
42	Valve-Flow-Area Fraction	+/-	Valid Valve	are always zero	are always zero	OK		OK
43	Valve Stem Position	+/-	Valid Valve	are always zero	are always zero	OK		OK
44	Reactor Mult. Constant, Keff	+/-	POWER or HS	are always zero	are always zero	OK		OK
45	Programmed Delta-K	+/-	POWER or HS	are always zero	are always zero	OK		OK
46	Total Feedback Delta-K	+/-	POWER or HS	are always zero	are always zero	OK		OK
47	Fuel Temp Feedback Delta-K	+/-	POWER or HS	are always zero	are always zero	OK		OK
48	Coolant Temp Feedback Delta-K	+/-	POWER or HS	are always zero	are always zero	OK		OK
49	Void Fraction Feedback Delta-K	+/-	POWER or HS	are always zero	are always zero	OK		
50	Boron Conc. Feedback Delta-K	+/-	HS only	are always zero	are always zero	OK		
51	Power Weighted Core Avg Fuel Temperature used for Reactivity Feedback (K, °F)	+/-	POWER or HS	are always zero	are always zero	OK		
52	Power Weighted Core Avg Coolant Temperature used for Reactivity Feedback (K, °F)	+/-	POWER or HS	are always zero	are always zero	OK		OK
53	Power Weighted Core Avg Void Fraction used for Reactivity Feedback	+/-	POWER or HS	are always zero	are always zero	OK		OK
54	Power Weighted Core Avg Boron Concentration used for Reactivity Feedback	+/-	POWER or HS	are always zero	are always zero	OK		OK
55	Trip Signal Value	+ only	Valid trip ID	are always zero	are always zero	OK		
56	Trip Set Status Value	+ only	Valid trip ID	are always zero	are always zero	OK		
57	Prompt-Fission Power (W, Btu/hr)	+/-	POWER or HS	are always zero	are always zero	OK		OK
58	Decay Heat Power (W, Btu/hr)	+/-	POWER or HS	are always zero	are always zero	OK		OK
59	Avg Slab/Rod Max SurFace Temp (K, °F)	+/-	HS only	are always zero	are always zero	OK		OK

Table 6-2. Summary of signal variable input specifications. (Continued)

ISVN	Name & Units	sign of ISVN	ILCN	when ISVN is negative,	when ISVN is positive,	Fun		
				ICN1 & ICN2	ICN1 & ICN2	Exact	Cell Diff	Time Diff
60	Add. Slab/Rod Max SurFace Temp (K, °F)	+/-	HS only	are always zero	are always zero	OK		OK
61	Pump head (m^2/s^2, lb_f*ft/lb_m)	+/-	Valid Pump	are always zero	are always zero	OK		OK
62	Pump Hydraulic Torque (Pa*m^3, lb_f*ft)	+/-	Valid Pump	are always zero	are always zero	OK		OK
63	Pump Momentum Source (m^2/s^2, lb_f*ft/lb_m)	+/-	Valid Pump	are always zero	are always zero	OK		OK
64	Valve Hydraulic Diameter (m, ft)	+/-	Valid Valve	are always zero	are always zero	OK		OK
65	YT-Face Hydraulic Diameter (m, ft)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
66	Z-Face Hydraulic Diameter (m, ft)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
67	XR-Face Hydraulic Diameter (m, ft)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
68	YT-Face Mix Mass Flow (kg/s, lb_m/hr)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
69	Z-Face Mix Mass Flow (kg/s, lb_m/hr)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
70	XR-Face Mix Mass Flow (kg/s, lb_m/hr)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
71	YT-Face Mix Avg Velocity (m/s, ft/s)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
72	Z-Face Mix Avg Velocity (m/s, ft/s)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
73	XR-Face Mix Avg Velocity (m/s, ft/s)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
74	Cell Vapor Density (kg/m^3, lb_m/ft^3)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
75	Cell Liquid Density (kg/m^3, lb_m/ft^3)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
76	Cell mixture Density (kg/m^3, lb_m/ft^3)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
77	Cell Air Density (kg/m^3, lb_m/ft^3)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
78	Cell Air mass (kg, lb_m)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK

Table 6-2. Summary of signal variable input specifications. (Continued)

ISVN	Name & Units	sign of ISVN	ILCN	when ISVN is negative,	when ISVN is positive,	Fun		
				ICN1 & ICN2	ICN1 & ICN2	Exact	Cell Diff	Tim Di
79	Cell Air pressure (Pa, psia)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
80	Cell Air internal energy (J/kg, Btu/lb_m)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
81	Cell Vapor internal energy (J/kg, Btu/lb_m)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
82	Cell Liquid internal energy (J/kg, Btu/lb_m)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
83	Cell Sat Temp Based on Steam P (K, °F)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
84	Cell Sat Temp Based on Total P (K, °F)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
85	Cell Vapor specific heat [J/(kg K), $Btu/(lb_m$ F)]	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
86	Cell Liquid specific heat [J/(kg K), $Btu/(lb_m$ F)]	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	[redacted]	[redacted]
87	Cell Latent Heat of Vaporization (J/kg, Btu/lb_m)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	[redacted]	[redacted]
88	Total SurFace Heat Loss to Vapor (W, Btu/hr)	+/-	1D or HS	can never be negative	at least one must be non-zero	OK	[redacted]	[redacted]
89	Total SurFace Heat Loss to Liquid (W, Btu/hr)	+/-	1D or HS	can never be negative	at least one must be non-zero	OK	OK	OK
90	Cell Vap/Liq Interfacial Heat Flow (W, Btu/hr)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
91	Slab/rod Vapor HTC [W/(m^2 K), Btu/(ft^2 F hr)]	+/-	HS only	can never be negative	at least one must be non-zero	OK	OK	OK
92	Slab/rod Liquid HTC [W/(m^2 K), Btu/(ft^2 F hr)]	+/-	HS only	can never be negative	at least one must be non-zero	OK	OK	OK
93	Cell Slab Vapor HTC [W/(m^2 K), Btu/(ft^2 F hr)]	+/-	1D only	can never be negative	at least one must be non-zero	OK	OK	OK
94	Cell Slab Liquid HTC [W/(m^2 K), Btu/(ft^2 F hr)]	+/-	1D only	can never be negative	at least one must be non-zero	OK	OK	OK
95	Cell Interfacial Area*Vap HTC [W/(m^2 K), Btu/(ft^2 F hr)]	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
96	Cell Interfacial Area*Liq HTC [W/(m^2 K), Btu/(ft^2 F hr)]	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
97	YT-Face Interfacial Drag Coeff (kg/m^4, lbm/ft^4)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK

Table 6-2. Summary of signal variable input specifications. (Continued)

ISVN	Name & Units	sign of ISVN	ILCN	when ISVN is negative,	when ISVN is positive,	Fun		
				ICN1 & ICN2	ICN1 & ICN2	Exact	Cell Diff	Tim Di
98	Z-Face Interfacial Drag Coeff (kg/m^4, lbm/ft^4)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
99	XR-Face Interfacial Drag Coeff (kg/m^4, lbm/ft^4)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
100	Cell Plated Solute Conc (kg/m^3, lb$_m$/ft^3)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
101	Cell Vapor Gen Rate (kg/s-m^2, lbm/hr-ft^3)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
102	Total Inner SurFace Heat Loss (W, Btu/hr)	+/-	1D or HS	are always zero	are always zero	OK		OK
103	Total Outer SurFace Heat Loss (W, Btu/hr)	+/-	1D or HS	are always zero	are always zero	OK		OK
104	Mixture Temperature (K, °F)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
105	Mixture Enthalpy (J/kg, Btu/lb$_m$)	+/-	1D or 3D	can never be negative	at least one must be non-zero	OK	OK	OK
106	BWR D/C Collapsed level (m, ft)	+/-	3D only	always positive & non-zero	are always zero	OK		OK
107	Feedwater Heater Shell-Side Level (m, ft)	+/-	Valid Heatr	are always zero	are always zero	OK		OK
108	Total Reactivity (deltak/k)	+/-	POWER or HS	are always zero	are always zero	OK		OK
109	Programmed Reactivity (deltak/k)	+/-	POWER or HS	are always zero	are always zero	OK		OK
110	Total Feedback Reactivity (deltak/k)	+/-	POWER or HS	are always zero	are always zero	OK		OK
111	Core Avg Fuel Temp Fdbk. Reactivity (deltak/k)	+/-	POWER or HS	are always zero	are always zero	OK		OK
112	Core Avg Coolant Temp Fdbk. Reactivity (deltak/k)	+/-	POWER or HS	are always zero	are always zero	OK		OK
113	Core Avg Void Fraction Fdbk. Reactivity (deltak/k)	+/-	POWER or HS that spawns a POWER	are always zero	are always zero	OK		OK
114	Core Avg Boron Conc. Fdbk. Reactivity (deltak/k)	+/-	POWER or HS that spawns a POWER	are always zero	are always zero	OK		OK

Table 6-2. Summary of signal variable input specifications. (Continued)

ISVN	Name & Units	sign of ISVN	ILCN	when ISVN is negative,	when ISVN is positive,	Fun		
				ICN1 & ICN2	ICN1 & ICN2	Exact	Cell Diff	Tim Di
115	Vol. Weighted Core Avg Fuel Temp (K, °F)	+/-	POWER or HS that spawns a POWER	are always zero	are always zero	OK		OK
116	Vol. Weighted Core Avg Coolant Temp (K, °F)	+/-	POWER or HS that spawns a POWER	are always zero	are always zero	OK		OK
117	Vol. Weighted Core Avg Void Fraction	+/-	POWER or HS that spawns a POWER	are always zero	are always zero	OK		OK
118	Vol. Weighted Core Avg Boron Conc	+/-	POWER or HS that spawns a POWER	are always zero	are always zero	OK		OK
119	3-D kinetics nodal power distribution (W, Btu/hr)	+	PW3D	are always zero	are always zero	OK		
120	Simulated LPRM reading (W, Btu/hr)	+	PW3D	are always zero	are always zero	OK		
121	Two-phase level location (m, ft)	+/-	1D & 3D only	always positive & non-zero	always positive & non-zero	OK		[redacted]
122	Axial power distribution (W, Btu/hr)	+/-	POWER or HS	are always zero	are always zero	OK		[redacted]
123	Axial surface heat flux distribution (W/m^2, $Btu/hr\text{-}ft^2$)	+/-	POWER or HS	are always zero	are always zero	OK		OK

User-Defined Units Data

When one or more of the NAMELIST variables **IOGRF**, **IOINP**, **IOLAB**, and **IOOUT** [for input/output (I/O) of data with SI/English units] is nonzero such that **IOALL** = |**IOGRF**|+|**IOINP**|+|**IOLAB**|+ |**IOOUT**| ≠ 0, the TRACE user is required to input the units-name labels of selected user-defined control-block and trip parameters. When **IOALL** = 0, the TRACE user does not input the units-name labels of these parameters. This allows previous input-data files to be used without modification. Because TRACE then does not know the units of these user-defined parameters, TRACE performs no units conversion on these parameters and outputs the symbol * when their units symbol is to be output (when NAMELIST variable **IOOUT** = 1). **Table 6-3** shows the units-name labels (left-most column beginning with the letters LU) defined in TRACE which the user may use to define the units of these parameters. If the units of some user-defined control-block or trip parameters cannot be defined by this internal set, the user must then input the additionally required units-name labels.

Table 6-3. Units Names, Units, and Conversion Factors for Control Block and Trip Parameters.

Units Name	SI Units	English Units	Factor	Number, Description
lunounit	(-)	(-)	1.00000000e+00	1, no units
lutime	s	s	1.00000000e+00	2, time
Note: lutemp has a UShift value of -459.67 °R. The UShift value for the other units is zero.				
lutemp	K	F	1.80000000e+00	3, temperature
lutempd	K	F	1.80000000e+00	4, differential temperature
lulength	m	ft	3.28083990e+00	5, length
luarea	m^2	ft^2	1.07639104e+01	6, area
luvolume	m^3	ft^3	3.53146667e+01	7, volume
luvel	m/s	ft/s	3.28083990e+00	8, velocity
luacc	m/s^2	ft/s^2	3.28083990e+00	9, acceleration
lupumphd	$m2/s^2$	lb_f*ft/lb_m	3.34552563e-01	10, pump head

User-Defined Units Data

Table 6-3. Units Names, Units, and Conversion Factors for Control Block and Trip Parameters. (Continued)

Units Name	SI Units	English Units	Factor	Number, Description
luvolflw	m^3/s	GPM	1.58503222e+04	11, volumetric flow
luspvol	m^3/kg	ft^3/lbm	1.60184634e+01	12, specific volume
lumass	kg	lb_m	2.20462262e+00	13, mass
lumassfw	kg/s	lb_m/hr	7.93664144e+03	14, mass flow
lumfwrat	kg/s^2	lb_m/s^2	2.20462262e+00	15, mass flow rate
lumassfx	$kg/(m^2*s)$	$lb_m/(ft^2*hr)$	7.37338117e+02	16, mass flux
luvapgen	$kg/(m^3*s)$	$lb_m/(ft^3*hr)$	2.24740658e+02	17, vapor generation rate
luden	kg/m^3	lb_m/ft^3	6.24279606e-02	18, density
luddendt	$(kg/m^3)/K$	$(lb_m/ft^3)/F$	3.46822003e-02	19, density per unit temperature
luidrag	kg/m^4	lb_m/ft^4	1.90280424e-02	20, drag
lupressa	Pa	psia	1.45037738e-04	21, absolute pressure
lupressd	Pa	psid	1.45037738e-04	22, differential pressure
luprsrat	Pa/s	psi/s	1.45037738e-04	23, derivative pressure
luminert	$kg*m^2$	lb_m*ft^2	2.37303604e+01	24, mass inertia
lutorque	$Pa*m^3$	lb_f*ft	7.37562149e-01	25, torque
lubtork	$(Pa*m^3)/(rad/s)$	$(lb_f*ft)/rpm$	7.72373277e-02	26, torque per unit radial velocity
luctork	$(Pa*m^3)/(rad/s)^2$	$(lb_f*ft)/rpm^2$	8.08827404e-03	27, torque per unit radial velocity squared
lupower	W	Btu/hr	3.41214163e+00	28, power

Table 6-3. Units Names, Units, and Conversion Factors for Control Block and Trip Parameters. (Continued)

Units Name	SI Units	English Units	Factor	Number, Description
lupowrat	W/s	(Btu/hr)/s	3.41214163e+00	29, derivative power
lulinhts	W/m	(Btu/hr)/ft	1.04002077e+00	30, linear heat rate
luheatfx	W/m^2	$(Btu/hr)/ft^2$	3.16998331e-01	31, heat flux
luvolhts	W/m^3	$(Btu/hr)/ft^3$	9.66210912e-02	32, volumetric power
luthcond	W/(m*K)	$Btu/(ft*^oF*hr)$	5.77789317e-01	33, thermal conductivity
luhtc	$W/(m^2*K)$	$Btu/(ft^2*^oF*hr)$	1.76110184e-01	34, convective heat transfer coefficient
luihttf	W/K	$(Btu/hr)/^oF$	1.89563424e+00	35, power per unit temperature
luenergy	J	Btu	9.47817120e-04	36, energy
luspener	J/kg	Btu/lb_m	4.29922614e-04	37, specific energy
luspheat	(J/kg)/K	$(Btu/lb_m)/^o\mathbf{F}$	2.38845897e-04	38, specific energy per unit temperature
lurtime	1/s	1/s	1.00000000e+00	39, per unit time
lurtemp	1/K	$1/^oF$	5.55555556e-01	40, per unit temperature
lurmass	1/kg	1/lbm	4.53592370e-01	41, per unit mass
lurpress	1/Pa	1/psi	6.89475729e+03	42, per unit pressure
luspeed	rad/s	rpm	9.54929659e+00	43, angular velocity
luradacc	rad/s^2	rpm/s	9.54929659e+00	44, angular acceleration
luangle	rad	deg	5.72957795e+01	45, angle
luburnup	MWd/MTU	MWd/MTU	1.00000000e+00	46, burnup

User-Defined Units Data

Table 6-3. Units Names, Units, and Conversion Factors for Control Block and Trip Parameters. (Continued)

Units Name	SI Units	English Units	Factor	Number, Description
luenfiss	mev/fiss	mev/fiss	1.00000000e+00	47, energy per fission
lugapgas	g-moles	**g-moles**	1.00000000e+00	48, molar density
lurtmsq	$1/K^2$	$1/(^oF)^2$	3.08641975e-01	49, inverse temperature squared
lunitnam	arbitrary	arbitrary	1.00000000e+00	50, arbitrary units
lume	m^2/s^2	ft^2/s^2	1.07639104e+01	51, mechanical energy per unit mass
luhtca	W/K	Btu/(^{o}F*hr)	1.895650021e+00	52, convective heat transfer coefficient multiplied by area
luviscos	kg/(m*sec)	lb_m/(ft*hr)	2.418940000e+03	53, viscosity
lusurftn	N/m	lb_f/ft	6.851874429e-02	54, surface tension
ludenkm1	$(kg/m^3)/K$	$(lb_m/ft^3)/^oF$	0.624279606e-01*0.555555556	55, density/temp
ludenkm2	$(kg/m^3)/K^2$	$(lb_m/ft^3)/^oF^2$	0.624279606e-01*0.555555556**2	56, density/temp**2
ludenkm3	$(kg/m^3)/K^3$	$(lb_m/ft^3)/^oF^3$	0.624279606e-01*0.555555556**3	57, density/temp**3
ludenkm4	$(kg/m^3)/K^4$	$(lb_m/ft^3)/^oF^4$	0.624279606e-01*0.555555556**4	58, density/temp**4
ludenk	$(kg*K)/m^3$	$(lb_m*^oF)/ft^3$	0.6242796062e-01*0.180e+01	59, density*temp
lushtkm2	$(J/kg)/K^2$	$(Btu/lb_m)/^oF^2$	0.238845897e-03*0.555555556	60, specific energy per unit temperature**2

Table 6-3. Units Names, Units, and Conversion Factors for Control Block and Trip Parameters. (Continued)

Units Name	SI Units	English Units	Factor	Number, Description
lushtkm3	(J/kg)/K^3	(Btu/lb$_m$)/^{o}F^3	0.238845897e-03*0.555555556**2	61, specific energy per unit temperature**3
lushtkm4	(J/kg)/K^4	(Btu/lb$_m$)/^{o}F^4	0.238845897e-03*0.555555556**3	62, specific energy per unit temperature**4
lushtkm5	(J/kg)/K^5	(Btu/lb$_m$)/^{o}F^5	0.238845897e-03*0.555555556**4	63, specific energy per unit temperature**5
luthcdk1	W/(m*K^2)	Btu/(ft*F^2*hr)	0.577789317*0.555555556	64, thermal conductivity per per unit unit temperature
luthcdk2	W/(m*K^3)	Btu/(ft*^{o}F^3*hr)	0.577789317*0.555555556**2	65, thermal conductivity per unit temperature**2
luthcdk3	W/(m*K^4)	Btu/(ft*^{o}F^4*hr)	0.577789317*0.555555556**3	66, thermal conductivity per unit temperature**3
luthcdk4	W/(m*K^5)	Btu/(ft*^{o}F^5*hr)	0.577789317*0.555555556**4	67, thermal conductivity per unit temperature**4
luthcdk	W/m	Btu/(ft*hr)	0.577789317*1.8	68, thermal conductivity * unit temperature
luemisk3	1/K^3	1/^{o}F^3	0.555555556**3	69, emissivity per unit temperature**3
luemisk4	1/K^4	1/^{o}F^4	0.555555556**4	70, emissivity per unit temperature**4

NAMELIST variable **IUNLAB** (default value is 0) is the user-defined number of these additional labels. When **IUNLAB** > 0, input **IUNLAB** of the following cards to define the additional unit-name labels. User-defined units-name label data are not written to the **trcdmp** file and not read from the **trcrst** file so the user needs to input the user-defined units-name label data to the **tracin** file for all (initial and restart) TRACE calculations.

Card Number 1. (Format 6X, A8, 1X, A13, 1X, A13, 2E14.4) **LULABEL, LUNITSI, LUNITENG, UFACTOR, USHIFT**

Variable	Description
LULABEL	Units-name label beginning with the letters LU followed by one to six non-blank characters (for example, the user might choose the units-name label LUDPDT for the derivative of pressure with respect to temperature, dP/dT).
LUNITSI	The SI-units symbol associated with the units-name label that begins with the letters LU followed by 1 to 11 non-blank characters. TRACE internally removes the LU prefix (required for preinput processing of character-string data) in defining the SI-units symbol for I/0 (for example, LUPA/K defines the SI-units symbol for the derivative of pressure with respect to temperature, dP/dT).
LUNITENG	The English-units symbol associated with the units-name label, which begins with the letters LU followed by 1 to 11 nonblank characters. TRACE internally removes the LU prefix in defining the English-units symbol for I/0 (for example, LUPSID/F defines the English-units symbol for the derivative of pressure with respect to temperature, dP/dT).
UFACTOR	The factor value for converting a parameter value in SI units to its value in English units where Parameter(SI) * UFACTOR + USHIFT = Parameter(English) (for example, UFACTOR = 8.05765E-05 (PSID×K)/(PA×°F) = 1.450377 E-04 PSID/PA divided by 1.8°F/K for the derivative of pressure with respect to temperature, dP/dT).
USHIFT	The shift value for converting a parameter value in SI units to its value in English units where Parameter(SI) *UFACTOR + USHIFT = Parameter(English) (for example, USHIFT = 0.0 PSID/°F for the derivative of pressure with respect to temperature, dP/dT, because pressure and temperature are both difference values rather than absolute values). **Note:** The value of UShift = -459.67 for lutemp in **Table 6-3**, it is zero for all others in the Table.

Control Block Data

Control-block data are defined when **NTCB** > 0 (Word 2 on **Main-Data Card 10**). Control blocks are mathematical functions that operate on 0 or more input parameters defined by signal variables and control blocks. The control-block output signal defines an input parameter for control blocks, a parameter for trip signals, the independent-variable parameter for component-action tables, and the component action directly. Either **NTCB** or fewer control blocks are input. When fewer than **NTCB** control blocks are input, conclude the data with a blank card or a card having a 0 defining the first input parameter, **IDCB** (0 must be entered explicitly if the free-format option is used). The remaining control blocks (for a total of **NTCB**) are obtained from the restart file. They are the control blocks on the restart file whose **IDCB** ID numbers differ from those defined on input. After all control-block data are read from input and obtained from the restart file, the control-blocks are automatically sorted to obtain the optimal order of evaluation, even taking into account possible implicit loops that might exist. Each control block is defined by, at least, two cards. When the control block is a tabular function of 1, 2, or 3 independent variables (**ICBN** = 101 or 102), additional **Card Number 3** data cards are needed to define the function table. When the control block is a PI or PID controller (**ICBN** = 200 or 201), an additional **Card Number 4** is needed.

Card Number 1. (Format 5I14) **IDCB, ICBN, ICB1, ICB2, ICB3**

Variable	Description
IDCB	Control-block ID number (-99000 ≤ **IDCB** ≤ –1).
ICBN	Control-block operation number (1 ≤ **ICBN** ≤ 65, 76, 77, 100 ≤ **ICBN** ≤ 104, or 200 ≤ **ICBN** ≤ 204). Refer to the list at the end of this section for the control-block operation numbers and the mathematical description of the operation each performs.
ICB1	ID number for the first input parameter (X_1) to the control block. **ICB1** > 0 defines a signal-variable parameter; **ICB1** < 0 defines a control-block output parameter.
ICB2	ID number for the second input parameter (X_2) to the control block. **ICB2** > 0 defines a signal-variable parameter; **ICB2** < 0 defines a control-block output parameter. For **ICBN** = 100 or 101, **ICB2** is the number of entry pairs in the control block's function table.
ICB3	ID number for the third input parameter (X_3) to the control block. **ICB3** > 0 defines a signal-variable parameter; **ICB3** < 0 defines a control-block output parameter.

Card Number 2. (Format 5A14) **LUGAIN, LUXMIN, LUXMAX, LUC**

Note:	If |**IOGRF**|+|**IOINP**|+|**IOLAB**|+|**IOOUT**| ≠ 0 (NAMELIST variables), input this card. See **Table 6-2** for a list of unit names and their SI and English units, and SI to English conversion factors and shifts for these control-block parameters

Variable	Description
LUGAIN	Units-name label of the control-block gain factor.
LUXMIN	Units-name label of the control-block minimum value of its output parameter (also defines the units of the control-block output parameter).
LUXMAX	Units-name label of the control-block maximum value of its output parameter (also defines the units of the control-block output parameter).
LUCON1	Units-name label of the control-block first constant.
LUCON2	Units-name label of the control-block second constant.

Card Number 3. (Format 2A12) **IDSTRING, CBTITLE**

Note:	Input this card only if **ICBN** = -9. **ICBN** = -9 specifies constant value control block. Its value is allowed to change via the SNAP Runtime Intervention.

Variable	Description
IDSTRING	Enter the string “CBTITLE” without quotation marks
CBTITLE	Enter the title of the control block used for identification when using SNAP. Maximum length is 12 characters

Card Number 4. (Format 5E14.4) **CBGAIN, CBXMIN, CBXMAX, CBCON1, CBCON2**

Variable	Description
CBGAIN	Control-block gain factor, G.
CBXMIN	Control-block minimum value of its output parameter.
CBXMAX	Control-block maximum value of its output parameter.

Card Number 4. (Format 5E14.4) **CBGAIN, CBXMIN, CBXMAX, CBCON1, CBCON2**

Variable	Description
CBCON1	Control-block first constant. For **ICBN** = 102, **CBCON1** is a composite number defining the number of values to be input for the function table. For **ICBN** = 103, **CBCON1** is the A_0 additive constant which appears in the summation expression (see **ICBN** number 103 below for more detail).
CBCON2	Control-block second constant is required input for the **ICBN** = 11, 30, 51, 59, 200, and 201 control-block functions. XOUT is initialized by TRACE to its initial evaluated value for control-block functions **ICBN** = 11 and 59. For the Laplace-transform function control blocks, **ICBN** = 26, 30, and 51, XOUT is initialized to **CBGAIN** * XIN(ICB1). For the PI- and PID-controller function control blocks, **ICBN** = 200 and 201, XOUT is initialized to the **CBCON2** value. For all other control-block function **ICBN** values, XOUT is initialized to its initial evaluated value when **CBCON2** is 0.0 or defined by a blank field. Otherwise, XOUT is initialized to the nonzero input specified **CBCON2** value.

Card Number 5. (Format 4A14) **LUYTAB,** (LUXTAB(i), i = 1, n)

Note: If **ICBN** = 101 or 102 (Word 2 on Control-Block Data **Card Number 1**) and **IOALL** = |IOGRF|+|IOINP|+|IOLAB|+|IOOUT| ≠ 0, input this card. The number of entries on this card depend on the number of independent variables defined by the user. An entry for **LUYTAB** and entries for **LUXTAB** must be entered. If **ICBN** = 101, n = 1; if **ICBN** = 102, n = 2 or 3 depending on the number of independent variables. See **Table 6-2** for a list of units-name labels, their SI and English units symbols, and their SI to English conversion factors and shifts for these control-block function table parameters.

This card is units label input for table-input control blocks. There are two table-input control blocks, control block 101 and control block 102. Control block 101 is a table input where the dependent variable is a function of one independent variable; e.g., a table of flow vs. pressure or a table pump rpm vs. time. Control block 102 is a table input where the dependent variable is a function of two or three independent variables e.g., a table of fluid density as a function of pressure and temperature (two independent variables) or a table of fluid density as a function of pressure, temperature, and a composition fraction (three independent variables).

For control block 101, the user only has to input two units-name labels on this card, **LUYTAB** and **LUXTAB(1)**. For example, a table of flow vs. pressure, the input for **LUYTAB** would be `lumassfw` and the input for **LUXTAB(1)** would be `lupressa`. (See **Table 6-2** for the units names).

Variable	Description
LUYTAB	Units-name label of the control-block table dependent-variable values.
LUXTAB(1)	Units-name label of the control-block table first independent-variable values.
LUXTAB(2)	Units-name label of the control-block table second independent-variable values.
LUXTAB(3)	Units-name label of the control-block table third independent-variable values.

Card Number 6. (Load Format) **CBFTAB(I), I = (1, N)**

Note: If ICBN = 101 or 102 (Word 2 on Control-Block Data **Card Number 1**), input this card.		
Variable	**Dimension**	**Description**
CBFTAB	N	Control-block function table data (*,*); input N values where N = 2 × ICB2 for ICBN = 101 or N = $N_1 + N_2 + N_3 + [N_1 \times N_2 \times \max(1,N_3)]$ for ICBN = 102 where CBCON1 = $10000.0 \times N_1 + 100.0 \times N_2 + N_3$ (refer to control block descriptions below for additional information about the defining form of these control blocks).

Card Number 7. (Format 4A14) **LUWTA**

Note: If ICBN = 103 (Word 2 on Control-Block Data **Card Number 1**) and ICB2 = 1 (Word 4 on Control-Block Data **Card Number 1**), and |**IOGRF**|+|**IOINP**|+|**IOLAB**|+|**IOOUT**| ≠ 0 (NAMELIST variables), then input this card. See **Table 6-2** for a list of unit names and their SI and English units, and SI to English conversion factors and shifts for these control-block parametersinput this card.	
Variable	**Description**
LUWTA	Units-name label for all N elements of the WTA array that is input by **Card Number 8**

Card Number 8. **WTA(I), I = (1, N)** Load Format

Note: If ICBN = 103 (Word 2 on Control-Block Data **Card Number 1**), input this card.		
Variable	**Dimension**	**Description**
WTA	N	Weighting factor for each of the parameter values of the N elements of the IDX array that is input by **Card Number 9**.

Card Number 9. (Load Format) **IDX(I), I = (1, N)**

Note: If ICBN = 103 or 104 (Word 2 on Control-Block Data **Card Number 1**), input this card.

Variable	Dimension	Description
IDX	N	ID numbers for the Ith input parameter to the control block whose value is to be weighted and summed or multiplied. IDX(I) > 0 defines a signal variable parameter; IDX(I) < 0 defines a control block output parameter.

Card Number 10. (Format 3E14.4) **CBDT, CBTAU, CBWT**

Note: If ICBN = 200 or 201 (Word 2 on Control-Block Data **Card Number 1**), input this card.

Variable	Description
CBDT	The Δt_d time constant (s) for removal of PI-controller or PID-controller error (where convergence of the form $\Delta F(t) = \Delta F_o \times \exp[(t_o - t)/\Delta t_d]$ is assumed).
CBTAU	The τ time constant (s) for the first-order lag function operation.
CBWT	The first constant Wt value (–) for the weighted summing function operation when ICBN = 201.

In the following control block function operations G is the Gain (CBGAIN word 1 on **Card Number 4**). X1, X2, and X3 are inputs to the control block from output of ICB1, ICB2 and ICB3; respectively; (words 3, 4 and 5 on **Card Number 1**). C1 and C2 are CBCON1 and CBCON2 (word 4 and 5 on **Card Number 4**). Users may note large gaps in the numbering scheme for the ICBN parameter. This is by design; it does not represent a problem with the manual in terms of missing control blocks types.

ICBN = 1. Absolute value (ABSV)

Description: $X_{out} = G \cdot |X_1|$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally.

ICBN = 2. Arccosine (ACOS)

Description: $X_{out} = G \cdot \cos^{-1}(X_1)$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

Control Block Data

- when CBCON2 <> 0.0, the control block’s initial value is set to CBCON2; otherwise, the control block’s initial state is evaluated internally
- the units label of the output value should be an angle (radians or degrees)

ICBN = 3. Add (ADD)

Description: $X_{out} = G \cdot (X_1 + X_2)$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	Yes	ID number of input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block’s initial value is set to CBCON2; otherwise, the control block’s initial state is evaluated internally

ICBN = 4. Integerizer (INT)

Description: $X_{out} = G \cdot REAL(INT(X_1))$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block’s initial value is set to CBCON2; otherwise, the control block’s initial state is evaluated internally

- as per the FORTRAN definition of the INT intrinsic function, if $|X_1| < 1$, then $INT(X_1)$ has the value 0; if $|X_1| >= 1$, then $INT(X_1)$ is the integer whose magnitude is the largest integer that does not exceed the magnitude of X_1 and whose sign is the same as the sign of X_1
- the input signal should be less than or equal to 2.81474976710654d14 to ensure proper integerization. If it is greater than this value, the control block will simply maintain its last calculated value

ICBN = 5. Logical AND (AND)

Description:

$$X_{out} = \begin{cases} G \text{ , if } (X_1 = 1.0) \text{ .AND. } (X_2 = 1.0) \\ 0.0 \text{ , } otherwise \end{cases}$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block’s initial value is set to CBCON2; otherwise, the control block’s initial state is evaluated internally
- The input values given by the ICB1 and ICB2 ID numbers must be logical in nature (0.0 or 1.0)

ICBN = 6. Arcsine (ASIN)

Description: $X_{out} = G \cdot \sin^{-1}(X_1)$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	

ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the units label of the output value should be an angle (radians or degrees)
- if the input value is not within the allowable range of -1.0 to +1.0, the control block will simply maintain it's previously calculated value

ICBN = 7. Arctangent (ATAN)

Description: $X_{out} = G \cdot \tan^{-1}(X_1)$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the units label of the output value should be an angle (radians or degrees)

ICBN = 8. Arctangent 2 (ATN2)

Description: $X_{out} = G \cdot ATAN2(X_1, X_2)$

where ATAN2 is the actual FORTRAN 90 intrinsic function used to evaluate the expression.

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- this result of this function is the principal value of the non-zero complex number (X_2,X_1) formed by the real arguments X_1 and X_2.
- A FORTRAN reference manual should be consulted for a more detailed explanation concerning the behavior of this function.
- the rules of the ATAN2 FORTRAN intrinsic function dictate that if X_1 has the value zero, then X_2 must not have the value zero either

ICBN = 9. Constant (CONS)

Description: $X_{out} = G \cdot C_1$

Notes:

	Required?	Comment
ICB1	No	
ICB2	No	
ICB3	No	
CBCON1	Yes	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the user can optionally set icbn to -9 and provide a control block title. This is used when coupling

TRACE to the VEDA post-processor.

ICBN = 10. Cosine (COS)

Description: $X_{out} = G \cdot \cos(X_1)$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the units label of the input value should be an angle (radians or degrees)

ICBN = 11. Dead band (DEAD)

Description:

$$X_{out} = \begin{cases} G \cdot (X_1 - C_2)\text{ , if } X_1 > C_2 \\ G \cdot (X_1 - C_1)\text{ , if } X_1 < C_1 \\ 0.0\text{ , } otherwise \end{cases}$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	Yes	lower bound of the dead band zone
CBCON2	Yes	upper bound of the dead band zone

- for this control block, the user has no control for specifying the initial value. The code will evaluate it internally
- CBCON2 must be greater than CBCON1 or an input error will result

ICBN = 12. Derivative (DERV)

Description: $X_{out} = G \cdot \frac{d}{dt}(X_1)$

The following functional form is actually used by the computational engine:

$$X_{out} = G \cdot \frac{(X_1^{\ n} - X_1^{\ n-1})}{\Delta t}$$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the control block output is hardwired to 0.0 when the initial value is evaluated internally

ICBN = 13. Double limited integrator (DINL)

Description:

$$X_{out} = \begin{cases} G \cdot \frac{1}{2}\left(\left(\frac{1}{2}X_1\Delta t\right) + X_{sum}\right)\Delta t + X_{out} & \text{, if } C_1 = 1.0 \\ X_{sum}\Delta t + X_{out} & \text{, if } C_1 = 0.0 \end{cases}$$

$$and$$

$$X_{sum} = \begin{cases} \sum_{j=0}^{n-1} \frac{1}{2} X_1^j \Delta t^j & \text{, if } C_1 = 1.0 \\ \sum_{j=0}^{n-1} G \cdot X_1^j \Delta t^j & \text{, if } C_1 = 0.0 \end{cases}$$

where n refers to the current timestep number. This means that X_{sum} is just a summation over all previous timesteps. X_1 and X_{sum} are reset to 0.0 if XOUT is against a limit and the sign of X_1 does not change.

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	Yes	polynomial order of integral
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the control block output is hardwired to 0.0 when the initial value is evaluated internally
- CBCON1 (= 0.0 or 1.0) is the polynomial order for approximating the time dependence of X_1 and its integral

ICBN = 14. Divide (DIV)

Description:

$$X_{out} = \begin{cases} G \cdot \dfrac{X_1}{X_2}, \text{ if } C_1 = 0.0 \\ G \cdot \dfrac{C_1}{X_1}, \text{ if } C_1 \neq 0.0 \end{cases}.$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of the numerator/denominator signal
ICB2	Optional	ID number of the denominator signal - required when CBCON1 = 0.0
ICB3	No	
CBCON1	Optional	use if constant numerator is desired
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- if a constant numerator is desired, then |CBCON1| must be greater than 1.0E-6 (accounts for numerical roundoff close to zero). Otherwise, a value of 0.0 is assumed causing the control block to default to its normal behavior of using the value given by the ICB1 ID number as the numerator

ICBN = 15. Logical exclusive OR (XOR)

Description:

$$X_{out} = \begin{cases} G, \; if\,(X_1 + X_2) = 1.0 \\ 0.0, \; otherwise \end{cases}$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal

Control Block Data

ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- The input values given by the ICB1 and ICB2 ID numbers must be logical in nature (0.0 or 1.0)

ICBN = 16. Logical equivalent (EQV)

Description:

$$X_{out} = \begin{cases} G\ , if\ X_1 = X_2 \\ 0.0\ , otherwise \end{cases}$$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- The input values given by the ICB1 and ICB2 ID numbers must be logical in nature (0.0 or 1.0)

ICBN = 17. Exponential Function (EXP)

Description:

$$X_{out} = G \cdot e^{X_1}$$

Notes:

	Required?	**Comment**

ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the input value given by ICB1 must lie within the range of -675.84 and 741.67, otherwise the previously calculated output value is used

ICBN = 18. Logical flip-flop (FLFP)

Description:

X_{out} = G or 0.0, flip-flop output value that changes whenever X_1 changes state (only if X_3 =1.0)

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	No	
ICB3	Yes	ID number of second input signal
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the control block output is hardwired to 0.0 when the initial value is evaluated internally
- the input values given by the ICB1 and ICB3 ID numbers must be logical in nature (0.0 or 1.0)

ICBN = 19. Gate (GATE)

Description:

$$X_{out} = \begin{cases} G \cdot X_1 \text{ , } if \ X_2 = 1.0 \\ 0.0 \text{ , } if \ X_2 = 0.0 \end{cases}$$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the input value given by the ICB2 ID number must be logical in nature (0.0 or 1.0)

ICBN = 20. Greater than or equal to (GREQ)

Description:

$$X_{out} = \begin{cases} G \text{ , } if \ X_1 \geq X_2 \\ 0.0 \text{ , } otherwise \end{cases}$$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 21. Greater than (GRTH)

Description:

$$X_{out} = \begin{cases} G \text{ , } if \ X_1 > X_2 \\ 0.0 \text{ , } otherwise \end{cases}$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 22. Input switch (INSW)

Description:

$$X_{out} = \begin{cases} G \cdot X_1 \text{ , } if \ X_3 = 1.0 \\ G \cdot X_2 \text{ , } if \ X_3 = 0.0 \end{cases}$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	Yes	ID number of third input signal
CBCON1	No	

CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- The input value given by the ICB3 ID number must be logical in nature (0.0 or 1.0)

ICBN = 23. Integrate (INTG)

Description:

$$X_{out} = \begin{cases} G \cdot \left(\frac{1}{2} X_1 \Delta t\right) + X_{out} \text{ , } if \; C_1 = 1.0 \\ G \cdot (X_1 \Delta t) + X_{out} \text{ , } if \; C_1 = 0.0 \end{cases}$$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	Yes	polynomial order of approximation
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the control block output is hardwired to 0.0 when the initial value is evaluated internally
- CBCON1 = 0.0 or 1.0 is the polynomial order for approximating the time dependence of X_1

ICBN = 24. Integrate with mode control (INTM)

Description:

$$X_{out} = \begin{cases} 0.0 \text{ , } if \; (X_2 + X_3) = 0.0, \text{ reset mode} \\ X_{out} \text{ , } if \; (X_2 + X_3) = 1.0, \text{ hold mode} \\ G \cdot \left(\frac{1}{2} X_1 \Delta t\right) + X_{out} \text{ , } if \; (X_2 + X_3) = 2.0, \text{ integrate mode} \end{cases}$$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	Yes	ID number of third input signal
CBCON1	Yes	polynomial order of approximation
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the control block output is hardwired to 0.0 when the initial value is evaluated internally
- The input values given by the ICB2 and ICB3 ID numbers must be logical in nature (0.0 or 1.0)
- CBCON1 = 0.0 or 1.0 is the polynomial order for approximating the time dependence of X_1

ICBN = 25. Logical inclusive OR (IOR)

Description:

$$X_{out} = \begin{cases} 0.0\ ,\ if\,(X_1 + X_2) = 0.0 \\ G\ ,\ otherwise \end{cases}$$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- The input values given by the ICB1 and ICB2 ID numbers must be logical in nature (0.0 or 1.0)

ICBN = 26. First-order lag transfer function (LAG1)

Description: $X_{out} = X_O(t)$

where $X_O(t)$ is the solution of the first order differential equation

$$C_1 \cdot \frac{d}{dt} X_O(t) + X_O(t) = G \cdot X_1(t)$$

where C_1 is the lag constant, and G is a constant gain factor. In the Laplace transform domain, X_O is given by

$$X_O(s) = \frac{G \cdot X_1(s) + C_1 \cdot X_O(\mathrm{t} = 0)}{C_1 \cdot s + 1}$$

X_O is initialized to $G*X_1$ at t=0.

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	Yes	Lag constant, must be >= 0.0
CBCON2	No	

- the user is not able to specify this control block's initial value - it is given by G*ICB1 at t=0
- if CBCON1 < 0.0, a fatal error is returned
- when CBCON1 = 0.0, X_{out} is given by G*ICB1

ICBN = 27. Logic delay (LDLY)

Description:

$$X_{out} = \begin{cases} 0.0 \text{ , } if\ X_1 = 0.0 \text{ OR time} > (\mathrm{C}_1 + t_s) \\ G \text{ , } if\ X_1 = 1.0 \text{ AND time} \le (C_1 + t_s) \end{cases}$$

where t_s is the time when L_1 switches from 0.0 to 1.0.

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	Yes	constant denoting the delay time
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- The input value given by the ICB1 ID number must be logical in nature (0.0 or 1.0)

ICBN = 28. Logic general-purpose counter (LGPC)

Description:

$$X_{out} = \begin{cases} 0.0 \text{ , } if\ X_3 = 0.0 \text{ , (reset mode)} \\ G \cdot N_{state} \text{ , } if\ X_3 = 1.0 \text{ , (count mode)} \end{cases}$$

where N_{state} = number of times L_1 has changed state since enabled (when $L_3 = 1.0$)

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of first input signal
ICB2	No	
ICB3	Yes	ID number of second input signal
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the control block output is hardwired to 0.0 when the initial value is evaluated internally

- The input values given by the ICB1 and ICB3 ID numbers must be logical in nature (0.0 or 1.0)

ICBN = 29. Logic input switch (LISW)

Description:

$$X_{out} = \begin{cases} G \cdot X_1 \text{ , } if\ X_3 = 1.0 \\ G \cdot X_2 \text{ , } if\ X_3 = 0.0 \end{cases}$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	Yes	ID number of third input signal
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- The input values given by the ICB2, ICB3 and ICB3 ID numbers must be logical in nature (0.0 or 1.0)

ICBN = 30. Lead-lag transfer function (LLAG)

Description: $X_{out} = X_O(t)$

where $X_O(t)$ is the solution of the first order differential equation

$$C_2 \cdot \frac{d}{dt}X_O(t) + X_O(t) = G \cdot \left(C_1 \cdot \frac{d}{dt}X_1(t) + X_1(t)\right)$$

where C_1 is the lead constant (always >= 0.0), C_2 is the lag constant (always >= 0.0), and G is a constant gain factor. In the Laplace transform domain, X_O is given by

$$X_O(s) = \frac{G \cdot X_1(s) \cdot (C_1 \cdot s + 1) + C_2 \cdot X_O(\mathrm{t} = 0) - C_1 \cdot G \cdot X_1(\mathrm{t} = 0)}{C_2 \cdot s + 1}$$

X_O is initialized to $G*X_1$ at t=0.

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	Yes	the lead constant, always >= 0.0
CBCON2	Yes	the lag constant, always >= 0.0

- the user is not able to specify this control block's initial value - it is given by $G*X_1$ at t=0
- CBCON1 and CBCON2 must always be >= 0.0
- if CBCON1 = CBCON2, the output value is given by $G*X_1$ (unless CBCON2 = 0.0)

ICBN = 31. Limited integrator (LINT)

Description:

$$X_{out} = \begin{cases} G \cdot \left(\frac{1}{2} X_1 \Delta t\right) + X_{out} \ , if\ C_1 = 1.0 \\ G \cdot (X_1 \Delta t) + X_{out} \ , if\ C_1 = 0.0 \end{cases}$$

X_1 is set to 0.0 if X_{OUT} is against a limit and the sign of X_1 does not change.

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	Yes	polynomial order of approximation
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the control block output is hardwired to 0.0 when the initial value is evaluated internally
- CBCON1 = 0.0 or 1.0 is the polynomial order for approximating the time dependence of X_1.

ICBN = 32. Natural logarithm (LOGN)

Description: $X_{out} = G \cdot \ln(X_1)$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the signal value associated with the ICB1 ID number should always be > 0.0, otherwise a fatal error will be produced

ICBN = 33. Less than or equal to (LSEQ)

Description: $$X_{out} = \begin{cases} G \text{ , } if(X_1 \le X_2) \\ 0.0 \text{ , } otherwise \end{cases}$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal

ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 34. Less than (LSTH)

Description:

$$X_{out} = \begin{cases} G\ ,\ if(X_1 < X_2) \\ 0.0\ ,\ otherwise \end{cases}$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 35. Maximum of two signals (MAX2)

Description:

$$X_{out} = MAX(X_1\ ,\ X_2)$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	

CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 36. Maximum during transient (MAXT)

Description: $X_{out} = G \cdot MAX(X_1\ , X_1^{max})$

where X_1^{max} is the maximum value of the input signal since the start of the transient

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the control block output is hardwired to X_1 when the initial value is evaluated internally

ICBN = 37. Minimum of two signals (MIN2)

Description: $X_{out} = MIN(X_1\ , X_2)$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	

CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 38. Minimum during transient (MINT)

Description: $X_{out} = G \cdot MIN(X_1 , X_1^{min})$

where X_1^{min} is the minimum value of the input signal since the start of the transient

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the control block output is hardwired to X_1 when the initial value is evaluated internally

ICBN = 39. Multiply (MULT)

Description: $X_{out} = G \cdot X_1 X_2$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	

CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 40. Logical NOT AND (NAND)

Description:

$$X_{out} = \begin{cases} 0.0 \, , \, if\,(X_1 + X_2) = 2.0 \\ G \, , \, otherwise \end{cases}$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- The input values given by the ICB1 and ICB2 ID numbers must be logical in nature (0.0 or 1.0)

ICBN = 41. Logical NOT equal (NEQL)

Description:

$$X_{out} = \begin{cases} G \, , \, if\,(X_1 \neq X_2) \\ 0.0 \, , \, otherwise \end{cases}$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal

ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- The input values given by the ICB1 and ICB2 ID numbers must be logical in nature (0.0 or 1.0)

ICBN = 42. Logical NOT OR (NOR)

Description:

$$X_{out} = \begin{cases} G \text{ , } if\,(X_1 + X_2) = 0.0 \\ 0.0 \text{ , } otherwise \end{cases}$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- The input values given by the ICB1 and ICB2 ID numbers must be logical in nature (0.0 or 1.0)

ICBN = 43. Logical NOT (NOT)

Description:

$$X_{out} = \begin{cases} G \text{ , } if\ X_1 = 0.0 \\ 0.0 \text{ , } if\ X_1 = 1.0 \end{cases}$$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- The input value given by the ICB1 ID number must be logical in nature (0.0 or 1.0)

ICBN = 44. Positive difference (PDIF)

Description:

$$X_{out} = \begin{cases} G \cdot (X_1 - X_2) \ , \ if(\ X_1 > X_2) \\ 0.0 \ , \ otherwise \end{cases}$$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 45. Quantizer (QUAN)

Description:

$$X_{out} = G \cdot NINT(X_1)$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- NINT is the actual F90 intrinsic used - it calculates the nearest integer given a real number, based on standard round-off rules.
- the input signal should be less than or equal to 2.81474976710654d14 to ensure proper quantization. If it is greater than this value, the code will produce a fatal error

ICBN = 46. Ramp (RAMP)

Description:

$$X_{out} = \begin{cases} G \cdot (time - C_1) \text{ , if time} > C_1 \\ 0.0 \text{ , } otherwise \end{cases}$$

Notes:

	Required?	Comment
ICB1	No	
ICB2	No	
ICB3	No	
CBCON1	Yes	constant denoting starting time of ramp operation
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 47. Random number generator (RAND)

Description:

$$X_{out} = \begin{cases} G \cdot RANF \text{, if time} \geq C_1 \\ 0.0 \text{ , } otherwise \end{cases}$$

where $0.0 \leq RANF \leq 1.0$

Notes:

	Required?	**Comment**
ICB1	No	
ICB2	No	
ICB3	No	
CBCON1	Yes	starting time of random number generation
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 48. Sign function (SIGN)

Description:

$$X_{out} = \begin{cases} G \cdot |X_1| \text{ , } if\ X_2 \geq 0.0 \\ -G \cdot |X_1| \text{ , } if\ X_2 < 0.0 \end{cases}$$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	

CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 49. Sine (SIN)

Description: $X_{out} = G \cdot \sin(X_1)$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the units label of input signal, X_1, should be an angle = (rad, deg)

ICBN = 50. Sign inversion (SINV)

Description: $X_{out} = -G \cdot X_1$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	

CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 51. Second-order transfer function (SOTF)

Description: $X_{out} = X_O(t)$

where $X_O(t)$ is the solution of the first order differential equation

$$C_2 \cdot \frac{d^2}{dt} X_O(t) + C_1 \cdot \frac{d}{dt} X_O(t) + X_O(t) = G \cdot X_1(t)$$

where C_1 is the lead constant (always ≥ 0.0), C_2 is the lag constant (always ≥ 0.0), and G is a constant gain factor. In the Laplace transform domain, X_O is given by

$$X_O(s) = \frac{G \cdot X_1(s) \cdot (C_1 \cdot X_O(\mathrm{t}=0)) + C_2 \cdot \left\{ s \cdot X_O(\mathrm{t}=0) + \frac{d}{dt} X_O(t) \Big|_{\mathrm{t}=0} \right\}}{C_2 \cdot s^2 + C_1 \cdot s + 1} \tag{6-1}$$

X_O is initialized to $G*X_1$ at t=0.

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	Yes	the lead constant, always >= 0.0
CBCON2	Yes	the lag constant, always >= 0.0

- the user is not able to specify this control block's initial value - it is given by G*ICB1 at t=0
- CBCON1 and CBCON2 must both be >= 0.0, otherwise an input error will occur

ICBN = 52. Square root (SQRT)

Description: $X_{out} = G \cdot \sqrt{X_1}$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the input value given by the ICB1 ID number should never be negative. If it is, a fatal error is reported

ICBN = 53. Step (STEP)

Description:

$$X_{out} = \begin{cases} G \text{ , if time} \geq C_1 \\ 0.0 \text{ , } otherwise \end{cases}$$

Notes:

	Required?	Comment
ICB1	No	
ICB2	No	
ICB3	No	
CBCON1	Yes	starting time of step operation
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block’s initial state is evaluated internally

ICBN = 54. Subtract (SUBT)

Description: $X_{out} = G \cdot (X_1 - X_2)$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block’s initial value is set to CBCON2; otherwise, the control block’s initial state is evaluated internally

ICBN = 55. Tangent (TAN)

Description: $X_{out} = G \cdot TAN(X_1)$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block’s initial value is set to CBCON2; otherwise, the control block’s initial state is evaluated internally
- the units label of input signal, X_1, should be an angle (radians or degrees)

ICBN = 56. Sum constant (TSCN)

Description: $X_{out} = G \cdot (X_1 + C_1)$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	Yes	constant to be summed with the input signal
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 57. Sum three (TSUM)

Description: $X_{out} = G \cdot (X_1 + X_2 + X_3)$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	Yes	ID number of third input signal
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 58. Variable limiter (VLIM)

Description:

$$X_{out} = \begin{cases} G \cdot X_2 \ , if\ X_1 > X_2 \\ G \cdot X_3 \ , if\ X_1 < X_3 \\ G \cdot X_1 \ , otherwise \end{cases}$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	Yes	ID number of third input signal
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 59. Weighted summer (WSUM)

Description: $X_{out} = G \cdot (C_1 X_1 + C_2 X_2)$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	Yes	weighting factor for the first input signal
CBCON2	Yes	weighting factor for the second input signal

- for this control block, the user has no control for specifying the initial value. The code will evaluate it internally

ICBN = 60. Raise to power (RPOW)

Description:

$$X_{out} = \begin{cases} G \cdot X_1^{X_2}, \text{ if } C_1 = 0.0 \\ G \cdot X_1^{C_1}, \text{ if } C_1 \neq 0.0 \end{cases}$$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of first input signal
ICB2	Optional	ID number of second input signal - required when CBCON1 = 0.0
ICB3	No	
CBCON1	Optional	use if a constant exponent is desired
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- if a constant exponent is desired, then |CBCON1| must be greater than 1.0E-6. Otherwise, a value of 0.0 (to account for numerical roundoff) is assumed, causing the control block to default to its default behavior of using the ICB2 input value as the exponent

ICBN = 61. Zero-order hold (ZOH)

Description:

$$X_{out} = \begin{cases} G \cdot X_1 \;, if\; X_2 = 1.0 \\ X_{out} \;, otherwise \end{cases}$$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- the control block output is hardwired to 0.0 when the initial value is evaluated internally
- The input value given by the ICB2 ID number must be logical in nature (0.0 or 1.0)

ICBN = 62. Trip (TRIP)

Description:

$$X_{out} = \begin{cases} G \text{ , } if\ X_1 = +1.0 \text{ or -1.0} \\ 0.0 \text{ , } otherwise \end{cases}$$

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- The input value given by the ICB1 ID number must be logical in nature (0.0 or 1.0). The user should beware that the input value should correspond to a trip's set status, although the code does not enforce this rule - any input with a logical value will work.

ICBN = 63. Trip Time (TRPTIM)

Description:

$$X_{out} = \begin{cases} G \cdot T_{set} \text{, if the trip signal denoted by } X_1 \text{ has a set status of } \pm 1.0 \text{ (on)} \\ -1.0 \text{ , if the trip signal denoted by } X_1 \text{ has a set status of 0.0 (off)} \end{cases}$$

where T_{set} is the time the trip (denoted by input signal X_1) last turned true.

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- if this control block type is added to a restart run and the trip to which it refers is already on at time zero, then the time that is used is the transient time pulled from the dump file, not when the trip actually turned on during the previous run.

ICBN = 64. Minimum of multiple Inputs (TRIP)

Description: $X_{out} = MIN(X_1 , X_2 , X_3 , \ \dots \ , X_n)$

Notes:

	Required?	**Comment**
ICB1	Yes	this field specifies the number of input ID table entries
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- an additional card is required by this control block type in order for the user to specify each of the input ID numbers that are needed. The number of entries corresponds to the value provided for ICB1.

ICBN = 65. Maximum of multiple inputs (TRIP)

Description: $X_{out} = MAX(X_1, X_2, X_3, \ldots, X_n)$

Notes:

	Required?	**Comment**
ICB1	Yes	this field specifies the number of input ID table entries
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- an additional card is required by this control block type in order for the user to specify each of the input ID numbers that are needed. The number of entries corresponds to the value provided for ICB1.

ICBN = 76. Pass Through (PSTH)

Description: $X_{out} = X_{in}$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of the input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 77. Time of Change (TOCH)

Description: $X_{out} = \text{current time if } (\Delta X_1 > 0) \text{ since last timestep}$

Notes:

	Required?	Comment
ICB1	Yes	ID number of the input signal
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 100. Time delay (TDLY)

Description:

$$X_{out} = \begin{cases} G \cdot X_1(t{=}0) \text{ , if time} \leq C_1 \\ G \cdot X_1(\text{t=time-C}_1) \text{ , } otherwise \end{cases}$$

To clarify, if (time .LE. C_1), X_1 is evaluated at the time the control block is input; otherwise X_1 is evaluated at time (time–C_1). The user must also provide the variable n, which is the number of storage table pairs for saving values of X_1 over the last C_1 seconds. X_1 is stored at intervals of approximately C_1/(n–1) s; the control block uses linear interpolation to obtain the desired value of X_1(time–C_1).

Notes:

	Required?	Comment
ICB1	Yes	ID number of input signal
ICB2	Yes	n, the number of storage table pairs
ICB3	No	
CBCON1	Yes	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 101. Function of one independent variable (FNG1)

Description: $X_{out} = G \cdot f(X_1)$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of input signal
ICB2	Yes	denotes the number of table entry pairs that define the lookup table
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 102. Function of 2 or 3 independent variables (FNG2)

Description: $X_{out} = G \cdot f(X_1, X_2, X_3)$

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of first input signal
ICB2	Yes	ID number of second input signal
ICB3	Yes	ID number of third input signal
CBCON1	Yes	denotes the number of table entry pairs that define the lookup table (in the form of a composite #)
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

- CBCON1, is a composite number with the following form: 10000.0 * N_1 + 100.0 * N_2 + N_3, where N_1 = number of X_1 values (2 <= N_1 <= 99), N_2 = number of X_2 values (2 <= N_2 <= 99), and N_3 = number of X_3 values (2 <= N_3 <= 99).
- Input zero for X_3 and N_3 for a tabular function of two independent variables.
- Input the function table in the following order: the N_1 values of X_1, the N_2 values of X_2, the N_3 values of X_3, and the [N_1*N_2* max(1,N_3)] function values.

ICBN = 103. Multiple summation (SUMN)

Description:

$$X_{out} = G \cdot \left(C_1 + \sum_{i=1}^{n} (A_i X_i) \right)$$

The variable n denotes the number of X_n entries which represent the control block input ID numbers. The ICB2 variable is used as a flag (0 or 1) to denote the presence of the A_n weighting factor data. When ICB2=1, an appropriate units label corresponding to the A_n factors is input immediately following control block **Card Number 3**. Then the weighting factors (A_1 through A_n) are specified (in load format). If ICB2=0, then all weighting factors are internally set to 1.0. The input ID's are included as an array of numbers (also in load format and dimension n) immediately following the weighting factors (when ICB2=1) or **Card Number 3** (when ICB2=0).

Notes:

	Required?	Comment
ICB1	Yes	the total number of input signal ID's specified in the table input
ICB2	Yes	flag denoting the presence of weighting factors (0 or 1)
ICB3	No	
CBCON1	Optional	leading constant
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally
- Additional input variables (beyond those listed above - see **Card Number 7**, **Card Number 8**, and **Card Number 9**) are required by this control block type in order for the user to specify each of the input ID numbers that are needed. The number of entries corresponds to the value provided

for ICB1.

ICBN = 104. Multiple product (MULTN)

Description: $$X_{out} = G \cdot \prod_{i=1}^{n} X_i$$

The variable n denotes the number of X_i table entries which represent the control block inputs ID's. These values are entered as an array of values immediately following control block card 3.

Notes:

	Required?	**Comment**
ICB1	Yes	this is n, the total number of input signal ID's specified in the table input
ICB2	No	
ICB3	No	
CBCON1	No	
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block's initial value is set to CBCON2; otherwise, the control block's initial state is evaluated internally

ICBN = 200. PI controller (PI)

Description: $$X_{out} = A = A_0 + \Delta A$$

Refer to **Figure 6-1** for a schematic of the functional form of this control block. X_1 = ID number of F, X_2 = ID number of F_d when F_d is an input parameter rather than a constant value; $C_1 = F_d$, a constant value; $C_2 = A_0$, the initial X_{OUT}; $G = (\Delta A/\Delta F)$; $X_{MIN} = A_{min}$; and $X_{MAX} = A_{max}$. A third input-data card is required to specify $\Delta t_d > 0.0$ and $\tau \geq 0.0$.

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of signal to be controlled

$$\Delta A_{PI} = \left(\frac{\Delta A}{\Delta F}\right)_{est}\left[\Delta F + \left(\frac{1}{\Delta t_d}\right)\int \Delta F dt\right]$$

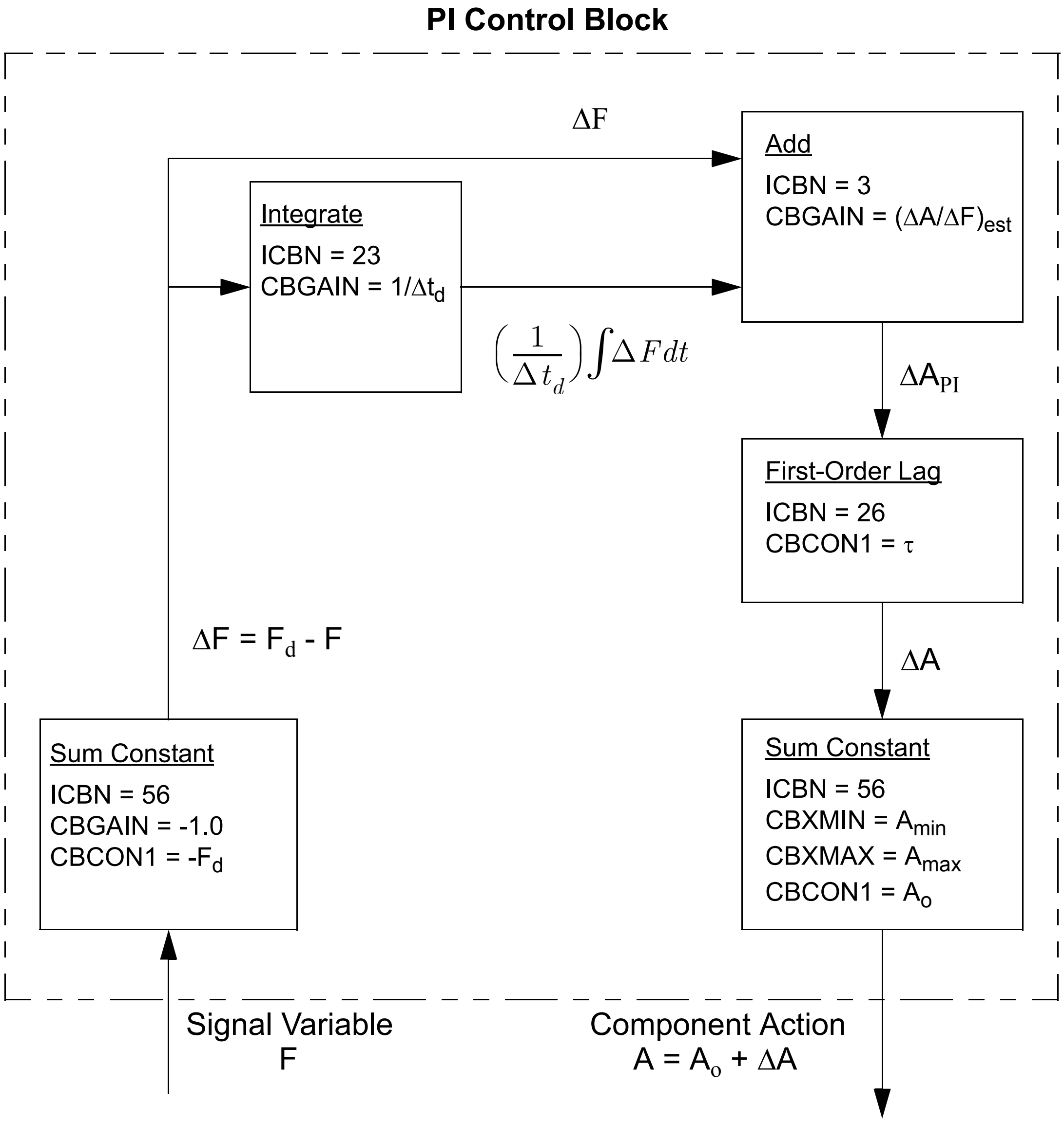


Figure. 6-1. Proportional Plus Integral Controller Diagram.

ICB2	Optional	desired setpoint, if dynamic
ICB3	No	
CBCON1	Optional	desired setpoint, if constant
CBCON2	Yes	control block initial value

- in this case, the CBCON2 value is taken as the control block's initial value; it is not evaluated internally, even when CBCON2 = 0.0
- the user has the choice of making the desired setpoint, F_d, either a constant value, or dynamically defined. If ICB2 is non-zero, then a new setpoint value is determined each timestep; otherwise a constant value defined by CBCON1 is used

ICBN = 201. PID controller (PID)

Description: $X_{out} = A = A_0 + \Delta A$

Refer to **Figure 6-2** for a schematic of the functional form of this control block. X_1 = ID number of F, X_2 = ID number of F_d when F_d is an input parameter rather than a constant value; $C_1 = F_d$, a constant value; $C_2 = A_0$, the initial X_{OUT}; $G = (\Delta A/\Delta F)$; $X_{MIN} = A_{min}$; and $X_{MAX} = A_{max}$. A third input-data card is required to specify $\Delta t_d > 0.0$, $\tau \geq 0.0$, and $0.0 \leq Wt \leq 1.0$.

Notes:

	Required?	**Comment**
ICB1	Yes	ID number of signal to be controlled
ICB2	Optional	desired setpoint, if dynamic
ICB3	No	
CBCON1	Optional	the desired setpoint, if constant
CBCON2	Yes	the control block initial value

- In this case, the CBCON2 value is taken as the control block's initial value; it is not evaluated internally, even when CBCON2 = 0.0
- The user has the choice of making the desired setpoint, F_d, either a constant value, or dynamically defined. If ICB2 is non-zero, then a new setpoint value is determined each timestep; otherwise a constant value defined by CBCON1 is used

ICBN = 202. Level controller (WLEV)

$$\Delta A_{PID} = \left(\frac{\Delta A}{\Delta F}\right)_{est}\left[\Delta F + \left(\frac{1}{\Delta t_d}\right)\int \Delta F dt + \overline{\Delta t_d\left(\frac{d\Delta F}{dt}\right) + \Delta F}\right]$$

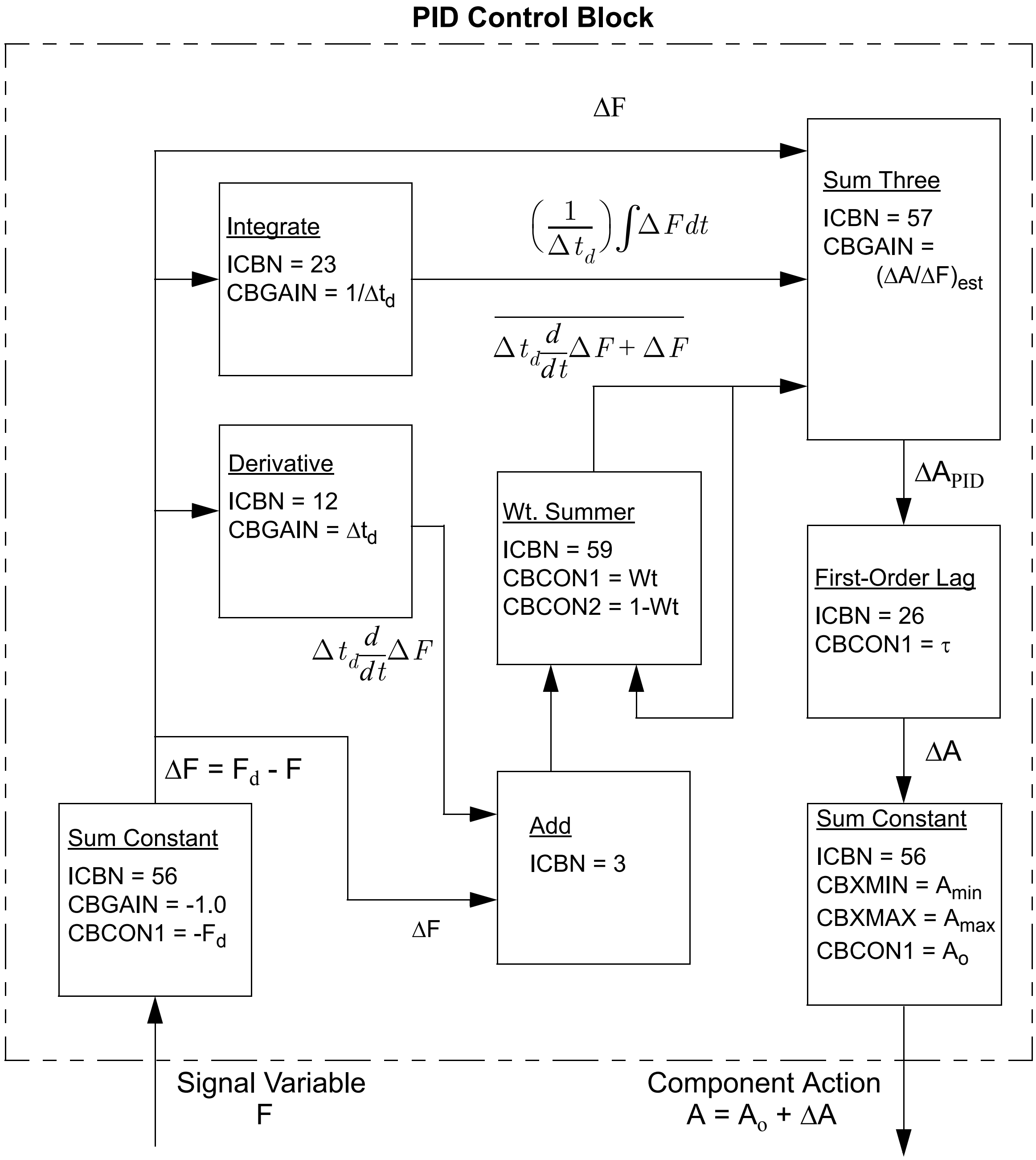


Figure. 6-2. Proportional Plus Integral Plus Derivative Controller Diagram.

Description: $X_{out} = f(X_1 , X_2 , X_3 , C_1 , C_2)$

This lumped controller performs BWR vessel downcomer water level control function. It can be used in both the steady state and the transient calculations. The output value of the control block is the desired feedwater mass flow rate which may be used to define the feedwater line FILL component mass flow rate. All three inputs (X_1, X_2 and X_3) require the output values from other control blocks or signal variables. X_1 corresponds to the vessel downcomer water level (which could be provided by the signal variable type 106). The units for X_1 are in meters. X_2 corresponds to the current time step feedwater line mass flow rate (units are in kg/sec). X_3 corresponds to the current time step steam line mass flow rate (units are in kg/sec). C_1 is the user desired vessel collapsed water level position (m) and C_2 is the nominal steady state feedwater line mass flow rate (kg/sec).

Notes:

	Required?	**Comment**
ICB1	Yes	actual vessel collapsed level position
ICB2	Yes	actual feedwater flow rate
ICB3	Yes	actual steam line flow rate
CBCON1	Yes	desired collapsed level setpoint
CBCON2	Yes	nominal feedwater flow rate

- for this control block, the user has no control for specifying the initial value. The code will evaluate it internally

ICBN = 203. Flow controller (FLOW)

Description: $X_{out} = f(X_1 , C_1 , C_2)$

The output of this controller represents the required BWR recirculation pump motor torque (N*m) to achieve the desired mass flow rate through the jet pump discharge. X_1 provides the controller with the current jet pump discharge line mass flow rate (kg/sec). C_1 is the user desired jet pump discharge line mass flow rate, and C_2 is the rated pump motor torque. Please note the controller can only adjust the pump motor torque between 75% to 125% of the rated motor torque.

Notes:

	Required?	**Comment**
ICB1	Yes	actual jet pump discharge flow rate

ICB2	No	
ICB3	No	
CBCON1	Yes	desired jet pump discharge flow rate
CBCON2	Yes	rated pump motor torque

- for this control block, the user has no control for specifying the initial value. The code will evaluate it internally

ICBN = 204. Pressure controller (PRES)

Description: $X_{out} = f(X_1\ ,\ C_1)$

The output of this controller represents the required valve open area ratio to achieve the desired pressure at the up-stream of the valve. X_1 provides the controller with the valve up-stream pressure (Pa). C_1 is the user desired pressure (Pa). C_1 should fall between the range of 6.5E+6 Pa to 7.5E+6 Pa.

Notes:

	Required?	**Comment**
ICB1	Yes	actual valve up-stream pressure
ICB2	No	
ICB3	No	
CBCON1	Yes	desired pressure setpoint
CBCON2	Optional	control block initial value, if non-zero

- when CBCON2 <> 0.0, the control block’s initial value is set to CBCON2; otherwise, the control block’s initial state is evaluated internally

Trip Data

Trip data are defined when **NTRP** > 0 (Word 4 on **Main-Data Card 10**). There are 7 categories of trip-input data. The first category, defined by **Card Number 1**, is always input when **NTRP** > 0. The five variables on this card and **NTRP** define the variable storage required for the remaining 6 trip-input data categories. In each remaining category, none, part, or all of the data can be input. Any data that are not input are obtained from the restart file.

Card Number 1. (Format 5I14) **NTSE, NTCT, NTSF, NTDP,NTSD**

Variable	Description
NTSE	The number of different signal-expression trip signals from input and the restart file (NTSE ≥ 0) (used to dimension variable storage).
NTCT	The number of different trip-controlled trip signals from input and the restart file (NTCT ≥ 0) (used to dimension variable storage).
NTSF	The number of different set-point factor tables referenced by trips from input and the restart file (NTSF ≥ 0) (used to dimension variable storage).
NTDP	The number of trips from input and the restart file that generate a restart dump and possible problem termination when they are set ON (NTDP ≥ 0) (used to dimension variable storage).
NTSD	The number of trip-controlled timestep data sets from input and the restart file that are used for timestep and edit control when their defined trips are set ON (NTSD ≥ 0) (used to dimension variable storage).

Trip-Defining Variables Cards.

Input from 0 to **NTRP** (Word 4 on **Main-Data Card 10**) of the following card set. If fewer than **NTRP** card sets are input, conclude these data with a blank card or a card with a 0 for the first input parameter **IDTP** (0 must be entered explicitly if the free-format option is used). The remaining trips that have trip **IDTP** ID numbers different from those input will be obtained from the restart file.

Card Number 2. (Format 5I14) **IDTP, ISRT, ISET, ITST, IDSG**

Variable	Description
IDTP	The trip ID number (1 ≤ |IDTP| ≤ 9999). Negative trip ID numbers have their trip set status evaluated during both the steady-state and transient calculations. Positive trip ID numbers have their trip set status evaluated only during the transient calculation with the input value of the trip set status, ISET, used throughout the steady-state calculation.
ISRT	The signal-range type number. Over the value range of the trip signal, the signal-range type number ISRT defines either one (ISRT = ±6 to ±11), two (ISRT = ±1 or ±2) or three (ISRT = ±3, ±4, or ±5) subranges with different set-status labels ($ON_{Reverse}$, OFF, or $ON_{Forward}$). Refer to **Table 6-4** for a description of these subranges and their delimiting setpoint values for all possible values of ISRT (1 ≤ |ISRT| ≤ 11).
ISET	The initial trip set-status number (only used during steady state when IDTP > 0). –1 = $ON_{Reverse}$; 0 = OFF; 1 = $ON_{Forward}$.
ITST	The trip-signal type number. ±1 = signal-variable trip, ±2 = signal-expression trip, or ±3 = trip-controlled trip. Defining the ITST value negative eliminates writing trip-status changes to the output files (when the trip-signal criterion is met and when the trip set status is changed), ±4 = simple setpoint trip.
IDSG	This variable can have one of three different meanings depending upon the value of ITST. For ITST = ±1 or ±4, IDSG is the ID number for the trip-signal variable (IDSG > 0 corresponds to IDSV in the signal-variable data and IDSG < 0 corresponds to IDCB in the control-block data) For ITST = ±2, IDSG is the trip-signal expression ID number (IDSG corresponds to IDSE in the trip-signal-expression data that follow), For ITST = ±3, ISDG is the trip-controlled trip signal (IDSG corresponds to IDTN in the trip-controlled trip data that follow).

Card Number 3. (Format I4) **ISLATCHED**

Note: If **ITST** = ±4 (simple trip), then input this card.	
Variable	**Description**
ISLATCHED	Integer value indicating whether this is a latched trip. Latched trips will not trip OFF once they have tripped ON.

Card Number 4. (Format A14) **LUTRPSIG**

Note: If **ITST** = ±2 (signal-expression trip) and **IOALL** = |IOGRF|+|IOINP|+ |IOLAB|+|IOOUT| ≠ 0 (NAMELIST variables), input this card. See **Table 6-3** for a list of units-name labels, their SI and English units symbols, and their SI to English conversion factors and shifts for the trip-signal and trip-signal setpoint parameters	
Variable	**Description**
LUTRPSIG	Units-name label of the trip signal and trip-signal setpoints.

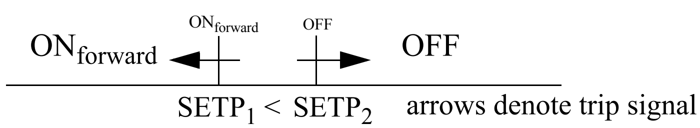
Card Number 5. (Format 4E14.4) **SETP(I), I = (1, NSP)**

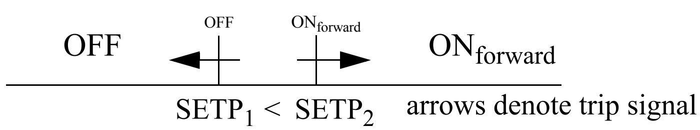
Variable	**Dimension**	**Description**
SETP	NSP	The trip-signal setpoint values (*) shown as $S_{\#}$ (where # = I) in the **Table 6-4** definition of ISRT (Word 2 on **Card Number 2**: Trip-Defining Variables). For ISRT = ±1 or ±2, NSP = 2; for ISRT = ±3, ±4, or ±5, NSP = 4. For ISRT= ±6, ±7, ±8, ±9, ±10, or ±11, NSP = 1. The setpoint values must satisfy SETP(1) < SETP(2) when ISRT = ±1 or ±2 or SETP(1) < SETP(2) < SETP(3) < SETP(4) when ISRT = ±3, ±4 or ±5. [Caution: For trip-controlled trips with real-value trip signals that have discrete integer values (0.0, 1.0, 2.0, etc.), the setpoint values should be midway between the two trip-signal values that change the trip's set status. Because of numerical roundoff when set-status values assigned to the trip signal are summed or multiplied, it is better to have the trip signal cross the setpoint value rather than reach and equal it to satisfy the set-status change criterion. For example, use S_1 = 0.4 and S_2 = 0.6 rather than S_1 = 0.0 and S_2 = 1.0 when the trip signal goes from 0.0 to 1.0 or 1.0 to 0.0 and changes the trip's set status.]

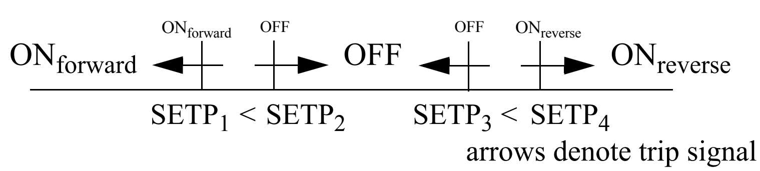
Card Number 6. (Format E14.4) **DTSP(I), I = (1, NSP)**

Variable	Dimension	Description
DTSP	NSP	The setpoint delay times (s) after the trip signal crosses the setpoint value to when the trip set status is changed. For ISRT = ±1 or ±2, NSP = 2; for ISRT = ±3, ±4, or ±5, NSP = 4. For ISRT= ±6, ±7, ±8, ±9, ±10, or ±11, NSP = 1.

Table 6-4. Trip Signal-range Types.

<table>
<tr><th>ISRT Signal-Range Type Number</th><th>Trip Signal-Range Diagrams and Description of the Relationship Between Trip Setpoints and Incoming Trip Signals and How the Trip Status is Determined</th></tr>
<tr><td>1*</td><td>

When $ON_{Forward}$, trip is set to OFF when the trip signal $\geq SETP_2$.
When OFF, trip is set to $ON_{Forward}$ when the trip signal $\leq SETP_1$.</td></tr>
<tr><td>2*</td><td>

When OFF, trip is set to $ON_{Forward}$ when the trip signal $\geq SETP_2$.
When $ON_{Forward}$, trip is set to OFF when the trip signal $\leq SETP_1$.</td></tr>
<tr><td>3*</td><td>

When $ON_{Forward}$, trip is set to OFF when trip signal $\geq SETP_2$ and $< SETP_4$.
When $ON_{Forward}$, trip is set to $ON_{Reverse}$ when the trip signal $\geq SETP_4$.
When OFF, the trip is set to $ON_{Forward}$ when the trip signal $\leq SETP_1$.
When OFF, trip is set to $ON_{Reverse}$ when the trip signal $\geq SETP_4$.
When $ON_{Reverse}$, trip is set to OFF when the trip signal $\leq SETP_3$ and $> SETP_1$.
When $ON_{Reverse}$, trip is set to $ON_{Forward}$ when the trip signal $\leq SETP_1$.</td></tr>
</table>

Table 6-4. Trip Signal-range Types. (Continued)

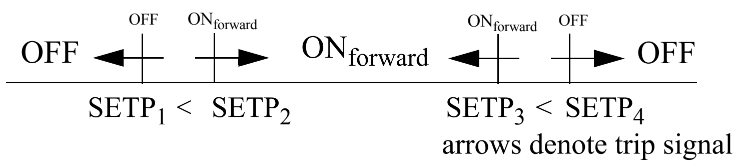
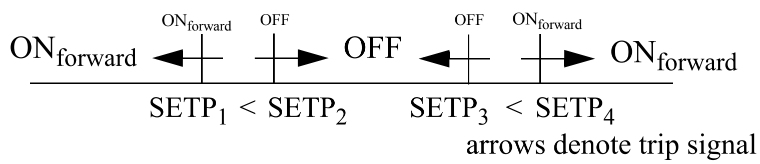
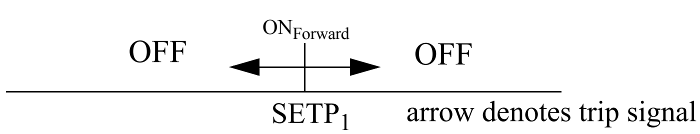
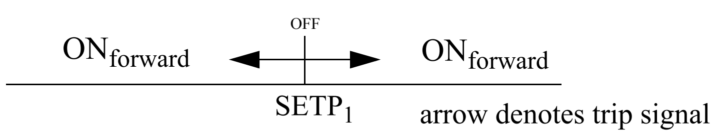
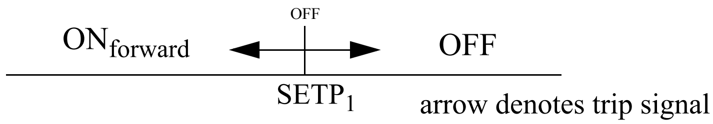
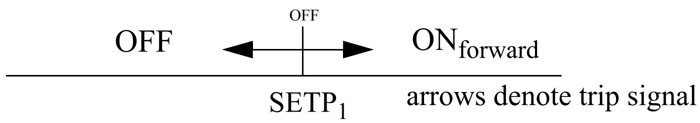
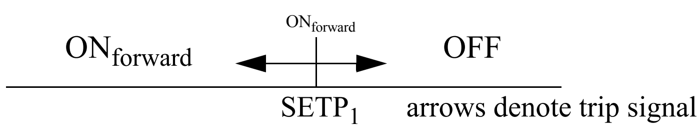
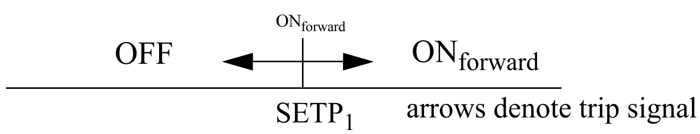
ISRT Signal-Range Type Number	Trip Signal-Range Diagrams and Description of the Relationship Between Trip Setpoints and Incoming Trip Signals and How the Trip Status is Determined
4*	 When OFF (left), trip is set to $ON_{Forward}$ when signal $\geq SETP_2$ and $< SETP_4$. When $ON_{Forward}$, trip is set to OFF when the trip signal $\leq SETP_1$ and $\geq SETP_4$. When OFF (right), trip is set to $ON_{Forward}$ when signal $\leq SETP_3$ and $> SETP_1$.
5*	 When $ON_{Forward}$ (left), trip is set to OFF when the trip signal $\geq SETP_2$ and $<$ $SETP_4$. When OFF, trip is set to $ON_{Forward}$ when the trip signal $\leq SETP_1$ or $\geq SETP_4$. When $ON_{Forward}$ (right), the trip is set to OFF when signal $\leq SETP_3$ and $>$ $SETP_1$.
6	 Trip is set to $ON_{Forward}$ if the trip signal = $SETP_1$. Trip is set to OFF, otherwise.
7	 Trip is set to $ON_{Forward}$ when the trip signal $\neq SETP_1$. Trip is set to OFF when the trip signal = $SETP_1$.

Table 6-4. Trip Signal-range Types. (Continued)

ISRT Signal-Range Type Number	Trip Signal-Range Diagrams and Description of the Relationship Between Trip Setpoints and Incoming Trip Signals and How the Trip Status is Determined
8	 Trip is set to $ON_{Forward}$ if the trip signal < $SETP_1$. Trip is set to OFF if the trip signal $\geq SETP_1$.
9	 Trip is set to $ON_{Forward}$ if the trip signal > $SETP_1$. Trip is set to OFF if the trip signal $\leq SETP_1$.
10	 Trip is set to $ON_{Forward}$ if the trip signal $\leq SETP_1$. Trip is set to OFF if the trip signal > $SETP_1$.
11	 Trip is set to $ON_{Forward}$ if the trip signal $\geq SETP_1$. Trip is set to OFF if the trip signal < $SETP_1$.
	*Making ISRT negative changes $ON_{Forward}$ to $ON_{Reverse}$ and $ON_{Reverse}$ to $ON_{Forward}$

Card Number 7. (Format 4I14) **IFSP(I), I = (1, NSP)**

Variable	Dimension	Description
IFSP	NSP	The setpoint factor-table ID numbers. The variable IFSP(I) corresponds to IDFT defined on the Trip Setpoint Factor-Table Card Number 1 that follows. Input IFSP(I) = 0 when no setpoint factor is to be applied to SETP(I); that is, the setpoint value remains constant during the problem. For ISRT = ±1 or ±2, NSP = 2; for ISRT = ±3, ±4, or ±5, NSP = 4. For ISRT= ±6, ±7, ±8, ±9, ±10, or ±11, NSP = 1.

Trip-Signal-Expression Signal Cards

Note: If none of the trip input has ITST = ±2 (Word 4 on **Card Number 2**: Trip-Defining Variables), do not input **Card Number 8** through **Card Number 11** (Trip-Signal-Expression Signal Cards).] Otherwise, input the following card data for each different IDSG trip-signal ID number of trips with ITST = ±2 that are input.

Card Number 8. (Format 3I14) **IDSE, INSE, INCN**

Variable	Description
IDSE	The trip-signal-expression signal ID number. This number corresponds to IDSG (Word 5 on **Card Number 2**: Trip-Defining Variables) for one or more of the input trips having ITST = ±2 (1 ≤ |IDSE| < 9999).
INSE	The number of subexpressions defining the trip-signal expression (1 ≤ INSE ≤ 10).
INCN	The number of different constants referenced in the subexpressions defining the trip-signal expression (0 ≤ INCN ≤ 5).

Trip Data

Card Number 9. (Format 3I14) **ISE(I,J), I = (1, 3)**

Variable	Description
Note:	Input **INSE** (Word 2 on **Card Number 8**) cards of this card to define the J = (1, INSE) arithmetic sub-expressions
ISE(1,J)	The arithmetic-operator ID number of the Jth arithmetic subexpression (see Table **Table 6-5**).
ISE(2,J)	The first argument ID number of the Jth arithmetic subexpression.
ISE(3,J)	The second argument ID number of the Jth arithmetic subexpression.

The first and second argument ID numbers define values that, when operated on by the arithmetic operator, give a value to their Jth arithmetic subexpression. There are five forms for the value of the first and second argument ID numbers:

1) a signal-variable or control-block output value evaluated each timestep when their ID number is a signal-variable ID number 1 ≤ IDSV ≤ 399 (Word 1 of the **Signal-Variable Card Number 1**) or a control-block ID number –9999 ≤ IDCB ≤ –1 (Word 1 of **Card Number 1**, **Chapter 6**);
2) a signal-variable value evaluated initially and at timesteps when the trip controlled by this signal expression is set to $ON_{Reverse}$ or $ON_{Forward}$ when their ID number is a signal-variable ID number IDSV plus 400 (400 < IDSV + 400 < 800);
3) a constant input on **Card Number 11** when its ID number is the ith subscript of SCN(I) plus 800 (800 < I + 800 < 806);
4) the value of an earlier subexpression J (0 < j < J ≤ INSE) when their ID number is J plus 900 (900 < J + 900 < 910); or
5) a trip output value evaluated each timestep when its ID number is a trip ID number 10001 ≤ |IDTP|+10000 ≤ 19999 (Word 1 on **Card Number 2**: Trip-Defining Variables).

Example: The signal expression,

$$\max \sqrt{(IDSV = 5) + (IDSV = 33)}\ ,\ 1.0 \times 10^{-10},$$

would be input as

1	5	33
5	901	801
6	902	802

where SCN(1) = 0.5, SCN(2) = 1.0×10^{-10}, INCN = 2, and INSE = 3.

Card Number 10. (Format A14) **LSCN(I), I = (1, INCN)**

Note: If INCN > 0 (Word 3 on **Card Number 8**) or IOALL = |IOGRF|+|IOINP|+|IOLAB|+|IOOUT| ≠ 0 (NAMELIST variables), input this card. See **Table 6-3** for a list of units-name labels, their SI and English units symbols, and their SI to English conversion factors and shifts for the trip signal-expression constants.		
Variable	**Dimension**	**Description**
LSCN	INCN	The units-name labels of the constants used to evaluate the subexpressions.

Table 6-5. Arithmetic-Operator ID Numbers of the Jth Arithmetic Subexpression

ID Number	Operator	Arithmetic Subexpression
1	**Addition**	(First argument ID number value) + (Second argument ID number value)
2	**Subtraction**	(First argument ID number value) – (Second argument ID number value)
3	**Multiplication**	(First argument ID number value) * (Second argument ID number value)
4	**Division**	(First argument ID number value) / (Second argument ID number value)
5	**Exponentiation**	(First argument ID number value) * (Second argument ID number value)
6	**Maximum value**	MAX [(First argument ID number value), (Second argument ID number value)]
7	**Minimum value**	MIN [(First argument ID number value), (Second argument ID number value)]
8	**Absolute value**	ABS (first argument ID number value)
9	**AND logical expression**	(First trip ID's status) .AND. (Second trip ID's status)
10	**OR logical expression**	(First trip ID's status) .OR. (Second trip ID's status)

Trip Data

Table 6-5. Arithmetic-Operator ID Numbers of the Jth Arithmetic Subexpression

ID Number	Operator	Arithmetic Subexpression
11	**XOR logical expression**	(First trip ID's status) XOR (Second trip ID's status)
12	**NOT XOR logical expression**	NOT[(First trip ID's status) XOR (Second trip ID's status)]

Card Number 11. ((Format E14.4) **SCN(I), I = (1, INCN)**

Note: If INCN > 0 (Word 3 on **Card Number 8**), input this card.		
Variable	**Dimension**	**Description**
SCN	INCN	The constants used to evaluate the subexpressions.

Trip-Controlled-Trip Signal Cards

Note: If none of the trips being input have **ITST** = ±3 (Word 4 on **Card Number 2**: Trip-Defining-Variables), do not input **Card Number 12** and **Card Number 13** (Trip-Controlled-Trip Signal Cards).

Input the following card data for each different IDSG trip-signal ID number of trips having ITST = ±3 that are input.

Card Number 12. (Format 2I14) **IDTN,INTN**

Variable	Description
IDTN	The trip-controlled-trip signal ID number. This number corresponds to IDSG (Word 5 on **Card Number 2**: Trip-Defining-Variables Card) for one or more of the input trips that have ITST = ±3 (1 ≤ |IDTN|≤ 9999).
INTN	The number of trip ID numbers whose ISET set-status values (Word 3 on **Card Number 2**: Trip-Defining Variables Card) are summed (IDTN > 0) or multiplied (IDTN < 0) to evaluate this trip-controlled-trip signal (2 ≤ INTN ≤ 10).

Card Number 13. (Format I14) **ITN(I), I = (1, INTN)**

Variable	Dimension	Description
ITN	INTN	The trip ID numbers whose ISET set-status values are summed (IDTN > 0) or multiplied (IDTN < 0) to evaluate this trip-controlled-trip signal.

Trip Setpoint-Factor Table Cards

Note: If all the trips have constant trip-signal set points because **IFSP(I) = 0 (Trip-Defining Variables Card Number 7)** was input for all the setpoints, do not input **Card Number 14** and **Card Number 15** (Trip Setpoint-Factor Table Cards).

Input the following card data for each different setpoint factor-table ID number, IFSP(I), defined in the input trips.

Card Number 14. (Format 3I14) **IDFT, IDSG, INFT**

Variable	Description
IDFT	The setpoint-factor table ID number. This number corresponds to **IFSP(I) (Trip-Defining Variables: Card Number 7)** for one or more trip setpoints.
IDSG	The signal-variable or control-block ID number defining the setpoint-factor table independent variable. This number corresponds to one of the ID numbers in the list of signal variables (IDSG > 0) or control blocks (IDSG < 0), either from input or from the restart file.
INFT	The number of setpoint-factor table entry pairs (2 ≤ INFT ≤ 10).

Card Number 15. (Format E14.4) **FT(I), I = (1, 2 ¥ INFT)**

Variable	Dimension	Description
FT	2 × INFT	Setpoint factor-table data (*,–); input INFT table-defining data pairs having the following form (table-independent variable value associated with parameter ID number IDSG and its setpoint-factor value).

Trip Data

Trip-Initiated Restart-Dump and Problem-Termination Cards

Note: If NTDP = 0 (Word 4 on **Card Number 1**: Trip-Dimension Variables Card), do not input **Card Number 16** and **Card Number 17** (Trip-Initiated Restart-Dump and Problem-Termination Cards).

Card Number 16. (Format I14) **NDMP**

Variable	Description
NDMP	The total number of trips from the input file and the restart dump that generate a restart dump and possible problem termination when any one of the trips is set to $ON_{Reverse}$ or $ON_{Forward}$ ($0 \le NDMP \le NTDP$).

Card Number 17. (Format I14) **IDMP(I), I = (1, NDMP)**

Note: The input deck defines NDMP trip ID numbers, and the NTDP-NDMP remaining trip ID numbers will be obtained from the restart file. If NDMP = 0, do not input this card because all NTDP trip ID numbers will be obtained from the restart file.

Variable	Dimension	Description
IDMP	NDMP	The absolute value of the trip ID numbers that generate a restart data dump when any one of the trips is set to $ON_{Reverse}$ or $ON_{Forward}$. If IDMP(I) is given a negative sign, problem termination will occur after the restart data dump is generated.

Trip-Initiated Timestep Data Cards

Note: If NTSD = 0 (Word 5 on **Card Number 1**: Trip-Dimension Variables Card), do not input **Card Number 18** through **Card Number 21** (Trip-Initiated Timestep Data card set).

Input from zero to NTSD of the following card set. If fewer than NTSD sets are input, conclude these data with a blank card or a card having an integer zero defining the first parameter, NDID (a zero must be entered if the free-format option is used). The remaining Card Sets will be obtained from the restart file.

Card Number 18. (Format 2I14) **NDID, NTID**

Variable	Description
NDID	The ID number for the following set of trip-initiated timestep data.
NTID	The number of trip ID numbers that initiates the use of this timestep data set when any one of the trips is set to $ON_{Reverse}$ or $ON_{Forward}$ ($1 \le NTID \le 5$).

Card Number 19. (Format I14) **ITID(I), I = (1, NTID)**

Variable	Dimension	Description
ITID	NTID	The trip ID numbers that initiate use of this timestep data set when any one of the trips is set to $ON_{Reverse}$ or $ON_{Forward}$.

Card Number 20. (Format 4E14.4) **DTMIN, DTMAX, DTEND, DTSOF**

Variable	Description
DTMIN	The minimum timestep size (s).
DTMAX	The maximum timestep size (s).
DTEND	The problem time interval (s) during which these timestep data are used.
DTSOF	The next timestep DTSOF (s) (when DTSOF > 0.0) or the factor –DTSOF (–) to be applied to the existing timestep (when DTSOF < 0.0) in defining the timestep to be used at the start of the DTEND (Word 3 above) time interval when implementing these special timestep data.

Card Number 21. (Format 4E14.4) **EDINT, GFINT, DMPIT, SEDINT**

Variable	Description
EDINT	Long-print edit interval (s).
GFINT	Graphics edit interval (s).
DMPIT	Restart-dump edit interval (s).
SEDINT	Short-print edit interval (s).

Timestep data on **Card Number 20** and **Card Number 21** replace the timestep data defined later in **Chapter 6** for a time interval DTEND (Word 3 on **Card Number 20**) after any one of the timestep data set assigned trip is set to $ON_{Reverse}$ or $ON_{Forward}$. This timestep data can be replaced by this or any other trip-controlled timestep data if any trip assigned to that timestep data set is set to $ON_{Reverse}$ or $ON_{Forward}$ before the time interval DTEND of this set ends.

General Table Data

The general heat structure table data can be used by the **HTSTR** component (See **Chapter 6**, **Card Set 11**, **Card Set 16**, **Card Set 17**, **Card Set 23**, and **Card Set 24**). If the NAMELIST variable **NUMGENTBL** is greater than zero, then the general heat structure data must be input. If general heat structure tables are used and restarts are made, NAMELIST variable **NUMGENTBL** and **GENTABLENUMBER** (**Card Number 1**) are required in the restart input file.

The GENTABLENUMBER array contains the general table numbers for the general tables that will be read from the TRACE input and/or restart file. The GENTABLENUMBER array is NUMGENTBL elements long and is defined below:

Card Number 1. [Format 5(3X,I11)] **GENTABLENUMBER** (IORDER(I), I = 1, NCOMP) Load Format.

Variable	Dimension	Description
GENTABLENUMBER	NUMGENTBL	General table numbers for the general tables that will be read from the TRACE input and/or restart file.

The GENTABLENUMBER array input is followed by 1 to NUMGENTBL sets of general table data (**Card Number 2**, **Card Number 3**, and **Card Set 4**). All, some, or none of the general heat structure table data may be changed at restart. If data is changed in some of the tables at restart, input **Card Number 2**, **Card Number 3**, and **Card Set 4** for those changed tables and terminate table input with a negative number if less than NUMGENTBL sets are input. The remaining tables will be read from the restart file. If none of the table data is changed at restart put a negative number in the card following **Card Number 1** in the TRACE restart input file. In this case all of the tables will be read from the restart file.

Card Number 2. (Format I14) **TABLENUMBER**

Variable	Description
TABLENUMBER	General table number (**GENTABLENUMBER, Card Number 1**). Must be a unique number. Must not be zero.

Card Number 3. (Format 5I14) **NPTS, TABLETYPE, XCBSVID, TRIPID, OUTBOUNDS**

Variable	Description
NPTS	Number of points (i.e. x-y pairs) in this general table. If NPTS is one, then this general table is a constant table. The y(1) table value will always be the result independent of the x independent value used to evaluate this table.
TABLETYPE	Table type. 1 = Power (W, Btu/hr) versus Time table. 2 = Heat transfer rate [W/s, (Btu/hr)/s] versus Time table . 3 = Heat transfer coefficient(HTC) [W/(m2 K), Btu/(ft2 oF hr)] versus Time table. 4 = HTC [W/(m2 K), Btu/(ft2 oF hr)] versus Surface temperature (K, oF) table. 5 = HTC [W/(m2 K), Btu/(ft2 oF hr)] versus Surface temperature (ST) (K, oF) table. 6 = Temperature (K, oF) versus Time table. 7 = Reactivity versus Time table. 8 = Normalized valve flow area versus Valve stem position table. 9 = HTC [W/(m2 K), Btu/(ft2 oF hr)] versus Control block/Signal variable table. 10 = Heat flux [W/m2, (Btu/hr)/ft2] versus Control block/Signal variable table. 11 = Surface temperature (K, oF) versus Control block/Signal variable table.
XCBSVID	Control block/signal variable id. Positive number implies a signal variable id. Negative number implies a control block id. **XCBSVID** cannot be zero.
TRIPID	Trip id. Only used if x independent variable for this table is time.
OUTBOUNDS	Out of bounds flag. The out of bounds flag determines the action that will be taken when an out of bounds error occurs. -2 = out of table bounds error will result in fatal error. -1 = out of table bounds error will result in a warning message and last point in table will be used for the y dependent variable result. 0 = out of table bounds error will result in last point in table will be used for the y dependent variable result. 1 = out of table bounds error will result in linear extrapolation based on the last two points in the table to determine the y dependent variable result.

General Table Array Card.

One array card will be input for each general table data set.

Card Set Number	Variable	Dimension	Description
4	**TABLE1D**	2 × NPTS	General table data consisting of NPTS of x-y pairs. The x independent value is followed by the corresponding y dependent value for the table.

The following examples illustrate the use of the general heat structure table data.

Example 1: New input file

```
free format
*
*************
* main data       *
*************
*
*       numtcr          ieos          inopt          nmat
            14             0              1             0
*-*-*TEST PROBLEM idbc3
 Testing constant heat flux (from table) bc
 Replaces pipe wall with new heat structure
 Pipe wall includes power = 50 kw
 Coolant is liquid at Tliq = 300 K.
 Flow rate through pipe is = 1 kg/sec.
 Pipe has a flow area of 0.2 m**2, four cells long with,
 each cell 0.5 m long, volume of each cell is 0.1 m**2.
 Pipe wall thickness is 0.05 m and has 4 nodes in pipe wall.
 Pipe outside wall heat flux  is 22586.7 W/m2 == 50 kW input.
 Total energy input: 100 kW
 Pipe inner diameter = 0.25231 m and a radius of 0.12616 m
 Asurf-inner = pi*D*L = pi*0.25231*2 = 1.58531 m**2
*
*****************
* namelist data          *
*****************
*
 &inopts
 nhtstr=1, cpuflg=1, npower=1, numGenTbl = 4, (see Main-Data Card 4)
 &end
*
*        dstep         timet
             0    0.0000e+00
*       stdyst        transi          ncomp          njun           ipak
             1             0              5             2              1
*         epso          epss
```

```
    1.0000e-03    1.0000e-10
*       oitmax        sitmax        isolut        ncontr
            10            10             0             0
*         ntsv          ntcb          ntcf          ntrp          ntcp
             1             0             0             1             0
*
*************************
* component-number data         *
*************************
*
* iorder*              1             2             3             4  901e
*
**************************
* control-parameter data               *
**************************
*
*
* signal variables
*         idsv          isvn          ilcn          icn1          icn2
             1             0             0             0             0
*
* trips
*         ntse          ntct          ntsf          ntdp          ntsd
             0             0             0             0             0
*         idtp          isrt          iset          itst          idsg
             2             2             0             1             1
*      setp(1)       setp(2)
    0.0000e+00    0.0000e+00
*      dtsp(1)       dtsp(2)
    0.0000e+00    0.0000e+00
*      ifsp(1)       ifsp(2)
             0             0
*
*********************
* General Tables                *
*********************
* table numbers in this model
* Card Number 1
    1    2    30   4  e
*  tableNumber
* Card Number 2
             1
*Card Number 3
*      nPoints      tabletype         SigId        tripID     outBounds
             5             2             1             2            -2
* Card Set 4
*    Table Data
*      Time(s)   QFlux(w/m^2)
           0.0        22586.7s
         100.0        22586.7s
         300.0            0.0s
         500.0        22586.7s
        3000.0        22586.7e
*
*  tableNumber
* Card Number 2
             2
*      nPoints      tabletype         SigId        tripID     outBounds
*Card Number 3
             5             2             1             2            -1
* Card Set 4
*    Table Data
*      Time(s)   QFlux(w/m^2)
           0.0        22586.7s
```

```
          100.0        22586.7s
          300.0            0.0s
          500.0        22586.7s
         2500.0        22586.7e
*
*  tableNumber
* Card Number 2
               30
*Card Number 3
*       nPoints     tabletype         SigId         tripID    outBounds
              4             2             1              2            0
* Card Set 4
*    Table Data
*       Time(s)   QFlux(w/m^2)
            0.0        22586.7s
          100.0        22586.7s
          300.0            0.0s
          500.0        22586.7e
*
* Card Number 2
*  tableNumber
              4
*Card Number 3
*       nPoints     tabletype         SigId         tripID    outBounds
              5             2             1              2            1
* Card Set 4
*    Table Data
*       Time(s)   QFlux(w/m^2)
            0.0        22586.7s
          100.0        22586.7s
          300.0            0.0s
          500.0        22586.7s
          600.0        22586.7e
*
*
******************
* component data *
******************
*
*******   type            num            id        ctitle
pipe                        2             2 subcooled liquid channel
*        ncells         nodes          jun1          jun2          epsw
              4             0             1             3    0.0000e+00
*          ichf         iconc          iacc          ipow
              1             0             0             0
*         radin            th         houtl         houtv         toutl
        0.12616    1.0000e-01    0.0000e+00    0.0000e+00    3.0000e+02
*         toutv
     3.0000e+02
*
* dx     *  f   5.0000e-01e
* vol    *  f   1.0000e-01e
* fa     *  f   2.0000e-01e
* fric   *  f   0.0000e+00e
* grav   *  f   1.0000e+00e
* hd     *  f   2.5231e-01e
* nff    *  f            1e
* alp    *  f   0.0000e+00e
* vl     *  f   0.0000e+00e
* vv     *  f   0.0000e+00e
* tl     *      3.0000e+02 f 320.0e
* tv     *  f   3.0000e+02e
* p      *  f   2.0000e+06e
* pa     *  f   0.0000e+00e
```

```
*
*******   type            num             id        ctitle
fill                        1              1 velocity bc
*         jun1           ifty           ioff
             1              2              0
*       twtold           rfmx         concin          felv
    0.0000e+00     0.0000e+00     5.0000e-04     0.0000e+00
*         dxin          volin          alpin          vlin           tlin
    5.0000e-01     1.0000e-01     0.0000e+00     0.0000e+00     3.0000e+02
*          pin           pain         flowin          vvin           tvin
    2.0000e+06     0.0000e+00     1.0000e+00     0.0000e+00     3.0000e+02
*
*******   type            num             id        ctitle
break                       3              3 pressure bc
*         jun1           ibty           isat          ioff
             3              0              0              0
*         dxin          volin          alpin           tin            pin
    5.0000e-01     1.0000e-01     0.0000e+00     3.2000e+02     2.0000e+06
*         pain         concin           rbmx          poff           belv
    0.0000e+00     0.0000e+00     0.0000e+00     0.0000e+00     0.0000e+00
*******   type            num             id        ctitle
htstr                       4              4 powered-rod conductor
*         nzhtstr          ittc     hscyl            ichf (nzhtstr is flag
for general table use)
             4              0       1                   1
*       nopowr          plane          liqlev         iaxcnd
             0              2          0              0
*       nmwrx            nfci          nfcil          hdri           hdro
             1              0              0          0.25231    0.35231
*        nhot           nodes          irftr          nzmax
             0              4             0              4
*      dtxht(1)       dtxht(2)         dznht          hgapo          shelv
    5.0000e+00     1.0000e+01     5.0000e-02     0.0000e+00     0.0000e+00
* idbciN * 2   2   2   2e
* idbcoN * 3   3   3   3e
* hcomi nhcelii nhcelji nhcelki
           2  1  0  0 e
           2  2  0  0 e
           2  3  0  0 e
           2  4  0  0 e
* outside bc
* General Heat Structure Table Data usage (Card Set 17)
*    table Number
           1 e
           2 e
           30 e
           4 e
* dzhtstr * f 0.5 e
* rdx    *    1.0e
* radrd  *    1.2616e-01    1.4283e-01    1.5949e-01    1.7616e-01e
* matrd  * f          7e
* nfax   * f          0e
* rftn   * f  3.0000e+02e
* fpuo2  *    0.0000e+00e
* ftd    *    9.2500e-01e
* gmix   * f  0.0000e+00e
* gmles  *    0.0000e+00e
* pgapt  *    0.0000e+00e
* plvol  *    2.0000e-05e
* pslen  *    3.6576e+00e
* clenn  *    3.9576e+00e
* burn   * f  2.6620e+03e
*
*******   type            num             id        ctitle
```

```
  power         901            901 power data input test1
* npowr
   1
* htnid
   4e
*       irpwty          ndgx          ndhx          nrts         nhist
             5             0           -11             5             0
*       izpwtr        izpwsv        nzpwtb        nzpwsv        nzpwrf
             0             1             1             0             0
*        ipwrad       ipwdep
             0             0
*        nzpwz         nzpwi        nfbpwt
             0             0             0
*        react         tneut        rpwoff        rrpwmx        rpwscl
    0.0000e+00    0.0000e+00    0.0000e+00    0.0000e+00    1.0000e+00
*       rpowri         zpwin        zpwoff        rzpwmx
    5.0000e+04    0.0000e+00    0.0000e+00    0.0000e+00
*       extsou          pldr         pdrat        fucrac
    0.0000e+00    0.0000e+00    1.3000e+00    7.0000e-01
* rdpwr * f   1.0000e+00e
* cpowr *     1.0000e+00e
* zpwtb * f   1.0000e+00e
*
*
*
end
*
******************
* time-step data *
******************
*
*        dtmin         dtmax          tend         rtwfp
    1.0000e-02    5.0000e+00    3.0000e+03    1.0000e+02
*        edint         gfint        dmpint        sedint
    1.0000e+02    1.0000e+01    1.0000e+03    5.0000e+01
*
******************
* time-step data *
******************
*
*      endflag
   -1.0000e+00
```

Example 2: Restart with general heat structure table data. No changes to the general table data.

```
free format
*
*************
* main data *
*************
*
*       numtcr          ieos         inopt          nmat
            13             0             1             0
*-*-*TEST PROBLEM idbc3r
 Replaces pipe wall with new heat structure
 Pipe wall includes power = 50 kw
 Coolant is liquid at Tliq = 300 K.
 Flow rate through pipe is = 1 kg/sec.
```

```
 Pipe has a flow area of 0.2 m**2, four cells long with,
 each cell 0.5 m long, volume of each cell is 0.1 m**2.
 Pipe wall thickness is 0.05 m and has 4 nodes in pipe wall.
 Pipe outside wall heat flux  is 22586.7 W/m2 == 50 kW input.
 Total energy input: 100 kW
 Pipe inner diameter = 0.25231 m and a radius of 0.12616 m
 Asurf-inner = pi*D*L = pi*0.25231*2 = 1.58531 m**2
*
*****************
* namelist data *
*****************
*
 &inopts
 nhtstr=1, cpuflg=1, npower=1, numGenTbl = 4, (NAMELIST variable, Main-
Data Card 4)
 &end
*
*        dstep          timet
            -1     0.0000e+00
*       stdyst         transi          ncomp           njun           ipak
             0              1              5              2              1
*         epso           epss
    1.0000e-03     1.0000e-10
*       oitmax         sitmax         isolut         ncontr
            10             10              0              0
*         ntsv           ntcb           ntcf           ntrp           ntcp
             1              0              0              1              0
*
*************************
* component-number data *
*************************
*
* iorder*              1              2              3              4 901e
*
**************************
* control-parameter data *
**************************
*
*
* signal variables
*         idsv           isvn           ilcn           icn1           icn2
             0              0              0              0              0
*
* trips
*         ntse           ntct           ntsf           ntdp           ntsd
             0              0              0              0              0
*         idtp           isrt           iset           itst           idsg
             0              2              0              1              1
*
*   General tables to be obtained from the restart file.
* Card Number 1
  1 2 30 4e
* read the general table data from the restart file
* End of general table input.
 -1
*
******************
* component data *
******************
*
*
end
*
******************
```

```
* time-step data *
******************
*
*        dtmin          dtmax          tend          rtwfp
    1.0000e-02    1.0000e+00    3.0000e+02    1.0000e+02
*        edint          gfint        dmpint         sedint
    1.0000e+02    1.0000e+01    1.0000e+02    5.0000e+01
*
******************
* time-step data *
******************
*
*      endflag
   -1.0000e+00
```

Example 3: Restart with general heat structure table data. Changes to general table 1 and read table 2, 30, and 4 from the restat file.

```
free format
*
*************
* main data *
*************
*
*       numtcr           ieos          inopt           nmat
            13              0              1              0
*-*-*TEST PROBLEM idbc3r2
 Replaces pipe wall with new heat structure
 Pipe wall includes power = 50 kw
 Coolant is liquid at Tliq = 300 K.
 Flow rate through pipe is = 1 kg/sec.
 Pipe has a flow area of 0.2 m**2, four cells long with,
 each cell 0.5 m long, volume of each cell is 0.1 m**2.
 Pipe wall thickness is 0.05 m and has 4 nodes in pipe wall.
 Pipe outside wall heat flux  is 22586.7 W/m2 == 50 kW input.
 Total energy input: 100 kW
 Pipe inner diameter = 0.25231 m and a radius of 0.12616 m
 Asurf-inner = pi*D*L = pi*0.25231*2 = 1.58531 m**2
*
*****************
* namelist data *
*****************
*
 &inopts
 nhtstr=1, cpuflg=1, npower=1, numGenTbl = 4, (NAMELIST variable, Main-
Data Card 4)
 &end
*
*        dstep          timet
            -1    0.0000e+00
*       stdyst         transi          ncomp           njun           ipak
             0              1              5              2              1
*         epso           epss
    1.0000e-03    1.0000e-10
*       oitmax         sitmax         isolut         ncontr
            10             10              0              0
*         ntsv           ntcb           ntcf           ntrp           ntcp
             1              0              0              1              0
*
*************************
```

```
* component-number data *
*************************
*
* iorder*             1             2             3             4  901e
*
**************************
* control-parameter data *
**************************
*
*
* signal variables
*        idsv          isvn          ilcn          icn1          icn2
*           0             0             0             0             0
*
* trips
*        ntse          ntct          ntsf          ntdp          ntsd
*           0             0             0             0             0
*        idtp          isrt          iset          itst          idsg
*           0             2             0             1             1
*
*   General tables to be obtained from the restart file.
* Card Number 1
  1 2 30 4e
* Card Number 2
*  tableNumber
             1
* Card Number 3
*      nPoints     tabletype         SigId        tripID    outBounds
             5             2             1             0           -2
* Card Set 4
*   Table Data
*      Time(s)  QFlux(w/m^2)
           0.0       22586.7s
         100.0       22586.7s
         300.0           0.0s
         500.0       22586.7s
        3000.0       22586.7e
* read the general table data from the restart file
* End of general table input.
 -1
*
******************
* component data *
******************
*
*
end
*
******************
* time-step data *
******************
*
*        dtmin         dtmax          tend         rtwfp
    1.0000e-02    1.0000e+00    3.0000e+02    1.0000e+02
*        edint         gfint        dmpint        sedint
    1.0000e+02    1.0000e+01    1.0000e+02    5.0000e+01
*
******************
* time-step data *
******************
*
*      endflag
   -1.0000e+00
```

BREAK Component Data

Note: A **BREAK** component cannot be connected directly to a **FILL**, **PLENUM**, or **VESSEL** component.

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (BREAK left justified).
NUM	Component ID number (must be unique for each component, 1 ≤ NUM ≤ 999).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2A14) **EOS, PHASECHANGE**

Note: Only input this card when the number of inputs for FLUIDS (a NAMELIST variable) is more than one.

Variable	Description
EOS	EOS identifier for this component (i.e. "h2o" or "r5h2o", etc.).
PHASECHANGE	Phase change flag. Input TRUE or true, if phase change is allowed for this component. Input FALSE or false, if phase change is not allowed for this component.

Card Number 3. (Format 4I14) **JUN1, IBTY, ISAT, IOFF, ADJPRESS**

Variable	Description
JUN1	Junction number to which the BREAK is connected.

Card Number 3. (Format 4I14) **JUN1, IBTY, ISAT, IOFF, ADJPRESS** (Continued)

Variable	Description
IBTY	BREAK-type option. 0 = no tables input and not a Generalized BREAK (see IBTY = 6); 1 = input pressure table (array **PTB**, **Card Set 14**); 2 = input pressure and temperature tables (arrays **PTB** and **TLTB**, and **TVTB** if ISAT = 4, **Card Set 14**, **Card Set 15**, and **Card Set 16**); 3 = input above tables plus gas volume-fraction table (array **ALPTB**, **Card Set 17**); 4 = input above tables plus noncondensable-gas partial-pressure table (array **PATB**, **Card Set 18**); 5 = input above tables plus solute-to-coolant mass-ratio table (array **CONCTB**, **Card Set 19**), [requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**)]; 6 = Generalized-BREAK fluid parameters defined individually by a signal variable or control block (see **Card Number 10**). **Note:** this option is not under direct control by trip ID number IBTR (Word 1 on **Card Number 4**) and the rate of change of the fluid parameters is not constrained by RBMX (Word 3 on **Card Number 6**). 7 = Connected with CONTAN component. All BREAK fluid parameters are defined by the connecting CONTAN compartment.
ISAT	BREAK temperature table use options. 0 = use TIN or single table for liquid and gas temperatures; 1 = use TIN or table for liquid and set gas to T_{sat}; 2 = use TIN or table for gas and set liquid to T_{sat}; 3 = set liquid and gas to T_{sat}; 4 = use separate tables or separate signal variables and control blocks for the liquid and gas; 5 = set liquid and gas to input-specified offsets from T_{sat} (see **Card Number 4**). For IBTY = 6 (Word 2 on **Card Number 3**), ISAT= 1, 2, and 3 has same effect (liquid and/or gas temperature set to T_{sat}). ISAT = 0 or 4 behave as follows: user can have TIN, signal variable, or control block for liquid and/or gas temperature, depending on values of IBTLSV and IBTVSV (see **Card Number 10**).

Card Number 3. (Format 4I14) **JUN1, IBTY, ISAT, IOFF, ADJPRESS** (Continued)

Variable	Description
IOFF	The BREAK fluid-state option (defines the fluid state when the BREAK table's controlling-trip is OFF after being ON) [define IOFF when IBTR ≠ 0 or 6 (Word 1 on **Card Number 4**); Set IOFF = 0 for BREAK-type options IBTY = 0 or 6 (Word 2 on **Card Number 3**)]. 0 = the last BREAK table's interpolated fluid state is held constant; 1 = define the initial fluid state; 2 = input the pressure to be used, but maintain the fluid condition that existed when the trip was set OFF; 3 = input a complete fluid-state definition for when the controlling trip is OFF after being ON.
ADJPRESS	Active break option 0 = no relation between break pressure and adjacent pressure; 1 = break pressure is equal to the pressure in the adjacent cell.

Card Number 4. (Format 2E14.4) **DELTL, DELTV**

Note: If ISAT ≠ 5 (Word 3 on **Card Number 3**), do not input this card.

Variable	Description
DELTL	Liquid temperature (K, °F) offset from the BREAK-fluid saturation temperature. The BREAK-cell liquid temperature is set to T_{sat} + DELTL where DELTL is positive or negative valued.
DELTV	Gas temperature (K, °F) offset from the BREAK-fluid saturation temperature. The BREAK-cell gas temperature is set to T_{sat} + DELTV where DELTV is positive or negative valued.

Card Number 5. (Format 5I14) **IBTR, IBSV, NBTB, NBSV, NBRF**

Note: If IBTY = 0 or 7 (Word 2 on **Card Number 3**), do not input this card. If IBTY = 6, the 5 fields of this card should be input with 0.

Variable	Description
IBTR	The trip ID number that controls evaluation of the BREAK table (|IBTR| ≤ 9999). Input IBTR = 0 if there is no trip control or if IBTY = 6 (Word 2 on **Card Number 3**).

Card Number 5. (Format 5I14) **IBTR, IBSV, NBTB, NBSV, NBRF** (Continued)

Note: If IBTY = 0 or 7 (Word 2 on **Card Number 3**), do not input this card. If IBTY = 6, the 5 fields of this card should be input with 0.

Variable	Description
IBSV	The BREAK-table abscissa-coordinate variable ID number that defines the independent-variable parameter for the IBTY = 1 to 5 tables. IBSV > 0 defines the ID number for a signal-variable parameter; IBSV < 0 defines the ID number for a control-block output parameter. Input IBSV = 0 if IBTY = 6 (Word 2 on **Card Number 3**).
NBTB	The number of BREAK-table pairs (defined by the absolute value of NBTB) for break options **IBTY** = 1 to 5 (Word 2 on **Card Number 3**). NBTB > 0 defines the independent-variable form to be the IBSV parameter value; NBTB < 0 defines the independent-variable form to be the sum of the change in the IBSV parameter over the last timestep times the trip set-status value ISET (when the BREAK table is trip controlled, IBTR ≠ 0); NBTB = 0 (for IBTY = 1 only) defines the BREAK pressure to be the IBSV parameter value. Input NBTB = 0 if IBVTY = 6 (Word 2 on **Card Number 3**).
NBSV	The rate-factor table abscissa-coordinate variable ID number. NBSV > 0 defines the ID number for a signal-variable parameter; NBSV < 0 defines the ID number for a control-block output parameter; NBSV = 0 when NBRF ≠ 0 defines the difference between the trip signal and the setpoint value that turns the trip OFF (when the BREAK table or tables are trip controlled).
NBRF	The number of rate-factor table pairs (defined by the absolute value of NBRF). The rate factor is applied as a factor to the independent variable of the BREAK table or tables when the rate factor is defined. No rate factor is defined when NBSV and NBRF are both zero. NBRF > 0 defines the rate-factor table abscissa coordinate to be the sum of the NBSV parameter value; NBRF < 0 defines it to be the change in the NBSV parameter over the last timestep times the trip set-status value ISET (when the BREAK table is trip controlled, IBTR ≠ 0); NBRF = 0 defines the rate factor to be the NBSV parameter value.

Card Number 6. (Format 5E14.4) **DXIN, VOLIN, ALPIN, TIN, PIN**

Variable	Description
DXIN	Cell length (m, ft) (generally defined to be the same as its neighboring cell in the adjacent component). Used to define the BREAK-cell flow area, VOLIN/DXIN, and used in stratified-flow calculations.
VOLIN	Volume (m^3, ft^3) of the BREAK cell. Used to define the BREAK-cell flow area, VOLIN/DXIN, and used in stratified-flow calculations.

Card Number 6. (Format 5E14.4) **DXIN, VOLIN, ALPIN, TIN, PIN** (Continued)

Variable	Description
ALPIN	Initial gas volume fraction (–) at the BREAK.
TIN	Initial mixture temperature (K, °F) at the BREAK.
PIN	Initial pressure (Pa, psia) at the BREAK.

Card Number 7. (Format 5E14.4) **PAIN, CONCIN, RBMX, POFF, BELV**

Variable	Description
PAIN	Initial noncondensable-gas partial pressure (Pa, psia) at the BREAK.
CONCIN	Solute mass to liquid-coolant mass ratio at the BREAK [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)]. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
RBMX	Maximum rate of change of the BREAK pressure (Pa/s, psia/s) [0.0 ≤ RBMX]. RBMX is not used when IBTY = 6 (Word 2 on **Card Number 3**).
POFF	Pressure (Pa, psia) at the BREAK when the controlling-trip is set OFF after being ON. POFF is used only when IBTY ≠ 0 or 6 (Word 2 on **Card Number 3**), IBTR ≠ 0 (Word 1 on **Card Number 5**) and IOFF ≥ 2 (Word 4 on **Card Number 3**).
BELV	BREAK cell-centered elevation (m, ft) (used only to compute GRAV when IELV = 1).

Card Number 8. (I14) **COMPID**

Note: If IBTY ≠ 7, do not input this card.

Variable	Description
COMPID	|COMPID| represents the CONTAN compartment user defined ID. When COMPID>0, the BREAK is inside the vapor space of the compartment. When COMPID < 0, the BREAK is inside the liquid space of the compartment.

Card Number 9. (Format 2E14.4) **BDSPRAY, BDCOND**

Note: If IBTY ≠ 7, do not input this card.

Variable	Description

Card Number 9. (Format 2E14.4) **BDSPRAY, BDCOND** (Continued)

BDSPRAY	If the BREAK is connected with the vapor region of a compartment and it is injecting subcooled water into the containment, 'BDSPRAY' represents the mass fraction of the injected liquid which reaches thermal equilibrium with the fluid in the vapor space.
BDCOND	If the BREAK is connected with the liquid region of a compartment and it is injecting super-heated vapor and hot air into the containment, 'BDCOND' represents the mass fraction of the injected vapor which reaches thermal equilibrium with the fluid in the liquid space.

Card Number 10. (Format 5E14.4) **ALPOFF, TLOFF, TVOFF, PAOFF, CONOFF**

Note: If IBTY = 0 or 7 (Word 2 on **Card Number 3**), IBTR = 0 (Word 1 on **Card Number 5**), and IOFF ≠ 3 (Word 4 on **Card Number 3**), do not input this card.

Variable	Description
ALPOFF	BREAK gas volume fraction (–) when the controlling-trip is set OFF after being ON (used only when IBTY ≥ 3).
TLOFF	BREAK liquid temperature (K, °F) when the controlling-trip is set OFF after being ON (used only when IBTY ≥ 2).
TVOFF	BREAK gas temperature (K, °F) when the controlling-trip is set OFF after being ON (used only when IBTY ≥ 2).
PAOFF	BREAK noncondensable-gas partial pressure (Pa, psia) when the controlling-trip is set OFF after being ON (used only when IBTY ≥ 4).
CONOFF	BREAK solute mass to liquid-coolant mass ratio [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)] when the controlling-trip is set OFF after being ON. Used only when IBTY = 5 and requires ISOLUT = 1 (Word 3 on **Main-Data Card 6**).

Card Number 11. (Format 5E14.4) **PSCL, TLSCL, TVSCL, PASCL, CONSCL**

Note: If IBTY = 0 or 7 (Word 2 on **Card Number 3**) and NBTB = 0 (Word 3 on **Card Number 5**), do not input this card.

Variable	Description
PSCL	Pressure scale factor (–). The dependent variable in the pressure table PTB is multiplied by this factor to obtain absolute pressure (Pa, psia) (used only when IBTY ≥ 1).

Card Number 11. (Format 5E14.4) **PSCL, TLSCL, TVSCL, PASCL, CONSCL** (Continued)

Note: If IBTY = 0 or 7 (Word 2 on **Card Number 3**) and NBTB = 0 (Word 3 on **Card Number 5**), do not input this card.

Variable	Description
TLSCL	Liquid-temperature scale factor (–). The dependent variable in the liquid-temperature table TLTB is converted to absolute liquid temperature (K, °R), multi-plied by this factor to obtain the absolute liquid temperature (K, °R), and converted back to SI/English units liquid temperature (K, °F) (used only when IBTY ≥ 2).
TVSCL	Gas-temperature scale factor (–). The dependent variable in the vapor-temperature table TVTB is converted to absolute gas temperature (K, °R), multiplied by this factor to obtain the absolute gas temperature (K, ×°R), and converted back to SI/English units gas temperature (K, °F) (used only when IBTY ≥ 2 and ISAT = 4).
PASCL	Noncondensable-gas partial pressure scale factor (–). The dependent variable in the noncondensable-gas partial pressure table PATB is multiplied by this scale factor to obtain the absolute noncondensable-gas partial pressure (Pa, psia) (used only when IBTY ≥ 4).
CONSCL	Solute mass to liquid-mass ratio scale factor (–). The dependent variable in the solute mass to liquid-mass ratio table CONCTB is multiplied by this scale factor to obtain the absolute ratio value [kg(solute)/kg (liquid), lb_m (solute)/lb_m (liquid)]. Used only when IBTY = 5 and requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).

Card Number 12. (Format 5I14) **IBPSV, IBTLSV, IBTVSV, IBASV, IBPASV**

Note: If IBTY ≠ 6 (Word 2 on **Card Number 3**), do not input this card.

Variable	Description
IBPSV	Signal variable or control-block ID number defining the BREAK pressure.
IBTLSV	Signal variable or control-block ID number defining the BREAK liquid temperature.
IBTVSV	Signal variable or control-block ID number defining the BREAK gas temperature.
IBASV	Signal variable or control-block ID number defining the BREAK gas volume fraction.

Card Number 12. (Format 5I14) **IBPSV, IBTLSV, IBTVSV, IBASV, IBPASV** (Continued)

Variable	Description
Note: If IBTY ≠ 6 (Word 2 on **Card Number 3**), do not input this card.	
IBPASV	Signal variable or control-block ID number defining the BREAK noncondensable gas partial pressure.

Card Number 13. (Format 1I14) **IBCNSV**

Variable	Description
Note: If IBTY ≠ 6 (Word 2 on **Card Number 3**), do not input this card.	
IBCNSV	Signal variable or control-block ID number defining the BREAK solute-to-coolant mass ratio. Used only if ISOLUT = 1 (Word 3 on **Main-Data Card 9**).

BREAK Table Array Cards.

Note: Input each of the following arrays using LOAD format for **IBTY** 1 through 5 (Word 2 on **Card Number 3**). If **NBTB** = 0 (Word 3 on **Card Number 5**), do not input the BREAK Array Cards. Each array has its element values defined by a Card Set of one or more cards.

Card Set Number	Variable	Dimension	Description
Note: If IBTY < 1 (Word 2 on **Card Number 3**), do not input array PTB.			
14	**PTB**	2 × |NBTB|	BREAK pressure vs independent-variable-form table [(*,Pa), (*, psia)]. Input |NBTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IBSV (Word 2 on **Card Number 5**), pressure].

Card Set Number	Variable	Dimension	Description
Note: If IBTY < 2 (Word 2 on **Card Number 3**), do not input array TLTB.			
15	**TLTB**	2 × |NBTB|	BREAK liquid temperature vs independent-variable- form table [(*, K), (*,°F)]. Input |NBTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IBSV (Word 2 on **Card Number 5**), liquid temperature].
Note: If IBTY < 2 (Word 2 on **Card Number 3**) or ISAT ≠ 4 (Word 3 on **Card Number 3**), do not input array TVTB.			
16	**TVTB**	2 × |NBTB|	BREAK gas temperature vs independent-variable-form table [(*, K), (*, F)]. Input |NBTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IBSV (Word 2 on **Card Number 5**), gas temperature].
Note: If IBTY < 3 (Word 2 on **Card Number 3**), do not input array ALPTB.			
17	**ALPTB**	2 × |NBTB|	BREAK gas volume-fraction vs independent-variable-form table (*,–). Input |NBTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IBSV (Word 2 on **Card Number 5**), gas volume fraction].
Note: If IBTY < 4 (Word 2 on **Card Number 3**), do not input array PATB.			
18	**PATB**	2 × |NBTB|	BREAK noncondensable-gas partial pressure vs independent-variable-form table [(*, Pa), (*, psia)]. Input |NBTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IBSV (Word 2 on **Card Number 5**), noncondensable-gas partial pressure].

Card Set Number	Variable	Dimension	Description
Note: If IBTY ≠ 5 (Word 2 on **Card Number 3**), do not input array CONCTB.			
19	**CONCTB**	2 × |NBTB|	BREAK solute mass to liquid coolant-mass ratio vs independent-variable-form table [{*, kg(solute)/kg (liquid)}, {*, lb_m(solute)/lb_m(liquid)}]. Input |NBTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IBSV (Word 2 on **Card Number 5**) and the ratio of solute mass to liquid mass]. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: If NBRF = 0 (Word 5 on **Card Number 5**), do not input array RFTB.			
20	**RFTB**	2 × |NBRF|	Rate-factor table (*,–) for the BREAK function table's independent-variable form defined by IBSV (Word 2 on **Card Number 5**). Input |NBTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by NBSV (Word 4 on **Card Number 5**) and the rate factor to be applied to the BREAK function table's independent variable].
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
21	**XGNB**	NCELLS	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. If IGAS>11, then sum of mass fractions for non-condensable gas species must to sum to 1.0.
Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
22	**XLNB**	NCELLS	Mass fraction for liquid trace species.

CHAN Component Data

The CHAN component is used for BWR applications. Set NAMELIST variables TRACBOUT = 1, IAMBWR = .TRUE., if applicable, set USESJC = 2 if the CHAN model contains a leak path.

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (CHAN left justified).
NUM	Component ID number (must be unique for each component, $1 \leq$ NUM ≤ 999).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 4I14,E14.4) **NCELLS, NODES, JUN1, JUN2, EPSW**

Variable	Description
NCELLS	Number of fluid cells in this CHAN component.
NODES	Number of radial conduction nodes in the CHAN canister wall
JUN1	Junction number for junction interface adjacent to cell 1.
JUN2	Junction number for junction interface adjacent to cell NCELLS.
EPSW	Canister wall surface roughness (m, ft).

Card Number 3. (Format I14) **NSIDES**

Note: Input Card Number 3 if NAMELIST variable USESJC = 2 or 3. This will allow this component to have side junctions so that a leak path can be established from this component to another. NSIDES leak paths are established. See SJC model.

Variable	Description
NSIDES	Number of fluid leaks in canister wall plus 2 times the number of water rods to be spawned (i.e. NUMWATERRODS; Word 4 on **Card Number 9**).

Note: If NSIDES > 0 then input the next three cards as sets of 1, 2, or 3 cards per NSIDES. Examples include:

If USESJC = 2 and JUNLK (Word 2 on **Card Number 4**) is > 0 only **Card Number 4** is needed.

If USESJC = 2 and JUNLK is 0 input **Card Number 4** and **Card Number 5** in pairs.

If USESJC = 3 and JUNLK > 0 input **Card Number 4** and **Card Number 6** in pairs.

If USESJC = 3 and JUNLK is 0 input **Card Number 4**, **Card Number 5**, and **Card Number 6** in sets.

Card Number 4. (Format 5I14) **NCLK, JUNLK, NCMPTO, NCLKTO, NLEVTO**

Note: If NCELLS or NSIDES = 0, or USESJC = 1 do not input this card. Otherwise input this card for each NSIDES.

Variable	Description
NCLK	"From" cell number in the PIPE component.
JUNLK	Junction number. Enter a zero to have the code spawn a Single Junction Component internally or enter the junction number here and in the Vessel source cards, if this is a leak path junction. If this is a water rod junction, then enter a unique junction number for both the inlet and outlet for each water rod. The first 2*NUMWATERRODS (Word 4 on **Card Number 9**) side junction input will be associated with the water rod models for this CHAN component. The last junction input must be for the CHAN to bypass leakage path.
NCMPTO	Component number of "To" component of a leak path. Enter 0 if JUNLK ≠ 0.
NCLKTO	Cell number of "To" cell of a leak path Enter 0 if JUNLK ≠ 0.
NLEVTO	Axial level number of "To" cell of a leak path when "To" component is a VESSEL. Otherwise enter 0. Enter 0 if JUNLK ≠ 0.

Card Number 5. (Format 5E14.4) **FALK, CLOS, VLLK, VVLK, DELZLK**

Note: If NCELLS or NSIDES = 0 do not input this card. Input this card only if JUNLK = 0. If USESJC = 2 or 3, input this card for each NSIDES.	
Variable	**Description**
FALK	Leak path flow area (m^2, ft^2)
CLOS	Leak path loss coefficient
VLLK	Leak path initial liquid velocity (m/s, ft/s)
VVLK	Leak path initial vapor velocity (m/s, ft/s)
DELZLK	Elevation difference between center of "From" cell and center of "To" cell DELZLK > 0 when the center of the "From" cell is higher than the center of the "To" cell DELZLK < 0 when the center of the "From" cell is lower than the center of the "To" cell

Card Number 6. (Format E14.4, I14) **THETA, IENTRN**

Note: If NCELLS or NSIDES = 0, or USESJC = 1 or 2 do not input this card.	
Variable	**Description**
THETA	Angle between the main direction of flow and the flow through the side junction.
IENTRN	Offtake-model option. 0 = off; 1 = on (side-junction mass flow determined using offtake model)

CHAN Component Data

Card Number 7. (Format 5I14) **ICHF, ICONC, IAXCND, LIQLEV, IPVHT**

Variable	Description
ICHF	CHF calculation option. 0 = convection heat transfer only, no boiling heat transfer (i.e. no wall nucleation is allowed although phase change can still occur); 1 = CHF from AECL-IPPE CHF Table, no critical quality calculated. 2 = CHF from AECL-IPPE CHF Table, critical quality from Biasi correlation. 3 = CHF from AECL-IPPE CHF Table, critical quality from CISE-GE correlation.
ICONC	Solute in the liquid coolant option. Requires ISOLUT =1 (Word 3 on **Main-Data Card 9**) when ICONC > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated out solute.
IAXCND	Specification of axial conduction. 0 = no axial heat transfer conduction calculated; 1 = axial heat transfer conduction calculated (explicit numerics when NAMELIST variable NRSLV = 0; implicit numerics when NRSLV = 1).
LIQLEV	Specification of liquid level tracking. 0 = no 1 = yes (this produces a more accurate axial heat transfer solution).
IPVHT	The number of the component surrounding the CHAN.

Card Number 8. (Format 5E14.4) **WIDTH, TH, HOUTL, HOUTV, TOUTL**

Note: The four parameters, HOUTL, HOUTV, TOUTL, and TOUTV, allow flexibility in calculating possible heat losses from the outside of the PIPE wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
WIDTH	Inside perimeter (m, ft) of the canister wall.
TH	Wall thickness (m, ft).

Card Number 8. (Format 5E14.4) **WIDTH, TH, HOUTL, HOUTV, TOUTL** (Continued)

Note: The four parameters, HOUTL, HOUTV, TOUTL, and TOUTV, allow flexibility in calculating possible heat losses from the outside of the PIPE wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
HOUTL	CHAN outside wall heat transfer coefficient to liquid.
HOUTV	CHAN outside wall heat transfer coefficient to vapor.
TOUTL	CHAN outside constant wall liquid temperature.

Card Number 9. (Format E14.4, 3I14) **TOUTV, ADVBWRF, QUADSYM, NUMWATERRODS, NVFRAYS**

Variable	Description
TOUTV	CHAN outside wall vapor temperature.
ADVBWRF	Advanced BWR fuel design flag. ADVBWRF = 0, implies that this CHAN model does not include any advanced BWR fuel design. ADVBWRF = 1, implies that this CHAN model does include an advanced BWR fuel design.
QUADSYM	Symmetry flag for advanced BWR fuel design. QUADSYM = 0, implies that the pitch-to-diameter ratio is constant for fuel rods within this BWR fuel assembly. QUADSYM = 1, implies that the pitch-to-diameter ratio is constant for fuel rods within each of the four quadrants for this BWR fuel assembly. QUADSYM = 2, is the same as QUADSYM = 1, except there is also a water cross present in this BWR assembly. QUADSYM = 3 implies that the BWR assembly has four quadrants that are symmetric with the same pitch, but the fuel rod diameters may vary and a water cross water rod is present. Presence of a water cross water rod implies that no rod in a given quadrant of the BWR fuel assembly can be "seen" (as it relates to the view factor calculation) by a rod in another quadrant of the BWR fuel assembly.
NUMWATERRODS	Number of water rod models to be spawned by this CHAN component. Note the number of actual water rods in this BWR fuel assembly must be equal to or greater than NUMWATERRODS.

Card Number 9. (Format E14.4, 3I14) **TOUTV, ADVBWRF, QUADSYM, NUMWATERRODS, NVFRAYS** (Continued)

Variable	Description
NVFRAYS	Number of rays to be used per surface for ray tracing view factor calculation. If NVFRAYS = 0, then the cross-string method will be used except for fuel designs that have non-cylindrical water rods. For non-cylindrical water rod cases, NVFRAYS will be reset to a positive value. If NVFRAYS > 0, then the ray tracing method will be used to calculate view factors. If NVFRAYS > 0, then NVFRAYS should be at least 100,000 or larger to generate accurate view factors. For the non-cylindrical water rod cases where NVFRAYS is initially set to zero, NVFRAYS will be reset to 100,000 for the cases where QUADSYM = 0 and to 25,000 for the cases where QUADSYM > 0.

Card Number 10. (Format 5I14) **NGRP, NCHANS, NODESR, NROW, NCRZ**

Variable	Description
NGRP	Number of rod types modeled in the rod bundle. This number will get reset internally to NCRX = NRODS. The value entered here should include **both** water rods and fuel rods.
NCHANS	Number of fuel bundles represented by this CHAN.
NODESR	Number of radial conduction nodes in the CHAN rods.
NROW	Number of rods in a row.
NCRZ	Number of axial cells between the upper and lower tie-plate. If ADVBWRF (i.e. Word 2 on **Card Number 9**) = 1, then NCRZ is used only for the full length fuel rod groups. There must be at least one full length fuel rod group and the first fuel rod group must be a full length fuel rod group.

Card Number 11. (Format 5I14) **ICRNK, ICRLH, NMRWX, NFCI, NFCIL**

Variable	Description
ICRNK	Number of CHAN cells below the powered region. ICRNK + NCRZ (Word 5 of **Card Number 10**) must be less than or equal to NCELLS.
ICRLH	Number of CHAN cells below the lower tie plate.

Card Number 11. (Format 5I14) **ICRNK, ICRLH, NMRWX, NFCI, NFCIL** (Continued)

Variable	Description
NMWRX	Metal-water reaction option. 0 = off; 1 = on.
NFCI	Fuel clad interaction option..NFCI = 1 performs the dynamic gas-gap conductance calculation. 0 = off; 1 = on.
NFCIL	Maximum number of FCI calculations per time step. Input NFCIL = 1 when NFCI = 1.

Card Number 12. (Format 5I14) **FMON, REFLOODON, NZMAX, NZMAXW, IBEAM**

Variable	Description
FMON	Fine mesh flag. If it is non-zero, then the fine mesh algorithm is turned on.
REFLOODON	Reflood input flag. This flag is now redundant in that it behaves identically to FMON above - if it is non-zero, then the fine mesh algorithm is turned on (even if FMON is set to zero). As of V4.260, the code no longer distinguishes between reflood and non-reflood sets of physical models. The only reason this flag still remains is to maintain backward compatibility with older input decks which may have had the IRFTR flag (now called FMON) set to 0 and IRFTR2 (this variable) set to a non-zero number.
NZMAX	Maximum number of rows of nodes in the axial direction. The value supplied here is governed by the requirement that $NZMAX \geq 2 + \sum_{I=1}^{NCRZ} NFAX(I)$. Users should use small values of NZMAX if possible and especially if axial conduction heat transfer will not be calculated. Large values of NZMAX can lead to very large graphics files (if GRAPHLEVEL = ’full’) and large computer memory consumption for the simulation.
NZMAXW	Similar to NZMAX except for the canister wall. NZMAXW is a function of NCELLS instead of NCRZ.

Card Number 12. (Format 5I14) **FMON, REFLOODON, NZMAX, NZMAXW, IBEAM** (Continued)

Variable	Description
IBEAM	Set IBEAM to 1 if view factors and beam lengths are included in place of the MROD array (**Card Set 60**) and LevRod array. Otherwise set it to 0. Zero is the default value.

Card Number 13. (Format 5E14.4) **DZNHT, DZNHTW, DTXHT1, DTXHT2, UNHEATFR**

Variable	Description
DZNHT	Minimum ΔZ (m, ft) axial interval between rod node rows below which no additional row of nodes is inserted in the axial fine mesh heat transfer calculation (this value should be based on the diffusion number when explicit axial heat conduction numerics is being evaluated).
DZNHTW	Minimum ΔZ (m, ft) axial interval between wall node rows below which no additional row of nodes is inserted in the axial fine mesh heat transfer calculation (this value should be based on the diffusion number when explicit axial heat conduction numerics is being evaluated).
DTXHT1	Maximum ΔT (K, °F) surface temperature change between node rows above which a row of nodes is inserted in the axial fine mesh heat transfer calculation for the nucleate and transition boiling regimes [Currently not used]
DTXHT2	Maximum ΔT (K, °F) surface temperature change between node rows above which a row of nodes is inserted in the axial fine mesh heat transfer calculation for all heat transfer regimes except the nucleate and transition boiling regimes [Currently not used].
UNHEATFR	Fraction of the HS surface perimeter that is not heated. This input is only used when REFLOODON (Word 2 on **Card Number 12**) is not equal to zero.

Card Number 14. (Format 4E14.4, I14) **HGAPO, PDRAT, PLDR, FUCRAC, NORAD**

Variable	Description
HGAPO	Rod gas gap HTC [W/(m^2 K), Btu/(ft^2 °F hr)].
PDRAT	Rod pitch-to-diameter.
PLDR	Pellet dish radius (m, ft) [no calculation of pellet dishing is performed if PLDR = 0.0] (currently not used).

Card Number 14. (Format 4E14.4, I14) **HGAPO, PDRAT, PLDR, FUCRAC, NORAD** (Continued)

Variable	Description
FUCRAC	Fraction of the fuel (–) which is not cracked [used only when NFCI = 1 (Word 4 on **Card Number 11**)].
NORAD	If NORAD is equal to one, then radiation heat transfer model is turned off.

Card Number 15. (Format 3E14.4, 2I14) **EMCIF1, EMCIF2, EMCIF3, NOANI, NGRIDSPACERS**

Note: Emissivity as a function of surface temperature equation: $\epsilon = c_1 + c_2 T + c_3 T^2$.

Variable	Description
EMCIF1	Canister wall c_1 term in quadratic fit of emissivity.
EMCIF2	c_2 term.
EMCIF3	c_3 term.
NOANI	If NOANI is equal to one, then the anisotropic view factor corrections are not applied to the view factor calculation.
NGRIDSPACERS	Number of grid spacers associated with this CHAN component. Input zero for this parameter at this time. TRACE currently has no actual grid spacer model - this is merely a placeholder for a future planned feature.

Card Number 16. (Format 3E14.4) **EMCOF1, EMCOF2, EMCOF3**

Variable	Description
EMCOF1	Rod surface c_1 term in quadratic fit of emissivity.
EMCOF2	c_2 term.
EMCOF3	c_3 term.

CHAN Array Cards.

Note: Some of the following Card Sets may be skipped depending upon the input options. Use LOAD format. Each array has its element values defined by a Card Set of one or more cards.

All junction variables must match at component interfaces.

Card Set Number	Variable	Dimension	Description
17	**DX**	NCELLS	Cell lengths (m, ft).
18	**VOL**	NCELLS	Cell volumes (m^3, ft^3).
19	**FA**	NCELLS+1	Cell-edge flow areas (m^2, ft^2).
Note: Setting FRIC > 10^{20} at a cell edge invokes the steam-separator model (only the gas phase is allowed to flow through the cell interface). Setting FRIC < -10^{20} invokes the liquid-separator model (only the liquid is allowed to flow through the cell interface). If the reverse additive loss-coefficient option (NFRC1 = 2 in the NAMELIST data) is chosen, steam-separator and liquid-separator models may be used separately in each forward and reverse direction.			
20	**FRIC**	NCELLS+1	Additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
21	**FRICR**	NCELLS+1	Additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input.
22	**GRAV or ELEV**	NCELLS+1 (NCELLS for ELEV)	Gravity or elevation terms (– or m, ft). GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.
23	**HD**	NCELLS+1	Hydraulic diameters (m, ft).
Note: If NAMELIST variable NDIA1 ≠ 2 do not input array HD-HT.			
24	**HD-HT**	NCELLS+1	Heat transfer diameters (m, ft).

Card Set Number	Variable	Dimension	Description
Note: If NAMELIST variable ICFLOW = 0 or 1 do not input array ICFLG. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur..			
25	**ICFLG**	NCELLS+1	Cell edge choked flow model option. 0 = no choked flow model calculation; 1 = choked flow model calculation using default multipliers; 2 to 5 = choked flow model calculation using NAMELIST variable defined multipliers.
26	**NFF**	NCELLS+1	Friction factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous flow friction factor plus FRIC; –1 = homogeneous flow friction factor plus FRIC plus an abrupt flow area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow area change form loss evaluated internally by TRACE.
Note: If NCCFL = 0 (Word 5 **Main-Data Card 9**) do not input array LCCFL.			
27	**LCCFL**	NCELLS+1	Countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
28	**ALP**	NCELLS	Initial gas volume fractions (–).
29	**VL**	NCELLS+1	Initial liquid velocities (m/s, ft/s).
30	**VV**	NCELLS+1	Initial gas velocities (m/s, ft/s).
31	**TL**	NCELLS	Initial liquid temperatures (K, °F).
32	**TV**	NCELLS	Initial gas temperatures (K, °F).

Card Set Number	Variable	Dimension	Description
33	**P**	NCELLS	Initial pressures (Pa, psia).
34	**PA**	NCELLS	Initial noncondensable-gas partial pressures (Pa, psia).
Note: If NAMELIST variable NOLT1D = 1, do not input array ILEV.			
35	**ILEV**	NCELLS	Level tracking flags. ILEV = 1 indicates that the two-phase level exists in the current cell. ILEV = 0 indicates that the two-phase level does not exist in the current cell. If ILEV = -1, the level tracking calculation will be turned off for this cell.
Note: If NAMELIST variable MWFL = 0, do not input array WFMFL.			
36	**WFMFL**	NCELLS+1	Wall-friction multiplier factor for the liquid phase (–) [$0.9 \le$ WFMFL ≤ 1.1].
Note: If NAMELIST variable MWFV = 0, do not input array WFMFV.			
37	**WFMFV**	NCELLS+1	Wall-friction multiplier factor for the gas phase (–) [$0.9 \le$ WFMFL ≤ 1.1].
Note: If NODES = 0 (Word 2 on **Card Number 2**), do not input arrays QPPP, MATID, TW, IDROD, and NHCEL.			
38	**QPPP**	NODES × NCELLS	Input but not used.
39	**MATID**	NODES-1	Canister wall-material ID array, which specifies material ID between radial nodes. Dimension is 1 if NODES = 1 and 0 if NODES = 0. 1 = mixed oxide; 2 = zircaloy; 3 = fuel-clad gap gases; 4 = boron-nitride insulation; 5 = constantan/Nichrome heater wire; 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 11 = zircaloy dioxide; 12 = inconel, type 600.

<table>
<tr><th>Card Set Number</th><th>Variable</th><th>Dimension</th><th>Description</th></tr>
<tr><td>40</td><td>TW</td><td>NODES × NCELLS</td><td>Initial canister wall temperatures (K, °F) at cell edges.</td></tr>
<tr><td colspan="4">Note: If IPVHT = 0 (Word 5 on Card Number 7) do not input array IDROD.</td></tr>
<tr><td>41</td><td>IDROD</td><td>1</td><td>The (r,q)- or (x,y)-plane cell number of the VESSEL that the outer surface of the canister is connected to. Use 1 when connecting to a 1D component. See IDRODO description in HTSTR specification, HTSTR Component Data.</td></tr>
<tr><td colspan="4">Note: If IPVHT = 0 (Word 5 on Card Number 7) do not input array NHCELO.</td></tr>
<tr><td>42</td><td>NHCELO</td><td>NCELLS</td><td>Axial cell numbers of the hydraulic cells to which the CHAN outer surface is coupled starting with the first cell.</td></tr>
<tr><td colspan="4">Note: If ICONC = 0 (Word 2 on Card Number 7) do not input array CONC.</td></tr>
<tr><td>43</td><td>CONC</td><td>NCELLS</td><td>Initial ratio of solute mass to liquid coolant mass [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)]. Requires ISOLUT = 1 (Word 3 on Main-Data Card 9).</td></tr>
<tr><td colspan="4">Note: If ICONC = 0 or 1 (Word 2 on Card Number 7), do not input array S.</td></tr>
<tr><td>44</td><td>S</td><td>NCELLS</td><td>Initial macroscopic density of plated-out solute (kg/m, lb_m/ft^3). Requires ISOLUT = 1 (Word 3 on Main-Data Card 9).</td></tr>
<tr><td colspan="4">Note: Input array XGNB only if NTRACEG>0 (Word 1 on Main-Data Card 11) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.</td></tr>
<tr><td>45</td><td>XGNB</td><td>NCELLS</td><td>Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).</td></tr>
<tr><td colspan="4">Note: Input array XLNB only if NTRACEL>0 (Word 2 on Main-Data Card 11). Repeat this card set NTRACEL times.</td></tr>
<tr><td>46</td><td>XLNB</td><td>NCELLS</td><td>Mass fraction for liquid trace species.</td></tr>
</table>

Card Set Number	Variable	Dimension	Description
47	**RDX**	NGRP	Number of actual rods in each rod group. (A 'real' number). The RDX array is input for both fuel rods and water rod groups. For water rod groups RDX is the number of actual water rods represented by the water rod group.
48	**RADRD**	NODESR	Rod radii (m, ft) from the inside surface at no power cold conditions. This RADRD array will be used for all fuel rods in this CHAN component, but will not be used for water rods.
Note: Adjacent MATRD elements cannot both have the value 3 and MATRD(1) and MATRD(NODESR – 1) cannot be 3. Additional material properties can be input (see Sec. 6.3.3). The MATRD array will be used for all fuel rods in this CHAN component. This MATRD array will not be used for water rods. The water rods will have their own material properties array.			
49	**MATRD**	NODES –1	HTSTR-element material ID numbers [dimension is 1 if NODES = 1 (Word 2 on **Card Number 2**)]. 1 = mixed oxide; 2 = zircaloy; 3 = fuel-clad gap gases; 4 = boron-nitride insulation; 5 = constantan/Nichrome heater wire; 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 11 = zircaloy dioxide; 12 = inconel, type 600.

Card Set Number	Variable	Dimension	Description
50	**NFAX**	NCRZ	Number of permanent fine-mesh cells added in each coarse mesh cell (between the upper and lower tie plates) of the CHAN heat structures, when the fine-mesh calculation is set ON (see FMON (Word 1 on **Card Number 12**)). Odd numbers should be used. If even numbers are used, the code will change them to odd numbers (NFAX=NFAX+1). The total number of node rows, given by $2 + \sum_{I=1}^{NCRZ} NFAX(I)$, must not be greater than NZMAX (Word 3 on **Card Number 12**).
Note: ROD Temperature Array. Input an RFTN array for each of the NFGRP. Where NFGRP = NGRP - NUMWATERRODS			
51	**RFTN**	NODES x NCRZ 1 set per NFGRP	Rod (radial by axial) element temperatures (K, °F). For partial-length fuel rods, the RFTN input above the height of the rod will be ignored.
52	**RDPWR**	NODESR	Relative rod radial power density distribution (–) at the node locations defined by array RADRD (**Card Set 48**).
53	**CPOWR**	NFGRP	Radial power peaking factor for each rod group within the fuel bundle, where NFGRP = NGRP - NUMWATERRODS. Water rod groups must be input as the last rod groups. The values for the last NUMWATERRODS rod groups must be set to zero, indicating they have zero power.
54	**RADPW**	NCRZ	Core wide radial CHAN-to-CHAN power peaking factor for each axial conduction node set in the power fuel region. The numerical average of these numbers is used for the core wide peaking factor relative to other CHANs. This set of numbers is then normalized about 1.0 and used for the axial power peaking factor variation along this CHAN.

Card Set Number	Variable	Dimension	Description
55	**FPUO2**	NFGRP	Fraction (–) of plutonium dioxide (PuO2) in mixed oxide fuel, where NFGRP = NGRP - NUMWATERRODS.
56	**FTD**	NFGRP	Fraction (–) of theoretical fuel density, where NFGRP = NGRP - NUMWATERRODS.
57	**GMIX**	NFGRP*7	Mole fraction (–) of gap-gas constituents. GMIX is not used if NFCI = 0 (Word 4 on **Card Number 11**) but must be input. Enter data for NFGRP fuel rod groups for each gas in the order indicated. Where NFGRP = NGRP - NUMWATERRODS. 1. helium; 2. argon; 3. xenon; 4. krypton; 5. hydrogen; 6. air/nitrogen; 7. water vapor.
58	**PGAPT**	NFGRP	Average gap-gas pressure (Pa, psia). PGAPT is not used if NFCI = 0 (Word 4 on **Card Number 11**), but must be input. Where NFGRP = NGRP - NUMWATERRODS.
Note: Burnup Arrays. Input a BURN Card Set for each of the NFGRP fuel rod groups, where NFGRP = NGRP - NUMWATERRODS.			
59	**BURN**	NCRZ	Rod axial location fuel burnup (MWD/MTU). 1 set per NFGRP. Where NFGRP = NGRP - NUMWATERRODS.

Card Set Number	Variable	Dimension	Description
Note: Bundle Map of rods. Omit next Card if NGRP=1 or IBEAM>0 (Word 5 on **Card Number 12**).			

60	**MROD**	NROW*NROW+1	Layout of primary and supplemental rod positions in the bundle. The channel wall is the last radiating surface, or group. Water rod groups must come after fuel rod groups. Partial length fuel rod groups must come after full length fuel rod groups. A full length rod group must be the first rod group. This layout will be used to calculate view factors and beam lengths. Beginning in the upper left hand corner rod in **Figure 6-3**, the values of MROD that would be input for this particular rod grouping are:
			`1 1 1 1 s`
			`1 2 2 1 s`
			`1 2 2 1 s`
			`1 1 1 1 s`
			`3 e`

Note: Do not input VIEWGRP or BEAMGRP if IBEAM (Word 5 on **Card Number 12**) =0. Arrays VIEWGRP and BEAMGRP are repeated NCRZ times if ADVBWRF (Word 2 **Card Number 9**) = 1.			
61	**VIEWGRP**	$(NGRP+1)^2$	View factor array. For rod group 1 give NGRP+1 values representing the view factor from group 1 to all the other groups. Next enter NGRP+1 values for group 2. Repeat for all rod groups including the canister wall.
62	**BEAMGRP**	$(NGRP+1)^2$	Beam length array. Enter NGRP+1 values for NGRP+1 groups. View factors and beam lengths are checked for consistency.

CHAN Component Data

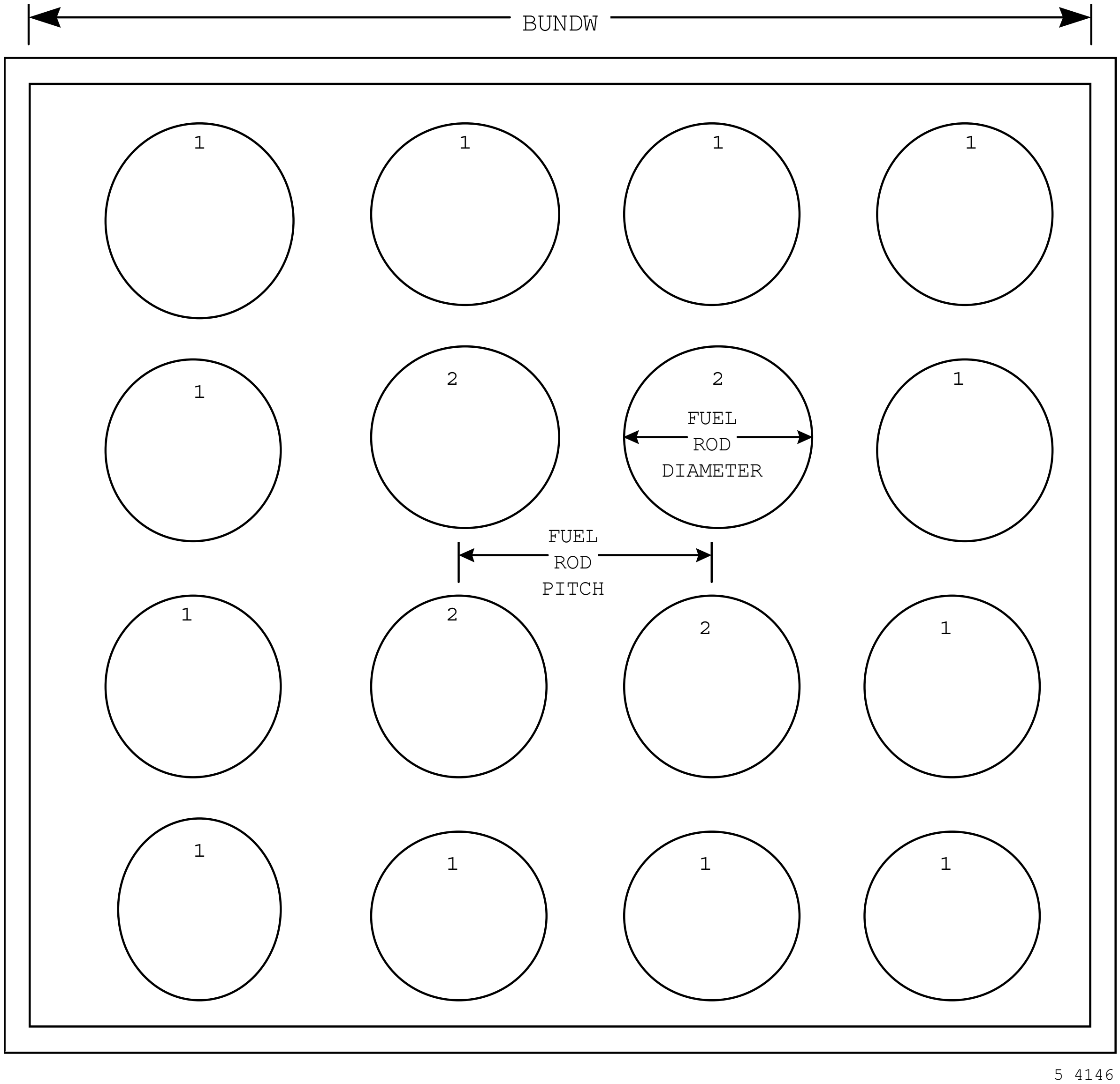


Figure. 6-3. 4-x-4 rod bundle with two rod groups (NGRP) and a canister wall.

Advanced BWR Fuel Input

Note: The Card Numbers 63-72 are only input if ADVBWRF = 1 (Word 2 on **Card Number 9**). These Cards use a combination of scalar input (Card Numbers) and array input (Card Sets in LOAD format).

Card Number 63. (Format 3I14) **I, J, LEVROD(i,j)**

Note: Input next Card if IBEAM (Word 5 on Card **Card Number 12**) = 0. Input one card for each i, j fuel rod location in the BWR fuel bundle that is not a full length fuel rod. Input is terminated with a -1 input for the I index. If all of the fuel rods for this BWR fuel assembly are full length, then input a -1 for the I index input. The I, J numbering scheme for a BWR fuel assembly is defined in **Figure 6-4**

Variable	Description
I	I Index for the fuel rod with a non-default length.
J	J Index for the fuel rod with a non-default length.
LEVROD	CHAN component cell index that corresponds to the last cell of the fuel rod at location I, J.

Note: The LEVROD(NROW, NROW) array is initially set to the index of the CHAN hydro cell that corresponds to the top of the full length fuel rod (i.e. NCRZ + ICRNK). The height of the first rod group is assumed to be the full length height for the BWR fuel assembly. The height of the first rod group is given by the SUM of the user input dx start at 1+ICRNK and summing to NCRZ+ICRNK

.

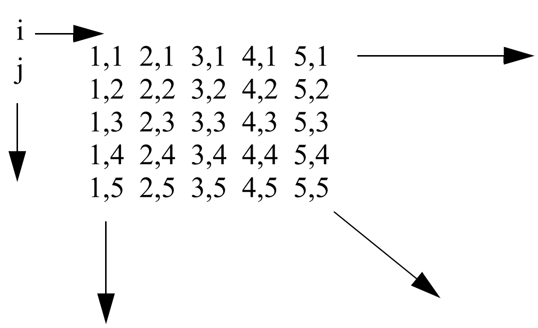


Figure. 6-4. I, J Numbering Scheme for a BWR Fuel Assembly.

Card Number 64. (Format 3I14, 2E14.4) **I, J, WATERRODFLG(i.j), XLOC, YLOC**

Note: Input next Card if IBEAM (Word 5 on **Card Number 12**) = 0.	
Variable	**Description**
I	I Index for the fuel rod with a non-zero WATERRODFLG
J	J Index for the fuel rod with a non-zero WATERRODFLG.
WATERRODFLG	WATERRODFLG for fuel location I, J. WATERRODFLG(I, J) = 0, implies that location i,j is occupied by a fuel rod. WATERRODFLG(I, J) \= 0, implies that location i,j is occupied by a water rod and value of WATERRODFLG(I, J) is the water rod geometry type number. The WATERRODFLG(NROW, NROW) array is initially set to zero. Input a flag value for each non-zero element in the WATERRODFLG array.
XLOC	x-coordinate for the center of this water rod. If a given water rod occupies more than one fuel rod location, then only one x coordinate should be non-zero. XLOC should be zero for all extra fuel rod locations occupied by this water rod. The origin for the BWR assembly is at the upper left hand corner of the channel box. All non-zero XLOC must be greater than zero. If all XLOCs and YLOCs are input as zero, then TRACE will attempt to locate the water rod at the center of the i,j fuel rod locations associated with this water rod.
YLOC	y-coordinate for the center of this water rod. If a given water rod occupies more than one fuel rod location, then only one y coordinate should be non-zero. yLoc should be zero for all extra fuel rod locations occupied by this water rod. The origin for the BWR assembly is at the upper left hand corner of the channel box. All non-zero yLoc must be less than zero. If all XLOCs and YLOCs are input as zero, then TRACE will attempt to locate the water rod at the center of the i,j fuel rod locations associated with this water rod.

Note: Input next 2 Cards if IBEAM (Word 5 on **Card Number 12**) = 1.			
Card Set Number	**Variable**	**Dimension**	**Description**
65	**LEVRODG**	NFGRP	CHAN cell index for the last fuel rod axial level for each NFGRP fuel rod group, where NFGRP = NGRP - NUMWATERRODS.

Note: Input next 2 Cards if IBEAM (Word 5 on Card Number 12) = 1.			
Card Set Number	**Variable**	**Dimension**	**Description**
66	**WRODFLG**	NGRP	WATERRODFLG input for each fuel rod and water rod group.

Water Rod Variables

Note: .**Card Number 67** through **Card Set 74** are repeated NUMWATERRODS (i.e. Word 4 on **Card Number 9**) times.

Card Number 67. (Format 2I14) **IGEOM, WRNODES**

Variable	Description
IGEOM	Geometry type for this water rod. 1 = cylindrical geometry. 2 = rectangular geometry. 3 = square geometry. 4 = general geometry.
WRNODES	Number of radial nodes to be used in the water rod wall. Radial node spacing through the water rod will be assumed to be uniform. The water rod heat structure will be a two sided HS with the inside surface in contact with the fluid in the water rod PIPE component and the outside surface in contact with the fluid inside the CHAN component. WRNODES must be larger than one. Lumped parameter heat structure is not allowed for the water rod model.

Card Number 68. (Format 2I14, 3E14.4) **WRINLET, WROUTLET, DIA, SIDEA, SIDEB**

Variable	Description
WRINLET	CHAN hydro cell index for the water rod inlet location.
WROUTLET	CHAN hydro cell index for the water rod outlet location.
DIA	Outer diameter of a cylindrical water rod, if IGEOM (i.e. Word 1 on **Card Number 67**) = 1, (m, ft). Not used if IGEOM is not equal to 1.

Card Number 68. (Format 2I14, 3E14.4) **WRINLET, WROUTLET, DIA, SIDEA, SIDEB**

Variable	Description
SIDEA	Length of the outside of a square water rod, if IGEOM (i.e. Word 1 on **Card Number 67**) = 3, (m, ft). Length of outside of side A of a rectangular water rod if IGEOM = 2, (m, ft). Not used if IGEOM equals 1 or 4.
SIDEB	Length of outside of side B of a rectangular water rod if IGEOM = 2, (m, ft). Not used if IGEOM equals 1, 3, or 4.

Card Number 69. (Format 5E14.4) **TH, RCORNER, FLOWAREA, FLWAREAI, FLWAREAO**

Variable	Description
TH	Thickness of the water rod wall (m, ft). TH must be larger than zero.
RCORNER	Radius of curvature for the corners of a square or rectangular water rod, (m, ft). Not used if IGEOM = 1 or 4.
FLOWAREA	Average flow area of the water rod, (m^2, ft^2). Must be greater than zero, if IGEOM is equal to 4. If IGEOM is equal to 1, 2, or 3, and FLOWAREA is less than or equal to zero, then FLOWAREA will be calculated by TRACE.
FLWAREAI	Flow area of the inlet of the water rod, (m^2, ft^2). Must be greater than zero, if IGEOM is equal to 4. If IGEOM is equal to 1, 2, or 3, and FLWAREAI is less than or equal to zero, then FLWAREAI will be calculated by TRACE.
FLWAREAO	Flow area of the outlet of the water rod, (m^2, ft^2). Must be greater than zero, if IGEOM is equal to 4. If IGEOM is equal to 1, 2, or 3, and FLWAREAO is less than or equal to zero, then FLWAREAO will be calculated by TRACE.

Card Number 70. (Format 5E14.4) **HD, HDRI, HDRO, THRMDIAI, THRMDIAO**

Variable	Description
HD	Average hydraulic diameter for the water rod (m, ft). Must be greater than zero, if IGEOM is equal to 4. If IGEOM is equal to 1, 2, or 3, and HD is less than or equal to zero, then HD will be calculated by TRACE.

Card Number 70. (Format 5E14.4) **HD, HDRI, HDRO, THRMDIAI, THRMDIAO** (Continued)

Variable	Description
HDRI	Hydraulic diameter for the inlet to the water rod, (m, ft). Must be greater than zero, if IGEOM is equal to 4. If IGEOM is equal to 1, 2, or 3, and HDRI is less than or equal to zero, then HDRI will be calculated by TRACE.
HDRO	Hydraulic diameter for the outlet to the water rod, (m, ft). Must be greater than zero, if IGEOM is equal to 4. If IGEOM is equal to 1, 2, or 3, and HDRO is less than or equal to zero, then HDRO will be calculated by TRACE.
THRMDIAI	Thermal diameter for the inside surface of the water rod, (m, ft). Must be greater than zero, if IGEOM is equal to 4. If IGEOM is equal to 1, 2, or 3, and THRMDIAI is less than or equal to zero, then THRMDIAI will be calculated by TRACE.
THRMDIAO	Thermal diameter for the outside surface of the water rod, (m, ft). Must be greater than zero, if IGEOM is equal to 4. If IGEOM is equal to 1, 2, or 3, and THRMDIAO is less than or equal to zero, then THRMDIAO will be calculated by TRACE.

CHAN Component Data

Card Number 71. (Format 4E14.4) **WRFLOSSI, WRFLOSSO, WRRLOSSI, WRRLOSSO**

Variable	Description
WRFLOSSI	Water rod inlet forward flow loss coefficient. Must be larger than or equal to zero.
WRFLOSSO	Water rod outlet forward flow loss coefficient. Must be larger than or equal to zero.
WRRLOSSI	Water rod inlet reverse flow loss coefficient. Must be larger than or equal to zero.
WRRLOSSO	Water rod outlet reverse flow loss coefficient. Must be larger than or equal to zero.

Card Set Number	Variable	Dimension	Description
72	**MATWR**	WRNODES - 1	Material type numbers for the radial heat structure nodes across the water rod wall.

Card Set Number	Variable	Dimension	Description
73	**TW**	WRNODES *[(WROUTLET-WRINLET) + 1]	Initial radial temperature profile through the water rod heat structure, (K, ^{o}F).

CHAN Grid Spacer Input

Note: Do not input this array data if NGRIDSPACERS (Word 5 on **Card Number 15**) is equal to zero.			
Card Set Number	**Variable**	**Dimension**	**Description**
74	**GRIDSPACERZ**	NGRIDSPACERS	Grid spacer locations. Input this array only if NGRIDSPACERS (Word 5 on **Card Number 15**) is not equal to zero. There should be no real need to enter this array at this time since the recommendation is to set NGRIDSPACERS = 0. TRACE currently has no actual grid spacer model - this is merely a placeholder for a future planned feature. Entering this array should not hurt anything - the code simply will not use the data in any meaningful context.

CONTAN Component Data

Note: A CONTAN component can only be used when NAMELIST parameter NCONTANT = 1.

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (CONTAN left justified).
NUM	Component ID number (must be unique for each component, 1 ≤ NUM ≤ 999 and should be greater than any other component ID.
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 5I14) **NCOMT, NHS, NCOOL, NJCT, NJCTF**

Variable	Description
NCOMT	Number of compartments in CONTAN.
NHS	Number of containment specific heat structures.
NCOOL	Number of coolers in the containment.
NJCT	Number of passive junctions in the containment.
NJCTF	Number of forced junctions in the containment.

Card Number 3. (Format 4I14) **NJCTS, NCOMTB, NCOMTV, NNLEV**

Variable	Description
NJCTS	Number of source or sink junctions in the containment.
NCOMTB	Total number of BREAK and FILL components connected with the containment.
NCOMTV	Vessel wall heat transfer inclusion flag (currently not used).
NNLEV	Contan-Vessel Heat Transfer Card. Currently not used. Default value is 0.

CONTAN Array Data

Note: Input each of the following arrays using LOAD format.

Card Set 4 - **Card Set 20**. *Compartment Data*

Card Set Number	Variable	Dimension	Description
4	**ITRKL**	NCOMT	Compartment pool level tracking flag. If ITRKL = 0, no pool depth is calculated in a compartment. If ITRKL = 1, the pool depth corresponding to the current liquid mass is computed. In order to utilize the heat structure level tracking option (ITRKH = 1), ITRKL must be set to 1 in both compartments attached to the heat structure. (Integer)
5	**ITRKS**	NCOMT	Compartment spilling option. If ITRKS = 0, no spilling calculation is done. If ITRKS > 0, the compartment pool is assumed to begin "spilling" when the liquid volume reaches VMAX. At this point, additional liquid entering the compartment is transferred to the pool region of the compartment whose user ID is specified by ITRKS. (Integer)
6	**ICTBL**	NCOMT	User ID for compartment (should be unique among all compartments. (Integer)
7	**VOL**	NCOMT	Total compartment volume. (Real) (m^3, ft^3)
8	**VMAX**	NCOMT	Compartment liquid pool volume when spilling begins. (Real)(m^3, ft^3)
9	**P**	NCOMT	Compartment initial gas pressure.(Real) (Pa, psia)
10	**TL**	NCOMT	Initial pool liquid temperature. (K, ^{o}F) (Real) If TL >0, the code will issue an ERROR message and terminate execution if the pool temperature approaches the saturation temperature corresponding to the compartment vapor region pressure to within 5 K. If TL <0, the code will continue execution regardless of the pool temperature.(Note, however, that the containment model in TRACE performs no boiling heat or mass transfer calculations).

Card Set 4 - Card Set 20. *Compartment Data* (Continued)

Card Set Number	Variable	Dimension	Description
11	**TV**	NCOMT	Initial Vapor Space Temperature (K, ^{o}F) (Real)
12	**FRSB**	NCOMT	Fraction of steam vented to pool that is not condensed in pool region.
13	**FRAB**	NCOMT	Effectiveness of heat transfer between noncondensible gas vented through pool region and pool liquid. FRAB may be given any value between 0.0 and 1.0. If FRAB = 0.0, no heat is transferred between noncondensible gas vented through the pool region and the liquid. If FRAB = 1.0, complete temperature equilibration is assumed between vented noncondensible gas and liquid.

Card Set 4 - Card Set 20. *Compartment Data* (Continued)

Card Set Number	Variable	Dimension	Description
14	CUCH	NCOMT	Condensation heat transfer multiplier. (Real) Modified UCHIDA condensation heat transfer correlation for a mixture of steam and noncondensible gas may or may not be used. If CUCH <0, only free convection heat transfer is assumed in the vapor region and the UCHIDA correlation is not used. If 0.0 < CUCH < 1.0, the following heat transfer coefficient (h) is used in the vapor region: $h = h_{TRAC} \times \frac{h_{umod}(r)}{h_{uo}}$ where h_{TRAC} = TRACE-generated HTC using free and forced-convection correlations in standard TRACE heat transfer package. $h_{umod}(r) = h_{uo} + [h_u(r) - h_{uo}] \times CUCH$ prevailing value of r. r = density ratio of noncondensable gas and vapor. h_{uo} = minimum value of the UCHIDA heat transfer correlation. $h_u(r)$ = UCHIDA prediction of h corresponding to r. CUCH = 1.0 is recommended for heat structure surfaces in the drywell region CUCH = -1.0 is recommended for heat structure surfaces in the wetwell region.

Card Set 4 - Card Set 20. *Compartment Data* (Continued)

Card Set Number	Variable	Dimension	Description
15	**DPDT**	NCOMT	Initial estimate of time rate of change of pressure in compartment.(Real) To smooth the step changes in containment back pressure during containment updates, the TRACE primary loop calculation extrapolates the containment pressure at each time step, based on the rate of change during the previous containment update. For reasonable containment update intervals (<2.0 seconds), DPDT may be initialized to zero without difficulty. If instabilities develop after the first containment update, it may be necessary to recommence the calculation, using the results of the
16	**APOOL**	NCOMT	Area of interface between pool and vapor region.(Real) (must be >1.0E-8) (m^2, ft^2).
17	**PA**	NCOMT	Initial partial pressure (Pa, psia) of air in compartment. (Real) (If PA<0.O, the code will compute the saturation pressure [PSAT(TV)] corresponding to TV and assign partial pressures of air (PA) and steam (PS): PS = MIN [PSAT(TV), P] PA = P-PS.
18	**RML**	NCOMT	Initial liquid mass (kg, lb_m) in compartment. (Real) Every compartment is assumed to contain a pool region, and thus RML must be nonzero. During containment initialization, the partial pressure of steam in each compartment is assumed to be the saturation pressure at temperature IV. If RML becomes so large during the transient calculation that the liquid displaces the entire compartment volume, a fatal error will result.
19	**NWORD**	NCOMT	Number of depth versus liquid volume data pair.

Card Set 4 - Card Set 20. *Compartment Data* (Continued)

Card Set Number	Variable	Dimension	Description
20	**DEPTH**	2*NWORD(i =1:NCOMT)	Liquid volume table versus pool depth [(m^3, m) or (ft^3, ft)].

Note: Heat structures are modeled as cylindrical shells with conduction in the radial direction only. The axis of the cylinder is assumed vertical and the inner and outer surfaces of the structure may lie in two separate compartments (e.g., a wall separating two compartments), depending on how the user specifies ICTI and ICTO.

Radial heat structure nodding is used in obtaining the heat structure temperature profile using the TRACE routine CYLHT. The axial nodding is used only to define the heat structure levels that lie in vapor and liquid regions of a compartment.

Card Set 21 - Card Set 42. *Heat Structure Array Data*

Card Set Number	Variable	Dimension	Description
Note: If NHS = 0 (Word 2 on **Card Number 2**), do not input these card sets.			
21	**ITRKH**	NHS	Flag for level tracking on heat structure. (Integer) 0 = the entire heat structure remains in the region specified by IREGI and IREGO throughout the containment calculation. 1 = the depth of the liquid pool will be used in determining the heat transfer coefficient used for each vertical subdivision (level) of the heat structure. If ITRKH = 1, then ITRKL = 1 must also be input for the compartments specified by ICI and ICTO.

Card Set 21 - **Card Set 42**. *Heat Structure Array Data* (Continued)

Note: If NHS = 0 (Word 2 on **Card Number 2**), do not input these card sets.

Card Set Number	Variable	Dimension	Description
22	**ICTCI**	NHS	User ID of compartment where inner heat structure surface is located. (Integer) Heat structures are treated internally as cylindrical slabs. The user may model a heat structure that is entirely contained in a single compartment by specifying the same value for ICTI and ICTO. A heat structure that is partially in one compartment and partially in another (e.g., a wall) may be modelled by specifying appropriate different values for ICTI and ICTO. Heat structures that do not have cylindrical geometry may still be modelled by choosing AREAI, AREAO, RADI, and RADO so as to represent the total surface area and characteristic thickness of the heat structure: (AREAI + AREAO) = (TOTAL AREA); (RADO - RADI) = (CHARACTERISTIC THICKNESS)].
23	**ICTCO**	NHS	User ID of compartment where outer heat structure surface is located. (Integer)
24	**NODAX**	NHS	Number of vertical nodes in heat structure (integer). (Must be "1" if ITRKH = 0)
25	**NODRA**	NHS	Number of radial nodes in heat structure (integer). (Must be "1" if ITRKH = 0)
26	**IHSTB**	NHS	User ID of heat structure [integer < 99;if IHSTB <0, the user inputs the heat transfer coefficients for the heat structure (see heat structure table cards); user ID's of all containment sub-component should be unique.
27	**IREGI**	NHS	Flag to indicate region where inner surface of heat structure is located (integer; 1 = liquid region, 0 = vapor region. If ITRKH = 1, input "0".)

CONTAN Component Data

Card Set 21 - **Card Set 42**. *Heat Structure Array Data* (Continued)

Note: If NHS = 0 (Word 2 on **Card Number 2**), do not input these card sets.			
Card Set Number	**Variable**	**Dimension**	**Description**
28	**IREGO**	NHS	Flag to indicate region where outer surface of heat structure is located (integer; see "IREGI").
29	**RADI**	NHS	Radius of curvature of inner surface of heat structure (m, ft).
30	**RADO**	NHS	Radius of curvature of outer surface of heat structure (m, ft).
31	**ROW**	NHS	Density of heat structure material (kg/m^3, lb_m/ft^3).
32	**CPW**	NHS	Heat capacity of heat structure material (J/(kg K), Btu/(lbm ^oF)).
33	**CW**	NHS	Thermal conductivity of heat structure material [W/(m K), Btu/(hr ft ^oF)].
34	**HLIC**	NHS	Elevation (m, ft) of lower extremity of heat structure inner surface above floor of compartment ICTI (input 0.0 if ITRKH = 0).
35	**HUIC**	NHS	Elevation (m, ft) of upper extremity of heat structure inner surface above floor of compartment ICTI (input 0.0 if ITRKH = 0).
36	**HLOC**	NHS	Elevation (m, ft) of lower extremity of heat structure outer surface above floor of compartment ICTO. (input 0.0 if ITRKH = 0).
37	**HUOC**	NHS	Elevation (m, ft) of upper extremity of heat structure outer surface above floor of compartment ICTO (input 0.0 if ITRKH = 0).
38	**HDAVG**	NHS	Characteristic length (m, ft) for computation of Grashof number for heat structure.
39	**AREAI**	NHS	Total heat structure area of inner surface (m^2, ft^2).
40	**AREAO**	NHS	Total heat structure area of outer surface (m^2, ft^2).

Card Set 21 - **Card Set 42**. *Heat Structure Array Data* (Continued)

Note: If NHS = 0 (Word 2 on **Card Number 2**), do not input these card sets.			
Card Set Number	**Variable**	**Dimension**	**Description**
41	**TEMPHT**	NODAX*NODRA (for each heat structure)	Heat structure initial temperatures (K, ^{o}F).
42	**HTCHT**	4*NODAX	User-input vapor and liquid heat transfer coefficients (HTC's) [W/(m^2 K), Btu/(ft^2 ^{o}F hr)] for heat structure. Input only if IHSTB < 0. (For each heat structure, NODAX*4 are required in the following order: Level 1, inner surface to liquid HTC, inner surface to vapor HTC, outer surface to liquid HTC, outer surface to vapor HTC; Level 2,..... etc.)

Card Set 43 - **Card Set 49**. *Cooler Array Data*

Note: If NCOOL = 0 (Word 3 on **Card Number 2**), do not input these card sets.			
Card Set Number	**Variable**	**Dimension**	**Description**
43	**ICLTB**	NCOOL	User ID for cooler (integer <= 99; user ID's of all containment and primary loop components should be unique).
44	**ICTCB**	NCOOL	User ID of compartment where cooler is located (integer).
45	**IREGC**	NCOOL	Fluid region cooled by cooler 0 = vapor region; 1 = liquid region.
46	**ITYPC**	NCOOL	Cooler type 1 = convective heat exchanger for which coolant temperature vs. time table and heat transfer coefficients and are required; 2 = heat source for which heating rate vs. time table is required).

CONTAN Component Data

Card Set 43 - **Card Set 49**. *Cooler Array Data* (Continued)

Note: If NCOOL = 0 (Word 3 on **Card Number 2**), do not input these card sets.			
Card Set Number	**Variable**	**Dimension**	**Description**
47	**HTC**	NCOOL	Heat transfer coefficient times heat transfer area [W/K, Btu/(^{o}F hr)] for a Type 1 cooler. (For Type 2 cooler, input 0.0.)
48	**NTQ**	NCOOL	Number of data pairs of temperature or volumetric flow rate versus time.
49	**TCORQC**	2*NTQ (i=1,NCOOL)	Data pairs of temperature or volumetric flow rate versus time [(s, K), (s, ^{o}F)] or [(s, m^3), s,ft^3)].

Card Set 50 - **Card Set 58**. *Passive Junction Array Data*

Note: If NJCT = 0 (Word 4 on **Card Number 2**), do not input these card sets.			
Card Set Number	**Variable**	**Dimension**	**Description**
50	**ICT1**	NJCT	User ID of first compartment connected by junction (integer).
51	**ICT2**	NJCT	User ID of second compartment connected by junction (integer).
52	**IJCTB**	NJCT	User ID of passive junction (integer; user ID's of all containment sub-components should be unique).

Card Set 50 - **Card Set 58**. *Passive Junction Array Data* (Continued)

Card Set Number	Variable	Dimension	Description
Note: If NJCT = 0 (Word 4 on **Card Number 2**), do not input these card sets.			
53	**ITYPP**	NJCT	Passive junction type (integer). 1 = a junction between the vapor regions in two compartments. Pressure-induced flow may occur in either direction. 2 = a one-way valve between the vapor regions in two compartments. Flow occurs in one direction only when the pressure difference between the two compartments reaches a critical minimum value specified by DPCR (e.g., a vacuum breaker valve or a pressure relief valve would be modeled as a passive junction with ITYPP = 2). 3 = a one-way flow junction between the vapor region of one compartment and the pool another. The minimum pressure difference for flow to occur is specified by DPCR (e.g., a vent pipe between the drywell and the pool region of the wetwell would be modeled as a passive junction with ITYPP = 3).
54	**HD**	NJCT	Hydraulic diameter for flow injunction. (m, ft)
55	**AREA**	NJCT	Cross-sectional area for flow injunction. (m^2, ft^2)
56	**RLEN**	NJCT	Equivalent pipe length (m, ft) for flow injunction. (In calculating the pressure-induced passive flow between two compartments two junction flow rates are computed: (1) that obtained by treating the junction as if it were a pipe and (2) that obtained by treating the junction as if it were an orifice between the two compartments. The lesser of the two flow rates is then used. RLEN is the equivalent pipe length for the junction. The input value must be nonzero.

Card Set 50 - **Card Set 58**. *Passive Junction Array Data* (Continued)

Note: If NJCT = 0 (Word 4 on **Card Number 2**), do not input these card sets.			
Card Set Number	**Variable**	**Dimension**	**Description**
57	**FR**	NJCT	Friction factor for junction pipe flow calculation.(Real) If the input value of FR is zero, the code will compute an appropriate value of FR. If the input value of FR is nonzero, this value will be used in the junction pipe flow calculation.
58	**DPCR**	NJCT	Minimum pressure difference for flow to occur in junction Types 2 and 3.(Real) If DPCR < 0, the code interprets DPCR as the elevation of the exit of the junction above the floor of the receiver compartment. It then computes a critical pressure difference equal to the hydrostatic pressure corresponding to the submergence depth of the junction exit in the receiver pool. (The DPCR < 0 option should be used only if ITRKL = 1 in the receiver compartment.)

Card Set 59 - **Card Set 66**. *Forced Convective Junction Array Data*

Note: If NJCTF = 0 (Word 5 on **Card Number 2**), do not input these card sets.			
Card Set Number	**Variable**	**Dimension**	**Description**
59	**ICTF1**	NJCTF	User ID of first compartment connected by the junction. (integer).
60	**ICTF2**	NJCTF	User ID of second compartment connected by junction (integer).

Card Set 59 - **Card Set 66**. *Forced Convective Junction Array Data* (Continued)

Note: If NJCTF = 0 (Word 5 on **Card Number 2**), do not input these card sets.

Card Set Number	Variable	Dimension	Description
61	IFTYP	NJCTF	Forced junction type (integer). 1 = a junction that transfers vapor from one compartment to the vapor region of another compartment at the volume flow rate specified by the user-input table for the junction. 2 = a junction that transfers liquid from the pool region of one compartment to the pool region of another compartment. 3 = a junction that transfers liquid from the pool region of one compartment to the vapor region of another compartment (e.g., a spray cooler).
62	IJCTF	NJCTF	User ID of forced junction (integer; user ID's of all containment sub-components systems should be unique). (Integer)
63	NQFJ	NJCTF	Number of volumetric flow rate versus time data pairs for each forced flow junction (Integer)
64	NSPRAY	NJCTF	Number of Spray Coefficients versus time data pairs for each forced flow junction.
65	QFJUNC	2*NQFJ(i=1, NJCTF)	Volumetric flow rate versus time data for each forced flow junction [(s, m^3), (s, ft^3)].
66	SPRAYE	2*NSPRAY(i =1,NJCTF)	Spray coefficients versus time data for each forced flow junction. (Real number between 0.0 and 1.0)

CONTAN Component Data

Card Set 67 - Card Set 73. *Source/Sink Junction Array Data*

Note: If NJCTS = 0 (Word 1 on **Card Number 3**), do not input these card sets.			
Card Set Number	**Variable**	**Dimension**	**Description**
67	**ISTYP**	NJCTS	Source/sink junction type (integer); 1 = source 2 = sink
68	**ICTS**	NJCTS	User ID of compartment where junction is located.(Integer)
69	**IJCTS**	NJCTS	User ID of source/sink junction (integer; user ID's of all containment sub-components should be unique).
70	**NQSO**	NJCTS	Number of volumetric flow rate versus time data pairs for each source/sink.
71	**NTSO**	NJCTS	Number of fluid temperature versus time data pairs for each source/sink.
72	**QSO**	2*NQSO(i=1, NJCTS)	Data pairs of fluid volumetric flow rate versus time [(s, m^3), (s, ft^3)].
73	**TSO**	2*NTSO(i=1, NJCTS)	Data pairs of fluid temperature versus time (K, ^oF). (TSO only affects the calculation when QSO>0.0)

EXTERIOR Component Data

This is just abbreviated information for a component that is modeled in another process. Presence of this component requires that the simulation is executing in multi-task mode. Include this for every component from which this process will require information. If a component on another task communicates indirectly via fluid flow through a third task to this one, it must be declared with this input, although the specific flow connections would not be listed.

The use of the Exterior Component requires the creation of a file called **TaskList**, which must be located in the same directory as the **tracin** input file. The **TaskList** file and details concerning multi-task processing are given in **Chapter 1**.

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (“EXTERIOR” left justified).
NUM	Component ID number (must be unique for each component, and in the range of 1 through 999).
ID	User ID number (arbitrary).
CTITLE	ASCII string giving a component description.

Card Number 2. (Format 3I14) **NJUNS, COMPTYPE, NDIM**

Variable	Description
NJUNS	Total number of flow junctions connecting between this exterior component and actual components in this processes. Do not include flow junctions in the actual component (as modeled on another process) that connect to any component not in this input deck. Do not include flow junctions that connect the actual component to another component listed as exterior within this input deck.
COMPTYPE	Indication of the generic type of component in the exterior process: 1 = fluid component 2 = heat structure (conduction) 3 = power source (e.g. neutron kinetics) 4 = special data processing

Card Number 2. (Format 3I14) **NJUNS, COMPTYPE, NDIM** (Continued)

Variable	Description
NDIM	Number of spatial dimensions associated with the component model

Card Number 3. (Format 3I14) **NX, NY NZ**

Variable	Description
NX	number of computational cells in the x or radial direction
NY	number of computational cells in the y or theta direction
NZ	number of computational cells in the z (axial) direction

Card Number 4. (Format 5I14) **JUNNUM, JUNIX, JUNIY, JUNIZ, JUNFACE**

Note: If NJUNS = 0 (Word 1 on **Card Number 2**), do not input these exterior flow junction cards.

Input one card for each of the NJUNS (Word 1 on **Card Number 2**). exterior fluid flow junctions for this component. Only provide input for those junctions representing fluid flow between this component and other non-exterior components in this input deck.

Variable	Description
JUNNUM	User assigned junction number (must match the user assigned number for the actual component model on another process).
JUNIX	junction cell index when NDIM = 1 or index in the x or radial direction when NDIM = 3
JUNIY	junction cell index in the y or θ direction (omit if NDIM = 1)
JUNIZ	junction cell index in the z direction (omit if NDIM < 3)
JUNFACE	Face number associated with the connection. A positive number indicates a connection to the upper or outer face of the cell; a negative number indicates a connection to the lower or inner face of the cell. 1 = θ or y direction; 2 = axial z direction; 3 = r or x direction.

FILL Component Data

A **FILL** component cannot be connected to a **BREAK** or **PLENUM**. It may be connected directly to a **VESSEL** or a side junction in a 1D component. In that case the cell volume and length (VOLIN and DXIN on **Card Number 9**) associated with the **FILL** are used to compute the flow area (FA = VOLIN/DXIN) connecting the **FILL** to the **VESSEL** or a side junction in a 1D component. For **FILL** options that directly specify velocities, choose VOLIN and DXIN to give a correct inlet pipe geometry and resulting correct mass flow. For **FILL** options specifying mass flow, choose VOLIN and DXIN to produce physically realistic velocities.

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (FILL left justified).
NUM	Component ID number (must be unique for each component, 1 ≤ NUM ≤ 999).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2A14) **EOS, PHASECHANGE**

Note: Only input this card when the number of inputs for FLUIDS (a NAMELIST variable) is more than one.

Variable	Description
EOS	EOS identifier for this component (i.e. “h2o” or “r5h2o”, etc.).
PHASE-CHANGE	Phase change flag. Input TRUE or true, if phase change is allowed for this component. Input FALSE or false, if phase change is not allowed for this component.

Card Number 3. (Format 3I14) **JUN1, IFTY, IOFF**

Note: When using IFTY = 1 without having ALPHA as 0 or 1 problems can result due to the momentum flux term. In essence, a slip velocity is specified which may not be equal to the one the code calculates for the given void fraction. Large pressure gradients can be induced which can lead to vaporization/condensation events not expected. The most user convenient option for a FILL is IFTY = 2, which sets the slip to be 1 at the FILL junction and the velocities and void fraction are set at the next junction by the code more smoothly.

Note: Negative FILL types (IFTY) -1, -2, -3, -4, -5, -6, -7, -8 indicate that the FILL component is coupled with the CONTAN compartment. The FILL cell edge fluid velocity will be determined in the same way as the option with positive IFTY. The FILL fluid state variables will be defined according to the CONTAN compartment fluid conditions when the compartment functions as the donor cell.

Variable	Description
JUN1	Junction number to which the FILL is connected. If NAMELIST variable USESJC ≥ 2, JUN1 may be zero (disconnected FILL).
IFTY	FILL-type options: 1 = constant velocity; 2 = constant mass flow; 3 = constant generalized state; (temperatures, pressures, void, fraction, solute ratio are specified) 4 = velocity vs independent-variable form table; 5 = mass flow vs independent-variable form table; 6 = generalized state vs independent-variable form table; 7 = constant velocity until the controlling trip is set ON then velocity vs independent-variable form table; 8 = constant mass flow until the controlling trip is set ON, then mass flow vs independent-variable form table. 9 = constant generalized state until the controlling trip is set ON, then generalized state vs independent-variable form table; 10 = Generalized-state parameters defined individually by a signal variable or control block. 11 = Generalized-state parameters defined individually by a signal variable or control block (This option replaces the liquid and vapor mass flow rates with the total mass flow rate assuming slip ratio=1).

Card Number 3. (Format 3I14) **JUN1, IFTY, IOFF** (Continued)

Note: When using IFTY = 1 without having ALPHA as 0 or 1 problems can result due to the momentum flux term. In essence, a slip velocity is specified which may not be equal to the one the code calculates for the given void fraction. Large pressure gradients can be induced which can lead to vaporization/condensation events not expected. The most user convenient option for a FILL is IFTY = 2, which sets the slip to be 1 at the FILL junction and the velocities and void fraction are set at the next junction by the code more smoothly.

Note: Negative FILL types (IFTY) -1, -2, -3, -4, -5, -6, -7, -8 indicate that the FILL component is coupled with the CONTAN compartment. The FILL cell edge fluid velocity will be determined in the same way as the option with positive IFTY. The FILL fluid state variables will be defined according to the CONTAN compartment fluid conditions when the compartment functions as the donor cell.

Variable	Description
IOFF	FILL fluid-state option (defines the fluid state when the fill-table controlling trip is OFF after being ON) [define IOFF when IFTY = 7, 8, or 9 (Word 2 on this card)]. 0 = the last FILL-table interpolated fluid state is held constant; 1 = define the initial fluid state; 2 = input the velocity [IFTY = 7 or 9 (Word 2 on this card)] or mass flow (IFTY = 8) to be used, but maintain the fluid condition that existed when the trip was set OFF; or 3 = input a generalized fluid-state definition (IFTY = 9 only).

Card Number 4. (Format E14.4, 3I14) **FALK, NCMPTO, NCLKTO, NLEVTO**

Note: Input this card only if JUN1=0 (Word 1 on **Card Number 3**).

Variable	Description
FALK	Leak flow area. (m^2, ft^2)
NCMPTO	Component number this leak path connects to.
NCLKTO	Cell number in the NCMPTO component. When leaking to a Vessel the cell number is the radial-azimuthal combined number.
NLEVTO	Vessel axial level number if leak is to a Vessel.

Card Number 5. (Format 5I14) **IFTR, IFSV, NFTB, NFSV, NFRF**

Note: If IFTY < 4 (Word 2 on Card Number 3), do not input this card	
Variable	**Description**
IFTR	The trip ID number for controlling the evaluation of the FILL table for FILL-type options IFTY = 7, 8, or 9 (Word 2 on **Card Number 3**) ($\lvert IFTR \rvert \leq 9999$). Input IFTR = 0 when IFTY < 7 or IFTY = 10 (Word 2 on **Card Number 3**).
IFSV	The FILL-table abscissa-coordinate variable ID number that defines the independent-variable parameter in the IFTY = 4 to 9 (Word 2 on **Card Number 3**) tables. IFSV > 0 defines the ID number for a signal-variable parameter; IFSV < 0 defines the ID number for a control-block output parameter. Input IFSV = 0 if IFTY = 10 or 11 (Word 2 on **Card Number 3**).
NFTB	The number of FILL-table data pairs (defined by the absolute value of NFTB) for FILL options IFTY = 4 to 9 (Word 2 on **Card Number 3**). NFTB > 0 defines the independent-variable form to be the IFSV parameter; NFTB < 0 defines the independent-variable form to be the sum of the change in the IFSV parameter over the last timestep times the trip set-status value ISET [when the FILL is trip controlled, IFTR ≠ 0 (Word 1 on **Card Number 5**) and IFTY = 7, 8, or 9 (Word 2 on **Card Number 3**)]. NFTB = 0 defines the FILL velocity or mass flow to be the IFSV parameter. Input NFTB = 0 if IFTY = 10 or 11 (Word 2 on **Card Number 3**).
NFSV	The rate-factor table abscissa-coordinate variable ID number. NFSV > 0 defines the ID number for a signal-variable parameter; NFSV < 0 defines the ID number for a control-block output parameter; NFSV = 0 (when NFRF ≠ 0) defines the difference between the trip signal and the setpoint value that turns the trip OFF when the FILL table is trip control
NFRF	The number of rate-factor table data pairs (defined by the absolute value of NFRF). The rate factor is applied as a factor to the FILL-table independent variable when the rate factor is defined. No rate factor is defined when NFSV and NFRF are both zero. NFRF > 0 defines the rate-factor table abscissa coordinate to be the NFSV parameter; NFRF < 0 defines it to be the sum of the change in the NFSV parameter over the last timestep times the trip set-status value ISET [when the FILL is trip controlled, IFTR = 0 (Word 1 on **Card Number 5**) and IFTY = 7, 8, or 9 (Word 2 on **Card Number 3**)]. NFRF = 0 defines the rate factor to be the NFSV parameter.

Card Number 6. (Format 4E14.4) **TWTOLD, RFMX, CONCIN, FELV**

Variable	Description
TWTOLD	The fraction (–) of the previous FILL fluid state that is averaged with the FILL-table-defined state to determine the FILL fluid state for this timestep (0.0 ≤ TWTOLD <1.0; it is suggested that a value of 0.0 be used). To avoid hydrodynamic instabilities, a value as large as 0.9 may be needed when the FILL table depends on a parameter (such as the adjacent component pressure) that couples strongly to the FILL velocity or a parameter that varies rapidly with time.
RFMX	The maximum rate of change of FILL velocity (m/s, ft/s) or FILL mass flow (kg/s, lb_m/s^2) [0.0 ≤ RFMX]. For FILL-type option IFTY = 10 or 11 (Word 2 on **Card Number 3**), RFMX is not used.
CONCIN	The initial solute mass to liquid-coolant mass ratio [{*, kg(solute)/kg (liquid)}, {*, lb_m (solute)/lb_m (liquid)}] in the FILL composition. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
FELV	FILL cell-centered elevation (m, ft) (used only to compute GRAV array when NAMELIST variable IELV = 1).

Card Number 7. (Format I14) **COMPID**

Note: If IFTY < 0 (Word 2 on **Card Number 3**), input this card.

Variable	Description
COMPID	|COMPID| represents the CONTAN compartment user defined ID. When COMPID>0, the FILL is inside the vapor space of the compartment. When COMPID < 0, the FILL is inside the liquid space of the compartment.

Card Number 8. (Format 2E14.4) **BDSPRAY, BDCOND**

Note: If IFTY < 0 (Word 2 on **Card Number 3**) input this card.

Variable	Description
BDSPRAY	If the FILL is connected with the vapor region of a compartment and it is injecting subcooled water into the containment, 'BDSPRAY' represents the mass fraction of the injected liquid which reaches thermal equilibrium with the fluid in the vapor space.

FILL Component Data

Card Number 8. (Format 2E14.4) **BDSPRAY, BDCOND** (Continued)

Variable	Description
Note:	If IFTY < 0 (Word 2 on **Card Number 3**) input this card.
BDCOND	If the FILL is connected with the liquid region of a compartment and it is injecting super-heated vapor and hot air into the containment, 'BDCOND' represents the mass fraction of the injected vapor which reaches thermal equilibrium with the fluid in the liquid space.

Card Number 9. (Format 5E14.4) **DXIN, VOLIN, ALPIN, VLIN, TLIN**

Variable	Description
DXIN	Cell length (m, ft) (generally defined to be the same as its neighboring cell in the adjacent component).
VOLIN	Cell volume (m^3, ft^3) (generally defined to be the same as its neighboring cell in the adjacent component).
ALPIN	Initial gas volume fraction (–) used for positive flow out of the fill.
VLIN	Initial liquid velocity (m/s, ft/s) (a positive value indicates flow into the adjacent component; a negative value indicates flow from the adjacent component) [used for fill options IFTY = 1, 3, 7 or 9 (Word 2 on **Card Number 3**)].
TLIN	Initial liquid temperature (K, °F) used for positive flow out of the fill.

Card Number 10. (Format 5E14.4) **PIN, PAIN, FLOWIN, VVIN, TVIN**

Variable	Description
PIN	Initial FILL pressure (Pa, psia).
PAIN	Initial FILL noncondensable-gas partial pressure (Pa, psia).
FLOWIN	Initial coolant mass flow (kg/s, lb_m/hr) (a positive value indicates flow into the adjacent component; a negative value indicates flow from the adjacent component) [used for FILL-type options IFTY = 2 or 8 (Word 2 on **Card Number 3**)].
VVIN	Initial gas velocity (m/s, ft/s) (a positive value indicates flow into the adjacent component; a negative value indicates flow from the adjacent component) [used for FILL-type options IFTY = 1, 3, 7 or 9 (Word 2 on **Card Number 3**)].

Card Number 10. (Format 5E14.4) **PIN, PAIN, FLOWIN, VVIN, TVIN** (Continued)

Variable	Description
TVIN	Initial gas temperature (K, °F) used for positive flow out of the FILL [used for FILL options IFTY = 1, 3, 7 or 9 (Word 2 on **Card Number 3**)].

Card Number 11. (Format 4E14.4) **FLWOFF, VLOFF, VVOFF, ALPOFF**

Note: If IFTY < 7, IFTY = 10 or 11, or IOFF < 2 (Words 2 and 3 on **Card Number 3**), do not input this card.

Variable	Description
FLWOFF	Coolant mass flow (kg/s, lb_m/hr) when the control-ling trip is set OFF after being ON [used when IFTY = 8 (Word 2 on **Card Number 3**)].
VLOFF	Liquid velocity (m/s, ft/s) [IFTY = 9 (Word 2 on **Card Number 3**)] or coolant-mixture velocity (IFTY = 7) when the controlling trip is set OFF after being ON (used when IFTY = 7 or 9).
VVOFF	Gas velocity (m/s, ft/s) when the controlling trip is set OFF after being ON [used when IFTY = 9 and IOFF = 3 (Words 2 and 3 on **Card Number 3**)].
ALPOFF	Gas volume fraction (–) for positive flow out of the FILL when the controlling trip is set OFF after being ON [used when IFTY = 9 and IOFF = 3 (Words 2 and 3 on **Card Number 3**)].

Card Number 12. (Format 5E14.4) **TLOFF, TVOFF, POFF, PAOFF, CONOFF**

Note: If IFTY ≠ 9 or IOFF ≠ 3 (Words 2 and 3 on **Card Number 3**), do not input this card

Variable	Description
TLOFF	Liquid temperature (K, °F) for positive flow out of the FILL when the controlling trip is set OFF after being ON.
TVOFF	Gas temperature (K, °F) for positive flow out of the FILL when the controlling trip is set OFF after being ON.
POFF	FILL pressure (Pa, psia) when the controlling trip is set OFF after being ON.
PAOFF	FILL noncondensable-gas partial pressure (Pa, psia) when the controlling trip is set OFF after being ON.

Card Number 12. (Format 5E14.4) **TLOFF, TVOFF, POFF, PAOFF, CONOFF** (Continued)

Note: If IFTY ≠ 9 or IOFF ≠ 3 (Words 2 and 3 on **Card Number 3**), do not input this card

Variable	Description
CONOFF	Solute mass to the liquid-coolant mass ratio [kg (solute)/kg (liquid), lb_m (solute)/ lb_m (liquid)] when the controlling trip is set OFF after being ON. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).

Card Number 13. (Format 2E14.4) **VMSCL, VVSCL**

Note: IFTY < 4 or IFTY = 10 or 11 (Word 2 on **Card Number 3**) or NFTB = 0 (Word 3 on **Card Number 5**), do not input this card.

Variable	Description
VMSCL	Mixture-velocity [IFTY = 4 or 7 (Word 2 on **Card Number 3**)], liquid-velocity [IFTY = 6 or 9], or mixture mass-flow (IFTY = 5 or 8) scale factor (–). The dependent variable in table VMTB is multiplied by this factor to obtain the absolute mixture velocity, liquid velocity, or mixture mass flow.
VVSCL	Gas-velocity scale factor (–). The dependent variable in fill table VVTB is multiplied by this factor to obtain the absolute gas velocity [used when IFTY = 6 or 9 (Word 2 on **Card Number 3**)].

Card Number 14. (Format 5E14.4) **TLSCL, TVSCL, PSCL, PASCL, CONSCL**

Note: If IFTY ≠ 6 and IFTY ≠ 9 (Word 2 on **Card Number 3**), do not input this card.

Variable	Description
TLSCL	Liquid-temperature scale factor (–). The dependent variable in table TLTB is converted to absolute liquid temperature (K, °R), multiplied by this factor to obtain the absolute liquid temperature (K, °R), and converted back to SI/English units liquid temperature (K, °F).
TVSCL	Gas-temperature scale factor (–). The dependent variable in table TVTB is converted to absolute gas temperature (K, R), multiplied by this factor to obtain the absolute gas temperature (K, °R), and converted back to SI/English units gas temperature (K, °F).
PSCL	Pressure scale factor (–). The dependent variable in table PTB is multiplied by this factor to obtain absolute pressure (Pa, psia).

Card Number 14. (Format 5E14.4) **TLSCL, TVSCL, PSCL, PASCL, CONSCL** (Continued)

Note: If IFTY ≠ 6 and IFTY ≠ 9 (Word 2 on Card Number 3), do not input this card.	
Variable	**Description**
PASCL	Noncondensable-gas partial-pressure scale factor (–). The dependent variable in table PATB is multiplied by this factor to obtain absolute air partial pressure (Pa, psia).
CONSCL	Solute mass to liquid-coolant mass ratio scale factor (–). The dependent variable in table CONCTB is multiplied by this factor to obtain the absolute solute mass to liquid-coolant mass ratio. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).

Card Number 15. (Format 5I14) **IFMLSV, IFMVSV, IFTLSV, IFTVSV, IFASV**

Note: If IFTY ≠ 10 (Word 2 on Card Number 3), do not input this card.	
Variable	**Description**
IFMLSV	Signal variable or control-block ID number defining the liquid mass flow (kg/s, lb_m/s).
IFMVSV	Signal variable or control-block ID number defining the gas mass flow (kg/s, lb_m/s).
IFTLSV	Signal variable or control-block ID number defining the liquid temperature (K, °F).
IFTVSV	Signal variable or control-block ID number defining the gas temperature (K, °F).
IFASV	Signal variable or control-block ID number defining the gas volume fraction (–).

Card Number 16. (Format 4I14) **IFMMSV, IFTLSV, IFTVSV, IFASV**

Note: If IFTY ≠ 11 (Word 2 on Card Number 3), do not input this card.	
Variable	**Description**
IFMMSV	Signal variable or control-block ID number defining the total mass flow (kg/s, lb_m/s).
IFTLSV	Signal variable or control-block ID number defining the liquid temperature (K, °F).
IFTVSV	Signal variable or control-block ID number defining the gas temperature (K, °F).
IFASV	Signal variable or control-block ID number defining the gas volume fraction (–).

FILL Component Data

Card Number 17. (Format 3I14) **IFPSV, IFPASV, IFCNSV**

Variable	Description
Note: If IFTY ≠ 10 or 11 (Word 2 on **Card Number 3**), do not input this card.	
IFPSV	Signal variable or control-block ID number defining the fluid pressure (Pa, psia).
IFPASV	Signal variable or control-block ID number defining the partial pressure of the noncondensable gas (Pa, psia).
IFCNSV	Signal variable or control-block ID number defining the solute mass to the liquid-coolant mass ratio (–). Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).

FILL Array Cards.

Note: Input each of the following arrays using LOAD format. Each array has its element values defined by a Card Set of one or more cards. If IFTY < 4 or IFTY = 10 or 11 (Word 2 on **Card Number 3**) or NFTB = 0 (Word 3 on **Card Number 5**), do not input the FILL Array Cards.

Card Set Number	Variable	Dimension	Description
Note: Input this array card only if IFTY = 4, 6, 7, or 9			
18	**VMTBV**	2 × |NFTB|	Mixture velocity [(*, m/s), (*, ft/s)] [IFTY = 4 or 7 (Word 2 on **Card Number 3**)], liquid velocity [(*, m/s), (*, ft/s)] [IFTY = 6 or 9], or mixture mass flow [(*, kg/s), (*, lb_m/hr)] (IFTY = 5 or 8) vs independent-variable-form table. Input |NFTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IFSV (Word 2 on **Card Number 5**); mixture velocity, liquid velocity, or mixture mass flow].
Note: Input the following array card only if IFTY = 5 or 8			

Card Set Number	Variable	Dimension	Description
19	VMTBM	2 × |NFTB|	Mixture velocity [(*, m/s), (*, ft/s)] [IFTY = 4 or 7 (Word 2 on **Card Number 3**)], liquid velocity [(*, m/s), (*, ft/s)] [IFTY = 6 or 9], or mixture mass flow [(*, kg/s), (*, lb_m/hr)] (IFTY = 5 or 8) vs independent-variable-form table. Input |NFTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IFSV (Word 2 on **Card Number 5**); mixture velocity, liquid velocity, or mixture mass flow].
Note: If IFTY ≠ 6 and IFTY ≠ 9 (Word 2 on **Card Number 3**), do not input arrays VVTB, TLTB, TVTB, ALPTB, PTB, and PATB.			
20	VVTB	2 × |NFTB|	Gas-velocity vs independent-variable-form table [(*, m/s), (*, ft/s)]. Input |NFTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IFSV (Word 2 on **Card Number 5**), gas velocity].
21	TLTB	2 × |NFTB|	Liquid-temperature vs independent-variable-form table [(*, K), (*, °F)]. Input |NFTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IFSV (Word 2 on **Card Number 5**), liquid temperature].
22	TVTB	2 × |NFTB|	Gas-temperature vs independent-variable-form table [(*, K), (*, °F)]. Input |NFTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IFSV (Word 2 on **Card Number 5**), gas temperature].
23	ALPTB	2 × NFTB|	Gas volume-fraction vs independent-variable-form table (*, –). Input |NFTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IFSV (Word 2 on **Card Number 5**), gas volume fraction].

Card Set Number	Variable	Dimension	Description
24	**PTB**	2 × |NFTB|	Pressure vs independent-variable-form table [(*, Pa), (*, psia)]. Input |NFTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IFSV (Word 2 on **Card Number 5**), pressure].
25	**PATB**	2 × |NFTB|	Noncondensable-gas partial pressure vs independent-variable-form table [(*, Pa), (*, psia)]. Input |NFTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IFSV (Word 2 on **Card Number 5**), noncondensable-gas partial pressure].
Note: If ISOLUT = 0 (Word 3 on **Main-Data Card 9**) or IFTY ≠ 6 or 9 (Word 2 on **Card Number 3**), do not input array CONCTB.			
26	**CONCTB**	2 ×|NFTB|	Solute mass to liquid-coolant mass ratio vs break independent-variable-form table [{*, kg(solute)/kg (liquid)}, {*, lb_m (solute)/lb_m (liquid)}]. Input |NFTB| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IFSV (Word 2 on **Card Number 5**), solute mass to liquid-coolant mass ratio]. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: If NFRF = 0 (Word 5 on **Card Number 5**), do not input array RFTB.			
27	**RFTB**	2 × |NFRF|	Rate-factor table (*,–) for the FILL-table's independent variable defined by IFSV and NFTB (Words 2 and 3 on **Card Number 5**). Input |NFRF| (Word 5 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by NFSV (Word 4 on **Card Number 5**), rate factor to be applied to the FILL-table independent variable].

Card Set Number	Variable	Dimension	Description
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
28	**XGNB**	NCELLS	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species.
Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
29	**XLNB**	NCELLS	Mass fraction for liquid trace species.

FLPOWER Component Data

To use this component the number of fluid power components must be specified by using NAMELIST variable nflpower.

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (FLPOWER left justified).
NUM	Component ID number (must be unique for each component, $1 \leq NUM \leq 999$).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2I14) **NPWRB, NPWRD**

Variable	Description
NPWRB	Number of cells for which this fluid power component specifies in-beam power data
NPWRD	Number of cells for which this fluid power component specifies decay power data.

Card Number 3. (Format 2I14) **IPOWB, IPOWD**

Variable	Description
IPOWB	Option to define in-beam power (Valid values are 5, 6, or 7) 5 = constant in-beam power 6 = table look-up 7 = trip-initiated table look-up
IPOWD	Option to define decay power (Valid values are 5, 6, or 7) 5 = constant decay power 6 = table look-up 7 = trip-initiated table look-up

Card Number 4. (Format 3I14) **IPOWBTR, IPOWBSV, NPOWBTB**

Note: Input this card if NPWRB (Word 1 on **Card Number 2**) > 0 and IPOWB (Word 1 on **Card Number 3**) = 6 or 7.

Variable	Description
IPOWBTR	Trip ID number that controls in-beam power
IPOWBSV	ID number of the signal variable used as the independent variable in the in-beam power table
NPOWBTB	Number of pairs in the in-beam power table (of the form [independent variable, power]).

Card Number 5. (Format 3I14) **IPOWDTR, IPOWDSV, NPOWDTB**

Note: Input this card if NPWRD (Word 2 on **Card Number 2**) > 0 and IPOWD (Word 2 on **Card Number 3**) = 6 or 7.

Variable	Description
IPOWDTR	Trip ID number that controls decay power.
IPOWDSV	ID number of the signal variable used as the independent variable in the decay power table.
NPOWDTB	Number of pairs in the decay power table (of the form [independent variable, power]).

Card Number 6. (Format 2E14.4) **POWB, POWD**

Variable	Description
POWB	Initial in-beam power (W, Btu/hr)
POWD	Initial decay power (W, Btu/hr)

Card Number 7. (Format 4I14,E14.4) **NUMB, CELLIB, CELLJB, CELLKB, BFRAC**

Note: Input NPWRB (Word 1 on **Card Number 2**) sets of the following card to specify distribution of total in-beam power in different fluid cells	
Variable	**Description**
NUMB	Fluid component number.
CELLIB	Cell index for 1D fluid component. Cell index in the x/r direction for 3D fluid component.
CELLJB	Cell index in the y/theta direction for 3D fluid component.
CELLKB	Cell index in the z direction for 3D fluid component.
BFRAC	Fraction of the total power to be assigned to this cell.

Card Number 8. (Format 4I14,E14.4) **NUMD, CELLID, CELLJD, CELLKD, DFRAC**

Note: Input NPWRD (Word 2 on **Card Number 2**) sets of the following card to specify distribution of total decay power in different fluid cells	
Variable	**Description**
NUMD	Fluid component number.
CELLID	Cell index for 1D fluid component. Cell index in the x/r direction for 3D fluid component.
CELLJD	Cell index in the y/theta direction for 3D fluid component.
CELLKD	Cell index in the z direction for 3D fluid component.
DFRAC	Fraction of the total power to be assigned to this cell.

FLPOWER Array Cards

Note: Input each of the following arrays using LOAD format.

Card Set Number	Variable	Dimension	Description
Note: Input array POWBTB if NPOWBTB (Word 3 on **Card Number 4**) > 0.			
9	**POWBTB**	NPOWBTB *2	Table of pairs of in-beam power versus independent variable. Input NPOWBTB pairs of data of the form [Independent variable specified by IPOWBSV, in-beam power]
Note: Input array POWDTB if NPOWDTB (Word 3 on **Card Number 5**) > 0.			
10	**POWDTB**	NPOWDTB *2	Table of pairs of decay power versus independent variable. Input NPOWDTB pairs of data of the form [Independent variable specified by IPOWDSV, decay power]

The input listing for a sample problem is provided below. Component 123 defines a FLPOWER component, which specifies the fluid power distribution for a total of five cells in hydro components 30 and 70. The fractions are all equal to 0.2, meaning the power is distributed equally among the 5 cells specified. The POWB table is in terms of time, and the table has 4 pairs of data. From t=0 to t=30 s, the power is held at zero, and then it is ramped up to 1.0e+5 W over an interval of 30 sec. It is held constant thereafter.

```
**********************************************************
* type   num    id   ctitle cd 1
flpower 123    123 $123$ power for components 30 and 70
* npwrb npwrd
5 0
* ipowb ipowd
6
*ipowbtr ipowbsv npowbtb
0 1 4
*powb powd
0.0 0.0
*component celli cellj cellk frac
70 1 0 0 0.2
70 2 0 0 0.2
70 3 0 0 0.2
30 1 0 0 0.2
30 2 0 0 0.2
*powb table
0.00 0.00 30.0 0.0s
60.0 1.0e05 1.0e+10 1.0e05 e
```

HEATR Component Data

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (HEATR left justified).
NUM	Component ID number (must be unique for each component, $1 \leq \text{NUM} \leq 999$).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2A14) **EOS, PHASECHANGE**

Note: Only input this card when the number of inputs for FLUIDS (a NAMELIST variable) is more than one.

Variable	Description
EOS	EOS identifier for this component (i.e. “h2o” or “r5h2o”, etc.).
PHASECHANGE	Phase change flag. Input TRUE or true, if phase change is allowed for this component. Input FALSE or false, if phase change is not allowed for this component.

Card Number 3. (Format 3I14,2E14.4) **JCELL, NODES, ICHF, COST, EPSW**

Variable	Description
JCELL	Main-tube cell number that has the side tube connected to it.
NODES	Number of radial heat-transfer nodes in the wall. A value of zero specifies no wall heat transfer.

Card Number 3. (Format 3I14,2E14.4) **JCELL, NODES, ICHF, COST, EPSW** (Continued)

Variable	Description
ICHF	CHF-calculation option. 0 = convection heat transfer only, no boiling heat transfer (i.e. no wall nucleation is allowed although phase change can still occur); 1 = CHF from AECL-IPPE CHF Table, no critical quality calculated. 2 = CHF from AECL-IPPE CHF Table, critical quality from Biasi correlation. 3 = CHF from AECL-IPPE CHF Table, critical quality from CISE-GE correlation.
COST	Cosine of the angle from the low-numbered cell portion of the main tube to the side tube.
EPSW	Wall surface roughness (m, ft).

Card Number 4. (Format 5I14) **ICONC1, NCELL1, JUN1, JUN2, IPOW1**

Variable	Description
ICONC1	Solute in the main-tube coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC1 > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.
NCELL1	Number of fluid cells in the main tube.
JUN1	Junction number for the junction interface adjacent to cell 1.
JUN2	Junction number for the junction interface adjacent to cell NCELL1.
IPOW1	Power-to-the-fluid option in the main tube. 0 = no; 1 = yes.

Card Number 5. (Format 4I14) **IVERT, NSHTB, NDCTB, NLLTB**

Variable	Description
IVERT	Vertical heater flag (=0 for horizontal, 1 for vertical)
NSHTB	Number of data pairs in shell liquid heat transfer area vs. shell void fraction table (minimum = 2).

Card Number 5. (Format 4I14) **IVERT, NSHTB, NDCTB, NLLTB** (Continued)

Variable	Description
NDCTB	Number of data pairs in drain cooler liquid heat transfer area vs. drain cooler void fraction table (minimum = 2).
NLLTB	Number of data pairs in shell liquid level vs. shell void fraction table (minimum = 2).

Card Number 6. (Format 3E14.4) **DTUBE, DBAFF, HDCIN**

Variable	Description
DTUBE	Outer diameter of individual tube bank tubes (m, ft).
DBAFF	Distance between tube bank baffles (>0.0 for a vertical heater) (m, ft).
HDCIN	Height of drain cooler inlet above bottom of heater shell (m, ft).

Card Number 7. (Format 2I14, 3E14.4) **IVSV, IVPS, AVLVE, HVLVE, FAVLVE**

Variable	Description
IVSV	The independent variable ID number for the valve table. IVSV > 0 defines the ID number for a signal-variable parameter; IVSV < 0 defines the ID number for a control-block output parameter
IVPS	Mesh cell interface number where the drain flow control valve area is adjusted.
AVLVE	VALVE adjustable-interface flow area (m^2, ft^2) when the VALVE adjustable-interface IVPS is at a flow-area fraction or relative valve-stem position of 1.0 corresponding to 100% open.
HVLVE	VALVE adjustable-interface hydraulic diameter (m, ft) when the VALVE adjustable-interface is 100% open.
FAVLVE	Initial flow-area fraction at the VALVE adjustable-interface IVPS ($0.0 \le FAVLVE \le 1.0$).

Card Number 8. (Format 5I14) **IPWTR1, IPWSV1, NPWTB1, NPWSV1, NPWRF1**

Note: If IPOW1 = 0 (Word 5 on **Card Number 4**) do not input this card

Variable	Description
IPWTR1	Trip ID number that controls evaluation of the power-to-the-fluid table defined by **Card Set 50** (array POWTB1) for the main tube ($\lvert IPWTR1 \rvert \leq 9999$). [Input IPWTR1 = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation].
IPWSV1	The independent-variable ID number for the power-to-the-fluid table for the main tube. IPWSV1 > 0 defines the ID number for a signal-variable parameter; IPWSV1 < 0 defines the ID number for a control-block output parameter.
NPWTB1	The number of power-to-the-fluid table data pairs for the main tube (defined by the absolute value of NPWTB1). NPWTB1 > 0 defines the table independent-variable form to be the IPWSV1 parameter; NPWTB1 < 0 defines the table independent-variable form to be the sum of the change in the IPWSV1 parameter each last timestep times the trip set-status value ISET during that timestep (when the power-to-the-fluid table is trip controlled); NPWTB1 = 0 defines the power to the fluid to be the IPWSV1 parameter.
NPWSV1	The independent-variable ID number for the rate factor that is applied to the main-tube power-to-the-fluid table independent variable. NPWSV1 > 0 defines the ID number for a signal-variable parameter; NPWSV1 < 0 defines the ID number for a control-block output parameter; NPWSV1 = 0 (when NPWRF1 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-fluid table is trip controlled.
NPWRF1	The number of rate-factor table data pairs (defined by the absolute value of NPWRF1). The rate factor is applied as a factor to the main-tube power-to-the-fluid table independent variable when the rate factor is defined. No rate factor is defined when NPWSV1 and NPWRF1 are both zero. NPWRF1 > 0 defines the rate-factor table independent variable to be the NPWSV1 parameter; NPWRF1 < 0 defines it to be the sum of change in the NPWSV1 parameter over each timestep times the trip set-status value ISET during the timestep (when the main-tube power-to-the-fluid table is trip controlled); NPWRF1 = 0 defines the rate factor to be the NPWSV1 parameter.

Card Number 9. (Format 5I14) **IQPTR1, IQPSV1, NQPTB1, NQPSV1, NQPRF1**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 41**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Variable	Description
IQPTR1	Trip ID number that controls evaluation of the power-to-the-wall table defined by **Card Set 52** (array QP3TB1) for the main tube (|IQPTR1| ≤ 9999). [Input IQPTR1 = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation].
IQPSV1	The independent-variable ID number for the main-tube power-to-the-wall table. IQPSV1 > 0 defines the ID number for a signal-variable parameter; IQPSV1 < 0 defines the ID number for a control-block output parameter.
NQPTB1	The number of power-to-the-wall table data pairs for the main tube (defined by the absolute value of NQPTB1). NQPTB1 > 0 defines the table independent-variable form to be the IQPSV1 parameter; NQPTB1 < 0 defines the table independent-variable form to be the sum of the change in the IQPSV1 parameter over each timestep times the trip set-status value ISET during each timestep (when the power-to-the-wall table is trip controlled); NQPTB1 = 0 defines the power to the wall to be the IQPSV1 parameter.
NQPSV1	The independent-variable ID number for the rate factor that is applied to the main-tube power-to-the-wall table independent variable. NQPSV1 > 0 defines the ID number for a signal-variable parameter; NQPSV1 < 0 defines the ID number for a control-block output parameter; NQPSV1 = 0 (when NQPRF1 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-wall table is trip controlled.
NQPRF1	The number of rate-factor table data pairs (defined by the absolute value of NQPRF1). The rate factor is applied as a factor to the main-tube power-to-the-wall table independent variable when the rate factor is defined. No rate factor is defined when NQPSV1 and NQPRF1 are both zero. NQPRF1 > 0 defines the rate-factor table independent variable to be the NQPSV1 parameter; NQPRF1 < 0 defines it to be the sum of the change in the NQPSV1 parameter over each timestep times the trip set-status value ISET during that timestep (when the main-tube power-to-the-wall table is trip controlled); NQPRF1 = 0 defines the rate factor to be the NQPSV1 parameter.

Card Number 10. (Format 5E14.4) **RADIN1, TH1, HOUTL1, HOUTV1, TOUTL1**

Note: The four parameters, HOUTL, HOUTV, TOUTL, and TOUTV, allow flexibility in calculating possible heat losses from the outside of the main-tube wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
RADIN1	Inner radius (m, ft) of the main-tube wall.
TH1	Wall thickness (m, ft) of the main tube.
HOUTL1	Heat-transfer coefficient (HTC) [W/(m^2 K), Btu/(ft^2 °F hr)] between outer boundary of the main-tube wall and the liquid outside the main-tube wall.
HOUTV1	HTC [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the main-tube wall and the gas outside the main-tube wall.
TOUTL1	Liquid temperature (K, °F) outside the main-tube wall.

Card Number 11. (Format 5E14.4) **TOUTV1, PWIN1, PWOFF1, RPWX1, PWSCL1**

Variable	Description
TOUTV1	Gas temperature (K, °F) outside the main-tube wall.
PWIN1	Initial total power (W, Btu/hr) deposited in (to) the main-tube fluid [not used when IPOW1 = 0 (Word 5 on **Card Number 4**)]. The power is distributed uniformly along the HEATR main-tube length.
PWOFF1	Total power (W, Btu/hr) to the main-tube fluid when the controlling trip is OFF after being ON [not used if IPOW1 = 0 (Word 5 on **Card Number 4**) or IPWTR1 = 0 (Word 1 on **Card Number 8**)]. If PWOFF1 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr), the power to the fluid is held constant at the last table-evaluated power when the trip was ON.
RPWMX1	The maximum rate of change of the main-tube power to the fluid [W/s, (Btu/hr)/s] [RPWMX1 $\geq$ 0.0] [not used if IPOW1 = 0 (Word 5 on **Card Number 4**)].

Card Number 11. (Format 5E14.4) **TOUTV1, PWIN1, PWOFF1, RPWX1, PWSCL1** (Continued)

Variable	Description
PWSCL1	Scale factor (–) for the power-to-the-fluid table. The dependent variable in the table, defined by **Card Set 50** (array POWTB1), is multiplied by PWSCL1 to obtain absolute power (W, Btu/hr) deposited in the fluid [not used if IPOW1 = 0 (Word 5 on **Card Number 4**) or NPWTB1 = 0 (Word 3 on **Card Number 8**)].

Card Number 12. (Format 4E14.4, I14) **QPIN1, QPOFF1, RQPMX1, QPSCL1, NHCOM**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card.

Variable	Description
QPIN1	Initial power (W, Btu/hr) deposited in (to) the main-tube wall and distributed according to the QPPP array. If QPIN1 > 0.0, it is the total power to the entire wall. When QPIN1 < 0.0, the initial power to the wall in each cell is |QPIN1|, and the negative sign indicates the power to the wall is to be a cell-dependent array of NCELL1 (Word 2 on **Card Number 4**) power values. Each data pair of the power-to-the-wall table [for QPIN1 < 0.0] has 1 + NCELL1 values (an independent-variable value and NCELL1 power values for cells 1 through NCELL1). When the power-to-the-wall table is not being evaluated, the same power value of |QPIN1| or QPOFF1 [if QPOFF1 > -10^{19} W (-3.41×10^{19} Btu/hr)] is applied at each of the NCELL1 cells.
QPOFF1	Power (W, Btu/hr) to the main-tube wall when the controlling trip is OFF after being ON [not used if IQPTR1 = 0 (Word 1 on **Card Number 9**); use the last table-evaluated power when the trip was ON if QPOFF1 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr)].
RQPMX1	Maximum rate of change of the power to the wall for the main tube [W/s, (Btu/hr)/s] [RQPMX1 $\geq$ 0.0].
QPSCL1	Scale factor (–) for the power-to-the-wall table for the main tube. The dependent variable in the table defined by **Card Set 52** (array QP3TB1) is multiplied by QPSCL1 to obtain the absolute power (W, Btu/hr) to the wall.
NHCOM	Component number receiving outside wall energy.

Card Number 13. (Format 4I14) **ICONC2, NCELL2, JUN3, IPOW2**

Variable	Description
ICONC2	Solute in the side-tube coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC2 > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.
NCELL2	Number of fluid cells in the side tube.
JUN3	Junction number at the external-junction end of the side tube adjacent to cell NCELL2.
IPOW2	Power-to-the-fluid option in the side tube. 0 = no; 1 = yes.

Card Number 14. (Format 5I14) **IPWTR2, IPWSV2, NPWTB2, NPWSV2, NPWRF2**

Note: If IPOW2 = 0 (Word 4 on **Card Number 13**), do not input this card.

Variable	Description
IPWTR2	Trip ID number that controls evaluation of the power-to-the-fluid table defined by **Card Set 86** (array POWTB2) for the side tube (|IPWTR2| ≤ 9999). [input IPWTR2 = 0 if there is to be no trip control and the table is to be evaluated every timestep of the transient calculation].
IPWSV2	The independent-variable ID number of the power-to-the-fluid table for the side tube. IPWSV2 > 0 defines the ID number for a signal-variable parameter; IPWSV2 < 0 defines the ID number for a control-block output parameter.
NPWTB2	The number of power-to-the-fluid table data pairs for the side tube (defined by the absolute value of NPWTB2). NPWTB2 > 0 defines the table independent-variable form to be the IPWSV2 parameter; NPWTB2 < 0 defines the table's independent-variable form to be the sum of the change in the IPWSV2 parameter over the last timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-fluid table is trip controlled); NPWTB2 = 0 defines the power to the fluid to be the IPWSV2 parameter.

Card Number 14. (Format 5I14) **IPWTR2, IPWSV2, NPWTB2, NPWSV2, NPWRF2** (Continued)

Note: If IPOW2 = 0 (Word 4 on **Card Number 13**), do not input this card.

Variable	Description
NPWSV2	The independent-variable ID number for the rate factor that is applied to the side-tube power-to-the-fluid table independent variable. NPWSV2 > 0 defines the ID number for a signal-variable parameter; NPWSV2 < 0 defines the ID number for a control-block output parameter; NPWSV2 = 0 (when NPWRF2 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-fluid table is trip controlled.
NPWRF2	The number of rate-factor table data pairs (defined by the absolute value of NPWRF2). The rate factor is applied as a factor to the side-tube power-to-the-fluid table independent variable when the rate factor is defined. No rate factor is defined when NPWSV2 and NPWRF2 are both zero. NPWRF2 > 0 defines the rate-factor table independent variable to be the NPWSV2 parameter; NPWRF2 < 0 defines it to be the sum of the change in the NPWSV2 parameter over the last timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-fluid table is trip controlled); NPWRF2 = 0 defines the rate factor to be the NPWSV2 parameter.

Card Number 15. (Format 5I14) **IQPTR2, IQPSV2, NQPTB2, NQPSV2, NQPRF2**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 77**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Variable	Description
IQPTR2	Trip ID number that controls evaluation of the power-to-the-wall table defined by **Card Set 88** (array QP3TB2) for the side tube (|IQPTR2| ≤ 9999). (Input IQPTR2 = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation).
IQPSV2	The independent-variable ID number for the side-tube power-to-the-wall table. IQPSV2 > 0 defines the ID number for a signal-variable parameter; IQPSV2 < 0 defines the ID number for a control-block output parameter.
NQPTB2	The number of power-to-the-wall table data pairs for the side tube (defined by the absolute value of NQPTB2). NQPTB2 > 0 defines the table independent-variable form to be the IQPSV2 parameter; NQPTB2 < 0 defines the table independent-variable form to be the sum of the change in the IQPSV2 parameter over each timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-wall table is trip controlled); NQPTB2 = 0 defines the power to the wall to be the IQPSV2 parameter.

Card Number 15. (Format 5I14) **IQPTR2, IQPSV2, NQPTB2, NQPSV2, NQPRF2** (Continued)

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 77**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Variable	Description
NQPSV2	The independent-variable ID number for the rate factor that is applied to the side-tube power-to-the-wall table independent variable. NQPSV2 > 0 defines the ID number for a signal-variable parameter; NQPSV2 < 0 defines the ID number for a control-block output parameter; NQPSV2 = 0 (when NQPRF2 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-wall table is trip controlled.
NQPRF2	The number of rate-factor table data pairs (defined by the absolute value of NQPRF2). The rate factor is applied as a factor to the side-tube power-to-the-wall table independent variable when the rate factor is defined. No rate factor is defined when NQPSV2 and NQPRF2 are both zero. NQPRF2 > 0 defines the rate-factor table independent variable to be the NQPSV2 parameter; NQPRF2 < 0 defines it to be the sum of the change in the NQPSV2 parameter over each timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-wall table is trip controlled); NQPRF2 = 0 defines the rate factor to be the NQPSV2 parameter.

Card Number 16. (Format 5E14.4) **RADIN2, TH2, HOUTL2, HOUTV2, TOUTL2**

Note: The four parameters, HOUTL2, HOUTV2, TOUTL2, and TOUTV2, allow flexibility in calculating possible heat losses from the outside of the side-tube wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
RADIN2	Inner radius (m, ft) of the side-tube wall.
TH2	Wall thickness (m, ft) of the side tube.
HOUTL2	Heat-transfer coefficient (HTC) [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the side-tube wall and the liquid outside the side-tube wall.
HOUTV2	HTC [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the side-tube wall and the gas outside the side-tube wall.

Card Number 16. (Format 5E14.4) **RADIN2, TH2, HOUTL2, HOUTV2, TOUTL2** (Continued)

Note: The four parameters, HOUTL2, HOUTV2, TOUTL2, and TOUTV2, allow flexibility in calculating possible heat losses from the outside of the side-tube wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
TOUTL2	Liquid temperature (K, °F) outside the side-tube wall.

Card Number 17. (Format 5E14.4) **TOUTV2, PWIN2, PWOFF2, RPWX2, PWSCL2**

Variable	Description
TOUTV2	Gas temperature (K, °F) outside the side-tube wall.
PWIN2	Initial total power (W, Btu/hr) deposited in (to) the side-tube fluid [not used when IPOW2 = 0 (Word 4 on **Card Number 13**)]. The power is distributed uniformly along the side-tube length.
PWOFF2	Total power (W, Btu/hr) to the side-tube fluid when the controlling trip is OFF after being ON [not used when IPOW2 = 0 (Word 4 on **Card Number 13**) or IPWTR2 = 0 (Word 1 on **Card Number 14**)]. If PWOFF2 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr), the power to the fluid is held constant at the last table-evaluated power when the trip was ON.
RPWMX2	Maximum rate of change of the side-tube power to the fluid [W/s, (Btu/hr)/s^{-1}] [RPWMX1 $\geq$ 0.0] [not used if IPOW2 = 0 (Word 4 on **Card Number 13**)].
PWSCL2	Scale factor (–) for the power-to-the-fluid table. The dependent variable in the table defined by **Card Set 86** (array POWTB2) is multiplied by PWSCL2 to obtain the absolute power (W, Btu/hr) to the fluid [not used if IPOW2=0 (Word 4 on **Card Number 13**) or NPWTB2 = 0 (Word 3 on **Card Number 14**)].

Card Number 18. (Format 4E14.4) **QPIN2, QPOFF2, RQPMX2, QPSCL2**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card.	
Variable	**Description**
QPIN2	Initial power (W, Btu/hr) deposited in (to) the side-tube wall and distributed according to the QPPP array. If QPIN2 > 0.0, it is the total power to the entire wall. When QPIN2 < 0.0, the initial power to the wall in each cell is |QPIN2|, and the negative sign indicates the power to the wall is to be a cell-dependent array of NCELL2 (Word 2 on **Card Number 13**) power values. Each data pair of the power-to-the-wall table [for QPIN2 < 0.0] has 1+NCELL2 values (an independent-variable value and NCELL2 power values for cells 1 through NCELL2). When the power-to-the-wall table is not being evaluated, the same power value of |QPIN2| or QPOFF2 [if QPOFF2 > -10^{19} W (-3.41×10^{19} Btu/hr)] is applied at each of the NCELL2 cells.
QPOFF2	Power (W, Btu/hr) to the side-tube wall when the controlling trip is OFF after being ON [not used if IQPTR2 = 0 (Word 1 on **Card Number 15**); the last table-evaluated power when the trip was ON if QPOFF2 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr)].
RQPMX2	Maximum rate of change of the power to the wall for the side-tube [W/s, (Btu/hr)/s] [RQPMX2 $\geq$ 0.0].
QPSCL2	Scale factor (–) for the power-to-the-wall table for the side-tube. The dependent variable in table defined by **Card Set 88** (array QP3TB2) is multiplied by QPSCL2 to obtain the absolute power (W, Btu/hr) to the wall.

Card Number 19. (Format I14) **IENTRN**

Note: If NAMELIST variable IOFFTK = 0, do not input this card.	
Variable	**Description**
IENTRN	Offtake-model option. 0 = off; 1 = on (side tube internal-junction mass flow determined using offtake model).

HEATR Array Cards

Note: Input each of the following arrays using LOAD format. All junction variables must match at component interfaces. Model no flow-area change between cell JCELL and cells JCELL±1 and between the internal-junction interface and the side-tube first cell. A VOL/DX flow-area change between cell JCELL and cells JCELL±1 and their interface FA and between side-tube cell 1 and the internal-junction interface will not have any evaluated effect on flow from the current JCELL-interface momentum equations evaluated by TRACE.

Primary Side Array Cards

Card Set Number	Variable	Dimension	Description
20	**DX**	NCELL1	Main-tube cell lengths (m, ft).
21	**VOL**	NCELL1	Main-tube cell volumes (m^3, ft^3).
22	**FA**	NCELL1+1	Main-tube cell-edge flow areas (m^2, ft^2).
23	**FRIC**	NCELL1+1	Main-tube additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
24	**FRICR**	NCELL1+1	Main-tube additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input.
25	**GRAV or ELEV**	NCELL1+1 (NCELL1 for ELEV)	Main-tube gravity or elevation terms [(– or m), (– or ft)]. GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.
26	**HD**	NCELL1+1	Main-tube hydraulic diameters (m, ft). (See NAMELIST variable NDIA1 for additional input of heat-transfer diameters).
Note: If NAMELIST variable NDIA1 ≠ 2 do not input array HD-HT.			
27	**HD-HT**	NCELLS+1	Main-tube heat transfer diameters (m, ft).

Card Set Number	Variable	Dimension	Description
Note: If NAMELIST variable ICFLOW = 0 or 1 do not input array ICFLG.. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur..			
28	**ICFLG**	NCELL1+1	Main-tube cell-edge choked-flow model option. Cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.
29	**NFF**	NCELL1+1	Main-tube friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE. Input NFF ≥ 0 for the JCELL and JCELL+1 interfaces.
Note: If NCCFL = 0 (Word 5 on **Main-Data Card 9**), do not input array LCCFL.			
30	**LCCFL**	NCELL1+1	Main-tube countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
31	**ALP**	NCELL1	Main-tube initial gas volume fractions (–).
32	**VL**	NCELL1+1	Main-tube initial liquid velocities (m/s, ft/s).
33	**VV**	NCELL1+1	Main-tube initial gas velocities (m/s, ft/s).
34	**TL**	NCELL1	Main-tube initial liquid temperatures (K, °F).
35	**TV**	NCELL1	Main-tube initial gas temperatures (K, °F).

Card Set Number	Variable	Dimension	Description
36	**P**	NCELL1	Main-tube initial pressures (Pa, psia).
37	**PA**	NCELL1	Main-tube initial noncondensable-gas partial pressures (Pa, psia).
Note: If NAMELIST variable NOLT1D = 1 do not input array ILEV.			
38	**ILEV**	NCELL1	Level tracking flags. ILEV = 1 indicates that the two-phase level exists in the current cell. ILEV = 0 indicates that the two-phase level does not exist in the current cell. If ILEV = -1, the level tracking calculation will be turned off for this cell.
Note: If NAMELIST variable MWFL = 0, do not input array WFMFL.			
39	**WFMFL**	NCELL1+1	Main-tube wall-friction multiplier factor for the liquid phase (0.9 $\leq$ WFMFL $\leq$ 1.1).
Note: If NAMELIST variable MWFV = 0, do not input array WFMFV.			
40	**WFMFV**	NCELL1+1	Main-tube wall-friction multiplier factor for the gas phase (0.9 $\leq$ WFMFL $\leq$ 1.1).
Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input arrays QPPP, MATID, TW, IDROD, and NHCEL.			
41	**QPPP**	NODES × NCELL1	A relative power shape (–) in the main-tube wall. Input values for cell 1, node 1 through NODES; then cell 2, node 1 through NODES; etc. If the array is filled with the same nonzero constant, a uniform volumetric heat source in the wall results. TRACE internally normalizes the power shape to have a volume-averaged value of unity {each QPPP(I) is normalized to have the value QPPP(I) × [Σ_K VOL(K)]/{Σ_K QPPP(K) × VOL(K)]}. Filling the array with zeros results in no power being deposited in the wall regardless of the value of QPIN1, QPTB1, etc.

Card Set Number	Variable	Dimension	Description
42	MATID	NODES-1	Wall-material ID array, which specifies material ID between radial nodes. Dimension is 1 if NODES = 1. **ID Material Type** 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 12 = inconel, type 600.
43	TW	NODES × NCELL1	Initial wall temperatures (K, °F) in the main tube, which are input in the same order as QPPP.
Note: If NHCOM > 0 (Word 5 on **Card Number 12**) input IDROD.			
44	IDROD	1	Vessel radial-theta cell number or input 0 when NHCOM is a 1D component.
Note: If NHCOM>0 (Word 5 on **Card Number 12**) input NHCEL.			
45	NHCEL	NCELL1	Connecting axial cell numbers in component NHCOM.
Note: If ICONC1 = 0 (Word 1 on **Card Number 4**), do not input array CONC.			
46	CONC	NCELL1	Initial solute mass to liquid-coolant mass ratio [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)] in the main tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: If ICONC1 = 0 or 1 (Word 1 on **Card Number 4**), do not input array S.			
47	S	NCELL1	Initial macroscopic density of plated-out solute (kg/m^3, lb_m/ft^3) in the main tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
48	XGNB	NCELL1	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).

<table>
<tr><th>Card Set Number</th><th>Variable</th><th>Dimension</th><th>Description</th></tr>
<tr><td colspan="4">Note: Input array XLNB only if NTRACEL>0 (Word 2 on Main-Data Card 11). Repeat this card set NTRACEL times.</td></tr>
<tr><td>49</td><td>XLNB</td><td>NCELL1</td><td>Mass fraction for liquid trace species.</td></tr>
<tr><td colspan="4">Note: If IPOW1 = 0 (Word 5 on Card Number 4), do not input array POWTB1.</td></tr>
<tr><td>50</td><td>POWTB1</td><td>2×|NPWTB1|</td><td>Power-to-the-fluid vs independent-variable-form table [(*,W) (*,Btu/hr)] for the main tube. Input |NPWTB1| (Word 3 on Card Number 8) table-defining data pairs having the following form [independent-variable form defined by IPWSV1 (Word 2 on Card Number 8), power to the fluid]. The power is deposited directly into the main-tube fluid with a uniform power density along the main-tube length.</td></tr>
<tr><td colspan="4">Note: If IPOW1 = 0 (Word 5 on Card Number 4), do not input array POWRF1.</td></tr>
<tr><td>51</td><td>POWRF1</td><td>2×|NPWRF1|</td><td>Rate-factor table (*,–) for the main-tube power-to-the-fluid table independent variable. Input |NPWRF1| (Word 5 on Card Number 8) table-defining data pairs having the following form [independent-variable form defined by NPWSV1 (Word 4 on Card Number 8), rate factor to be applied to the power-to-the-fluid table independent variable].</td></tr>
<tr><td colspan="4">Note: If NQPTB1 = 0 (Word 3 on Card Number 9) or if NODES = 0 (Word 2 on Card Number 3), do not input array QP3TB1.</td></tr>
<tr><td>52</td><td>QP3TB1</td><td>2× |NQPTB1| when QPIN1 > 0.0; (1+NCELL1) ×|NQPTB1| when QPIN1 < 0.0.</td><td>Power-to-the-wall independent-variable-form table [(*,W) (*,Btu/hr)] for the main tube. Input |NQPTB1| (Word 3 on Card Number 9) table-defining data pairs having the following form [independent-variable form defined by IQPSV1 (Word 2 on Card Number 9), power to the wall]. If QPIN1 > 0.0, the dependent variable specifies the total power to the entire wall; if QPIN1 < 0.0, the dependent variable is a power shape that specifies the power to the wall at each cell from cell 1 to NCELL1.</td></tr>
<tr><td colspan="4">Note: If NSHTB = 0 (Word 2 on Card Number 5), do not input array SHLTB.</td></tr>
<tr><td>53</td><td>SHLTB</td><td>2×NSHTB</td><td>NSHTB pairs of shell void fraction, liquid heat transfer fraction data.</td></tr>
</table>

Card Set Number	Variable	Dimension	Description
Note: If NDCTB = 0 (Word 3 on **Card Number 5**), do not input array DCZTB.			
54	**DCZTB**	2×NDCTB	NDCTB pairs of drain cooler void fraction, liquid heat transfer fraction data.
Note: If NLLTB = 0 (Word 4 on **Card Number 5**), do not input array LEVTB.			
55	**LEVTB**	2×NLLTB	NLLTB pairs of shell void fraction, shell liquid level data.

Side Arm Array Cards

Card Set Number	Variable	Dimension	Description
56	**DX**	NCELL2	Side-tube cell lengths (m, ft).
57	**VOL**	NCELL2	Side-tube cell volumes (m^3, ft^3).
58	**FA**	NCELL2+1	Side-tube cell-edge flow areas (m^2, ft^2).
59	**FRIC**	NCELL2+1	Side-tube additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input. Input FRIC > 0.0 for internal-junction interface 1 of the side tube when a VOL/DX flow-area change occurs between JCELL and cell 1 of the side tube.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
60	**FRICR**	NCELL2+1	Side-tube additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input. Input FRICR > 0.0 for internal-junction interface 1 of the side tube when a VOL/DX flow-area change occurs between JCELL and cell 1 of the side tube.
61	**GRAV or ELEV**	NCELL2+1	Side-tube gravity elevation terms [(– or m), (– or ft)]. GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.
62	**HD**	NCELL2+1	Side-tube hydraulic diameters (m, ft) (see NAMELIST variable NDIA1 for additional input of heat-transfer diameters).
Note: If NAMELIST variable NDIA1 /= 2 do not input array HD-HT.			
63	**HD-HT**	NCELL2+1	Side-tube heat transfer diameters (m, ft).

Card Set Number	Variable	Dimension	Description
Note: If NAMELIST variable ICFLOW = 0 or 1, do not input array ICFLG.. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur..			
64	ICFLG	NCELL2+1	Side-tube cell-edge choked-flow model option. Cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.
65	NFF	NCELL2+1	Side-tube friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE. Input NFF ≥ 0 for the JCELL and JCELL+1 interfaces.
Note: If NCCFL = 0 (Word 5 **Main-Data Card 9**), do not input array LCCFL.			
66	LCCFL	NCELL2+1	Side-tube countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
67	ALP	NCELL2	Side-tube initial gas volume fractions (–).
68	VL	NCELL2+1	Side-tube initial liquid velocities (m/s, ft/s).
69	VV	NCELL2+1	Side-tube initial gas velocities (m/s, ft/s).
70	TL	NCELL2	Side-tube initial liquid temperatures (K, °F).
71	TV	NCELL2	Side-tube initial gas temperatures (K, °F).

Card Set Number	Variable	Dimension	Description
72	**P**	NCELL2	Side-tube initial pressures (Pa, psia).
73	**PA**	NCELL2	Side-tube initial noncondensable-gas partial pressures (Pa, psia).
Note: If NAMELIST variable NOLT1D = 1 do not input array ILEV.			
74	**ILEV**	NCELL2	Level tracking flags. ILEV = 1.0 indicates that the two-phase level exists in the current cell. ILEV = 0.0 indicates that the two-phase level does not exist in the current cell. If ILEV = -1.0, the level tracking calculation will be turned off for this cell.
Note: If NAMELIST variable MWFL = 0, do not input array WFMFL.			
75	**WFMFL**	NCELL2+1	Side-tube wall-friction multiplier factor for the liquid phase ($0.9 \leq$ WFMFL ≤ 1.1).
Note: If NAMELIST variable MWFV = 0, do not input array WFMFV.			
76	**WFMFV**	NCELL2+1	Side-tube wall-friction multiplier factor for the gas phase ($0.9 \leq$ WFMFL ≤ 1.1).
Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input arrays QPPP, MATID, TW, IDROD, and NHCEL.			
77	**QPPP**	NODES × NCELL2	A relative power shape in the side-tube wall. Input values for cell 1, node 1 through NODES; then cell 2, node 1 through NODES; etc. If the array is filled with the same nonzero constant, a uniform volumetric heat source in the wall results. TRACE internally normalizes the power shape to have a volume-average value of unity (each QPPP(I) is normalized to have the value QPPP(I) × [Σ_K VOL(K)]/[Σ_K QPPP(K) × VOL(K)]). Filling the array with zeros results in no power being deposited in the wall regardless of the values of QPIN2, QPTB2, etc.

Card Set Number	Variable	Dimension	Description
78	MATID	NODES-1	Wall-material ID array, which specifies material ID between radial nodes. Dimension is 1 if NODES = 1. **ID Material Type** 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 12 = inconel, type 600.
79	TW	NODES × NCELL2	Initial wall temperatures (K, °F) in the side tube, which are input in the same order as QPPP.
			Note: If NHCOM > 0 (Word 5 on **Card Number 12**) then input array IDROD.
80	IDROD	1	Vessel radial-theta cell number or input 0 when NHCOM is a 1D component.
			Note: If NHCOM > 0 (Word 5 on **Card Number 12**) then input array NHCEL.
81	NHCEL	NCELL2	Connecting axial cell numbers in component NHCOM.
			Note: If ICONC2 = 0 (Word 1 on **Card Number 13**), do not input array CONC.
82	CONC	NCELL2	Initial solute mass to liquid-coolant mass ratio [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)] in the side tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
			Note: If ICONC2 = 0 or 1 (Word 1 on **Card Number 13**), do not input array S.
83	S	NCELL2	Initial macroscopic density of plated-out solute (kg/ m^3, lb_m/ft^3) in the side tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
			Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.
84	XGNB	NCELL2	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).

Card Set Number	Variable	Dimension	Description
			Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.
85	**XLNB**	NCELL2	Mass fraction for liquid trace species.
			Note: If IPOW2 = 0 (Word 5 on **Card Number 13**), do not input array POWTB2.
86	**POWTB2**	2×|NPWTB2|	Power-to-the-fluid vs. independent-variable-form table [(*,W), (*,Btu/hr)] for the side tube. Input |NPWTB2| (Word 3 on **Card Number 14**) table-defining data pairs having the following form [independent-variable form defined by IPWSV2 (Word 2 on **Card Number 14**), power to the fluid]. The power is deposited directly into the side-tube fluid with a uniform volumetric power density along the HEATR side-tube length.
			Note: If IPOW2 = 0 (Word 5 on **Card Number 13**), do not input array POWRF2.
87	**POWRF2**	2×|NPWRF2|	Rate-factor table (*,–) for the side-tube power-to-the-fluid table independent variable. Input |NPWRF2| (Word 5 on **Card Number 14**) table-defining data pairs having the following form [independent-variable form defined by NPWSV2 (Word 4 on **Card Number 14**), rate factor to be applied to the power-to-the-fluid table independent variable].
			Note: If NQPTB2 = 0 (Word 3 on **Card Number 15**) or if NODES = 0 (Word 2 on **Card Number 3**), do not input array QP3TB2.
88	**QP3TB2**	2×|NQPTB2| when QPIN2>0.0; (1+NCELL2) ×|NQPTB2| when QPIN2<0.0.	Power-to-the-wall vs. independent-variable form table [(*,W), (*,Btu/hr)] for the side tube. Input |NQPTB2| (Word 3 on **Card Number 15**) table-defining data pairs having the following form [independent-variable form defined by IQPSV2 (Word 2 on **Card Number 15**), power to the wall]. If QPIN2 > 0.0, the dependent variable specifies the total power to the entire wall; if QPIN2 < 0.0, the dependent variable is a power shape that specifies the power to the wall at each cell from cell NCELL1 + 2 to cell NCELL1 + 1 + NCELL2.

HTSTR Component Data

See **POWER Component Data** for the POWER component input description. A sample problem which uses the HTSTR component is given at the end of this section.

If NOFUELROD=0 (Word 1 in **Card Number 3**), and NAMELIST variable NPOWER>0, power distribution must be specified via POWER component.

The HTSTR component replaces the old style ROD and SLAB heat structure component input. It is recommended old ROD and SLAB components be converted to new HTSTR components. The procedure for doing this is described in **Chapter 1** (See **Appendix A** for old style Rod and Slab input).

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (HTSTR left justified).
NUM	Component ID number (must be unique for each component, $1 \leq NUM \leq 999$).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 4I14) **NZHTSTR, ITTC, HSCYL, ICHF**

Variable	Description
NZHTSTR	Number of axial levels
ITTC	Specification of an external thermocouple (T/C) on the HTSTR element surface. It must be 0 for TRACE
HSCYL	Flag to indicate the geometry of the heat structure. 0 = slab geometry 1 = cylindrical geometry 2 = spherical geometry

Card Number 2. (Format 4I14) **NZHTSTR, ITTC, HSCYL, ICHF** (Continued)

Variable	Description
ICHF	CHF (Critical heat flux) flag 0 = convection heat transfer only, no boiling heat transfer (i.e. no wall nucleation is allowed although phase change can still occur); 1 = CHF from AECL-IPPE CHF Table, no critical quality calculated. 2 = CHF from AECL-IPPE CHF Table, critical quality from Biasi correlation. 3 = CHF from AECL-IPPE CHF Table, critical quality from CISE-GE correlation.

Card Number 3. (Format 4I14) **NOFUELROD, PLANE, LIQLEV, IAXCND**

Variable	Description
NOFUELROD	Fuel rod option. 0 = this HTSTR models fuel rods; 1 = this HTSTR does not model fuel rods.
PLANE	Flag to indicate the direction in the fluid component that corresponds to the axial direction for the heat structure. This input will be ignored for HTSTR's coupled to 1D components 1 = the x or r direction in the fluid component is the axial direction for the heat structure. 2 = the y or θ direction in the fluid component is the axial direction for the heat structure. 3 = the z direction in the fluid component is the axial direction for the heat structure.
LIQLEV	Specification of liquid-level tracking (Currently not used).
IAXCND	Specification of axial conduction. 0 = no axial heat-transfer conduction calculated; 1 = axial heat-transfer conduction calculated in the HTSTR element (explicit numerics when NAMELIST variable NRSLV = 0; implicit numerics when NRSLV = 1).

Card Number 4. (Format 3I14,2E14.4) **NMWRX, NFCI, NFCIL, HDRI, HDRO**

Variable	Description
NMWRX	Metal-water reaction option. 0 = off; 1 = on
NFCI	Fuel-clad interaction (FCI) option. NFCI = 1 performs the dynamic gas-gap conductance calculation. 0 = off; 1 = on.
NFCIL	Maximum number of FCI calculations per timestep. Input NFCIL = 1 when NFCI = 1.
HDRI	Heat-transfer diameter (m, ft) used to evaluate the heat-transfer coefficient (HTC) for the inside surface of the HTSTR element. HDRI is used when NAMELIST variable ITHD = 1 and the hydraulic diameter HD is used when ITHD = 0.
HDRO	Heat-transfer diameter (m, ft) used to evaluate the heat-transfer coefficient (HTC) for the outside surface of the HTSTR element. HDRO is used when NAMELIST variable ITHD = 1 and the hydraulic diameter HD is used when ITHD = 0.

Card Number 5. (Format 2I14) **IFRADI, IFRADO**

Note: Input the following card if nEnclosure (NAMELIST input)>0.

Variable	Description
IFRADI	Radiation heat transfer flag for the inner heat structure surface. If IFRADI=0, then there is no radiation heat transfer for the inner heat structure surface. If IFRADI=1, then there is radiation heat transfer for the inner heat structure surface.
IFRADO	Radiation heat transfer flag for the outer heat structure surface. If IFRADO=0, then there is no radiation heat transfer for the outer heat structure surface. If IFRADO=1, then there is radiation heat transfer for the outer heat structure surface.

Card Number 6. (Format 3E14.4) **EMCIF1, EMCIF2, EMCIF3**

Note: Input this card if IFRADI (Word 1 of **Card Number 5**)=1.	
Variable	**Description**
EMCIF1	First coefficient for the inner surface emissivity fit. emiss = emcif1 + emcif2*Ts + emcif3*Ts*Ts
EMCIF2	Second coefficient for the inner surface emissivity fit. emiss = emcif1 + emcif2*Ts + emcif3*Ts*T.
EMCIF3	Third coefficient for the inner surface emissivity fit. emiss = emcif1 + emcif2*Ts + emcif3*Ts*T.

Card Number 7. (Format 3E14.4) **EMCOF1, EMCOF2, EMCOF3**

Note: Input this card if IFRADO (Word 2 of **Card Number 5**)=1.	
Variable	**Description**
EMCOF1	First coefficient for the outer surface emissivity fit. emiss = emcof1 + emcof2*Ts + emcof3*Ts*Ts
EMCOF2	Second coefficient for the outer surface emissivity fit. emiss = emcof1 + emcof2*Ts + emcof3*Ts*T.
EMCOF3	Third coefficient for the outer surface emissivity fit. emiss = emcof1 + emcof2*Ts + emcof3*Ts*T.

Card Number 8. (Format E14.4, I14) **WIDTH or DTHETA**

Note: Input this card if HSCYL=0 or 2 (Word 3 on **Card Number 2**).	
Variable	**Description**
WIDTH or DTHETA	If HSCYL = 0, input WIDTH (m, ft) of HTSTR element surface (used to compute surface area) for the slab heat structure. If HSCYL = 2, input DTHETA, the number of radians in the theta direction for the spherical heat structure.

Card Number 9. (Format 5I14) **NHOT, NODES,FMON,NZMAX,REFLOODON**

Variable	Description
NHOT	Total number of supplemental HTSTR elements defined by this heat-structure component (supplemental elements do not affect the fluid-dynamic solution through heat-transfer coupling).
NODES	Number of radial (HSCYL=1, Word 3 on **Card Number 2**) or thickness (HSCYL=0) heat-transfer nodes in the HTSTR elements. A value of 1 invokes the lumped-parameter solution (see TRACE Theory Manual).
FMON	Fine mesh flag. If it is non-zero, then the fine mesh algorithm is turned on.
NZMAX	Maximum number of axial nodes. NZMAX must be greater or equal to NZHTSTR. With the fine mesh option on, NZMAX must be greater or equal to MAX((NZHTSTR+2), SUM(MAX(3, NFAX(1:)))).
REFLOODON	Reflood flag. This flag is now redundant in that it behaves identically to FMON above - if it is non-zero, then the fine mesh algorithm is turned on (even if FMON is set to zero). As of V4.260, the code no longer distinguishes between reflood and non-reflood sets of physical models. The only reason this flag still remains is to maintain backward compatibility with older input decks which may have had the IRFTR flag (now called FMON) set to 0 and IRFTR2 (now called REFLOODON) set to a non-zero number.

Card Number 10. (Format 4E14.4) **DTXHT(1), DTXHT(2), DZNHT, HGAPO**

Variable	Description
DTXHT(1)	Maximum ΔT (K, ºF) surface-temperature change between node rows above which a row of nodes is inserted in the axial fine-mesh calculation for the nucleate and transition boiling regimes. (No longer used).
DTXHT(2)	Maximum ΔT (K, ºF) surface-temperature change between node rows above which a row of nodes is inserted in the axial fine-mesh calculation for all heat transfer regimes other than the nucleate and transition boiling regimes. (No longer used).
DZNHT	Minimum Δz (m, ft) axial interval between node rows below which no additional row of nodes is inserted in the axial fine-mesh calculation.
HGAPO	HTSTR element gas-gap HTC [W/(m^2 K), Btu/(ft^2 ºF hr)].

HTSTR Array Cards.

Note: Use LOAD format. Each array has its element values defined by a Card Set of one or more cards.

Card Set Number	Variable	Dimension	Description
11	**IDBCIN**	NZHTSTR	Inner surface boundary condition for each axial level in the heat structure. 0 = Constant heat flux (positive direction is from solid to fluid) 1 = Constant heat transfer coefficient, and constant sink temperature 2 = Heat structure is coupled to the hydro component 3 = Heat flux is specified by heat flux vs. independent variable table (positive direction is from solid to fluid) 4 = Heat transfer coefficient is specified by table of heat transfer coefficient vs. independent variable; sink temperature is specified by sink temperature versus independent variable table. 5= Constant fixed surface temperature. 6 = Constant fixed heat transfer coefficient, with fluid/sink temperature determined by the connecting Hydro component. 7 = Surface temperature is determined by a signal variable or control block. 8 = Heat transfer coefficient is determined by a signal variable or control block. 9 = Sink temperature is determined by a signal variable or control block. 10 = Surface heat flux is determined by a signal variable or control block. (Positive direction is from solid to fluid). 11 = Surface temperature is determined by a general table. 12 = Surface HTC is determined by a general table.

Card Set Number	Variable	Dimension	Description
12	**IDBCON**	NZHTSTR	Outer surface boundary condition for each axial level in the heat structure. See above for input options.

Inner Surface Boundary Condition:

Note: Include one inside surface Card Sets for each of the NZHTSTR (Word 1 on **Card Number 2**) axial levels of HTSTR. Use LOAD format.

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCIN = 0 (**Card Set 11**) for this axial level.			
13	**QFLXBCI**	1	Inner surface heat flux for axial level [W/m^2, (Btu/hr)/ft^2].
Note: Input next Card only if IDBCIN = 1 (**Card Set 11**) for this axial level.			
14	**HTCLIQI, TFLUIDI**	2	Inner surface heat transfer coefficient [W/(m^2 K), Btu/(ft^2 ^{o}F hr)] and sink temperature (K, ^{o}F) for axial level.

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCIN = 2 (**Card Set 11**) for this axial level.			
15	**HCOMIN, HCELII, HCELJI, HCELKI**	4	HCOMIN: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELII,HCEJI,HCELKI: i-,j-,k-cell number of the fluid cell of component HCOMIN to which axial level of the HTSTR component is coupled. If HCOMIN is a 1D fluid component, only HCELII is used; it refers to the axial cell number in the fluid component. If NHCOMIN refers to a 3D vessel, HCELII refers to the radial cell number, HCELJI refers to the theta cell number, and HCELKI refers to the axial cell number.
Note: Input next card set only if IDBCIN = 3 (**Card Set 11**).			
16	**NUMBCI1**	1	Number of the general table for this surface boundary condition. IDBCIN = 3 implies the general table will be for a surface heat flux.
Note: Input next card set only if IDBCIN = 4 (**Card Set 11**).			
17	**NUMBCI1, NUMBCI2**	2	NUMBCI1 = general table number for the HTC BC for this inner surface at this axial level. NUMBCI2 = general table number for the sink temperature BC for this inner surface at this axial level.
Note: Input next Card only if IDBCIN = 5 (**Card Set 11**) for this axial level.			
18	**TSURFI**	1	Inner surface temperature BC for this axial level (K, ^{o}F).

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCIN = 6 (**Card Set 11**) for this axial level.			
19	**HTCLIQI, HTCVAPI, HCOMIN, HCELII, HCELJI, HCELKI**	6	HTCLIQI: Inside surface HTC [W/(m^2 K), Btu/(ft^2 ^oF hr)] for the liquid phase. HTCVAPI: Inside surface HTC [W/(m^2 K), Btu/(ft^2 ^oF hr)] for the vapor phase. HCOMIN: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELII,HCEJI,HCELKI: i-,j-,k-cell number of the fluid cell of component HCOMIN to which axial level of the HTSTR component is coupled. If HCOMIN is a 1D fluid component, only HCELII is used; it refers to the axial cell number in the fluid component. If NHCOMIN refers to a 3D vessel, HCELII refers to the radial cell number, HCELJI refers to the theta cell number, and HCELKI refers to the axial cell number. Note: use **s;** input no more than 5 numbers per card.
Note: Input next Card only if IDBCIN = 7 (**Card Set 11**) for this axial level.			
20	**NUMBCI1**	1	Signal variable or control block id for the inner surface temperature BC for this axial level.

HTSTR Component Data

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCIN = 8, or 9 (**Card Set 11**) for this axial level.			
21	**NUMBCI1, HCOMIN, HCELII, HCELJI, HCELKI**	5	NUMBCI1: Signal variable or control block id for the inner surface heat transfer coefficient BC for this axial level if IDBCIN = 8. NUMBCI1: Signal variable or control block id for the inner surface sink temperature BC for this axial level if IDBCIN = 9. HCOMIN: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELII,HCEJI,HCELKI: i-,j-,k-cell number of the fluid cell of component HCOMIN to which axial level of the HTSTR component is coupled. If HCOMIN is a 1D fluid component, only HCELII is used; it refers to the axial cell number in the fluid component. If HCOMIN refers to a 3D vessel, HCELII refers to the radial cell number, HCELJI refers to the theta cell number and HCELKI refers to the axial cell number.
Note: Input next Card only if IDBCIN = 10 (**Card Set 11**) for this axial level.			
22	**NUMBCI1**	1	NUMBCI1: Signal variable or control block id for the inner surface heat flux BC for this axial level.
Note: Input next card set only if IDBCIN = 11 (**Card Set 11**).			
23	**NUMBCI1**	1	Number of the general table for this surface boundary condition. IDBCIN = 3 implies the general table will be for a surface heat flux. IDBCIN = 11 implies the general table will be for a surface wall temperature.

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCIN = 12 (**Card Set 11**) for this axial level.			
24	**NUMBCI1, HCOMIN, HCELII, HCELJI, HCELK1**	5	NUMBCI1: General table number for the inner surface HTC BC for this axial level. HCOMIN: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELII,HCEJI,HCELKI: i-,j-,k-cell number of the fluid cell of component HCOMIN to which axial level of the HTSTR component is coupled. If HCOMIN is a 1D fluid component, only HCELII is used; it refers to the axial cell number in the fluid component. If HCOMIN refers to a 3D vessel, HCELII refers to the radial cell number, HCELJI refers to the theta cell number and HCELKI refers to the axial cell number.

Outer Surface Boundary Condition:

Note: Include one outside surface Card Sets for each of the NZHTSTR (Word 1 on **Card Number 2**) axial levels of HTSTR. Use LOAD format.

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCON = 0 (**Card Set 12**) for this axial level.			
25	**QFLXBCO**	1	Outer surface heat flux for axial level [W/m^2, (Btu/hr)/ft^2].
Note: Input next Card only if IDBCON = 1 (**Card Set 12**) for this axial level.			
26	**HTCLIQO, TFLUIDO**	2	Outer surface heat transfer coefficient [W/(m^2 K), Btu/(ft^2 ^{o}F hr)] and sink temperature for axial level.

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCON = 2 (**Card Set 12**) for this axial level.			
27	**HCOMON, HCELIO, HCELJO, HCELKO**	4	HCOMON: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELIO,HCEJO,HCELKO: i-,j-,k-cell number of the fluid cell of component HCOMON to which axial level of the HTSTR component is coupled. If HCOMON is a 1D fluid component, only HCELIO is used; it refers to the axial cell number in the fluid component. If NHCOMON refers to a 3D vessel, HCELIO refers to the radial cell number, HCELJO refers to the theta cell number, and HCELKO refers to the axial cell number.
Note: Input next card set only if IDBCON = 3 (**Card Set 12**).			
28	**NUMBCO1**	1	Number of the general table for this surface boundary condition. IDBCON = 3 implies the general table will be for a surface heat flux. IDBCON = 11 implies the general table will be for a surface wall temperature.
Note: Input next card set only if IDBCON = 4 (**Card Set 12**).			
29	**NUMBCO1, NUMBCO2**	2	NUMBCO1 = general table number for the HTC BC for this outer surface at this axial level. NUMBCO2 = general table number for the sink temperature BC for this outer surface at this axial level.
Note: Input next Card only if IDBCON = 5 (**Card Set 12**) for this axial level.			
30	**TSURFO**	1	Outer surface temperature BC for this axial level (K, ^{o}F).

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCON = 6 (**Card Set 12**) for this axial level.			
31	**HTCLIQO, HTCVAPO, HCOMON, HCELIO, HCELJO, HCELKO**	6	HTCLIQO: Outside surface HTC [W/(m^2 K), Btu/(ft^2 ^oF hr)] for the liquid phase. HTCVAPO: Outside surface HTC [W/(m^2 K), Btu/(ft^2 ^oF hr)] for the vapor phase. HCOMON: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELIO,HCEJO,HCELKO: i-,j-,k-cell number of the fluid cell of component HCOMON to which axial level of the HTSTR component is coupled. If HCOMON is a 1D fluid component, only HCELIO is used; it refers to the axial cell number in the fluid component. If NHCOMON refers to a 3D vessel, HCELIO refers to the radial cell number, HCELJO refers to the theta cell number, and HCELKO refers to the axial cell number. Note: use **s;** input no more than 5 numbers per card.
Note: Input next Card only if IDBCON = 7 (**Card Set 12**) for this axial level.			
32	**NUMBCO1**	1	Signal variable or control block id for the outer surface temperature BC for this axial level.

HTSTR Component Data

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCON = 8, or 9 (**Card Set 12**) for this axial level.			
33	**NUMBCO1, HCOMON, HCELIO, HCELJO, HCELKO**	5	NUMBCO1: Signal variable or control block id for the outer surface heat transfer coefficient BC for this axial level if IDBCON = 8. NUMBCO1: Signal variable or control block id for the outer surface sink temperature BC for this axial level if IDBCON = 9. HCOMON: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELIO,HCEJO,HCELKO: i-,j-,k-cell number of the fluid cell of component HCOMON to which axial level of the HTSTR component is coupled. If HCOMON is a 1D fluid component, only HCELIO is used; it refers to the axial cell number in the fluid component. If HCOMON refers to a 3D vessel, HCELIO refers to the radial cell number, HCELJO refers to the theta cell number and HCELKO refers to the axial cell number.
Note: Input next Card only if IDBCON = 10 (**Card Set 12**) for this axial level.			
34	**NUMBCO1**	1	NUMBCO1: Signal variable or control block id for the outer surface heat flux BC for this axial level.
Note: Input next card set only if IDBCON = 11 (**Card Set 12**).			
35	**NUMBCO1**	1	Number of the general table for this surface boundary condition. IDBCON = 11 implies the general table will be for a surface wall temperature.

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCON = 12 (**Card Set 12**) for this axial level.			
36	**NUMBCO1, HCOMON, HCELIO, HCELJO, HCELKO**	5	NUMBCO1: General table number for the outer surface HTC BC for this axial level. HCOMON: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELIO,HCEJO,HCELKO: i-,j-,k-cell number of the fluid cell of component HCOMON to which axial level of the HTSTR component is coupled. If HCOMON is a 1D fluid component, only HCELIO is used; it refers to the axial cell number in the fluid component. If HCOMON refers to a 3D vessel, HCELIO refers to the radial cell number, HCELJO refers to the theta cell number and HCELKO refers to the axial cell number.

Additional Array Data

Card Set Number	Variable	Dimension	Description
Note: If NAMELIST variable MHTLI = 0, or IRFTR ≠ 0 (Word 3 on **Card Number 9**), do not input array HTMLI.			
37	**HTMLI**	NZHTSTR	Liquid-phase wall heat-transfer multiplier factor for the inner surface (–) [0.9 ≤ HTMLI ≤ 1.1].
Note: If NAMELIST variable MHTLO = 0, or IRFTR ≠ 0 (Word 3 on **Card Number 9**), do not input array HTMLO.			
38	**HTMLO**	NZHTSTR	Liquid-phase wall heat-transfer multiplier factor for the outer surface (–) [0.9 ≤ HTMLO ≤ 1].

Card Set Number	Variable	Dimension	Description
Note: If NAMELIST variable MHTVI = 0, or IRFTR ≠ 0 (Word 3 on **Card Number 9**), do not input array HTMVI.			
39	**HTMVI**	NZHTSTR	Gas-phase wall heat-transfer multiplier factor for the inner surface (–) [0.9 ≤HTMVI ≤ 1.1].
Note: If NAMELIST variable MHTVO = 0, or IRFTR ≠ 0 (Word 3 on **Card Number 9**), do not input array HTMVO.			
40	**HTMVO**	NZHTSTR	Gas-phase wall heat-transfer multiplier factor for the outer surface (–) [0.9 ≤ HTMVO ≤ 1.1].
41	**DHTSTRZ**	NZHTSTR	Axial length of the heat structure cells (m, ft).
42	**RDX**	1	Number of actual HTSTR elements in the heat structure. This is a real-valued number, not an integer. A value with a fractional part models with the fractional part a HTSTR element that is partly within the mesh cell.
43	**RADRD**	NODES	HTSTR radii (HSCYL=1, Word 3 on **Card Number 2**) or thickness (HSCYL=0) (m, ft) from the inside surface at no power cold conditions.
Note: If ITTC=0 (Word 2 on **Card Number 2**), do not input this Card Set.			
44	**TC**	6	The following six thermocouple parameters are input as array elements. ANTC = Number of thermocouples per HTSTR element; DIA = Diameter of the thermocouple (m, ft); AW = Perimeter of the HTSTR-element surface to thermocouple weld (m, ft); ATW = Thickness of the HTSTR element at thermocouple weld (m, ft); CKW = The HTSTR element to thermocouple effective thermal conductivity [W/(m K), Btu/(ft ^{o}F hr)]; RADT = Distance from the HTSTR-element center to the center of the thermocouple (m, ft).

Card Set Number	Variable	Dimension	Description
Note: Adjacent MATRD elements cannot both have the value of 3 and MATRD(1) and MATRD(NODES – 1) cannot be 3. Additional material properties can be input.			
45	**MATRD**	NODES –1	HTSTR-element material ID numbers [dimension is 1 if NODES = 1 (Word 2 on **Card Number 9**)]. 1 = mixed oxide; 2 = zircaloy; 3 = fuel-clad gap gases; 4 = boron-nitride insulation; 5 = constantan/Nichrome heater wire; 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 11 = zircaloy dioxide; 12 = inconel, type 600.
46	**NFAX**	NZHTSTR	Number of permanent fine-mesh cells added in each coarse mesh cell of the heat structure, when the fine-mesh calculation is set ON. Odd numbers should be used. If even numbers are used, the code will change them to odd numbers (NFAX=NFAX+1).
Note: Input next Card Set (Temperature Array) for the average power rod and each of the supplemental rods NHOT (Word 1 on **Card Number 9**) HTSTR elements.			
47	**RFTN**	NODES x NZHTSTR	HTSTR (radial by axial if HSCYL=1, Word 3 on **Card Number 2**, and thickness by axial if HSCYL=0) element temperatures (K, °F). If fine mesh option is used, element temperatures at the heat structure ends must be added. In this case, the dimension of RFTN is NODES x (NZHTSTR+2).
Note: Omit the remaining 8 Cards if NOFUELROD (Word 1 on **Card Number 3**) = 1			
48	**FPUO2**	1	Fraction (–) of plutonium dioxide (PuO_2) in mixed-oxide fuel.
49	**FTD**	1	Fraction (–) of theoretical fuel density.

Card Set Number	Variable	Dimension	Description
50	GMIX	7	Mole fraction (–) of gap-gas constituents. GMIX is not used if NFCI = 0 (Word 2 on Card Number 4) but must be input. Enter data for 1 cell for each gas in the order indicated below. These values will be applied to every cell. 1. helium; 2. argon; 3. xenon; 4. krypton; 5. hydrogen; 6. air/nitrogen; 7. water vapor.
51	GMLES	1	Gram moles of gap gas (g-moles) for HTSTR element. GMLES is not used, but must be input.
52	PGAPT	1	Average gap-gas pressure (Pa, psia). PGAPT is not used if NFCI = 0 (Word 2 on Card Number 4), but must be input.
53	PLVOL	1	Plenum volume (m^3, ft^3) in the HTSTR element above the pellet stack. PLVOL is not used, but must be input.
54	PSLEN	1	Pellet-stack length (m, ft). PSLEN is not used, but must be input.
55	CLENN	1	Clad total length (m, ft). CLENN is not used, but must be input.
Note: Input this Card Set (Burnup Arrays) for the average rod and each of the NHOT (Word 1 on Card Number 9) supplemental elements of the HTSTR component.			
56	BURN	NZHTSTR	HTSTR element axial-location fuel burnup (MWD/MTU).

Sample Input using HTSTR, POWER, and RADENC

```
free format
*
*************
* main data *
*************
*
*       numtcr           ieos         inopt          nmat
             1              0             1             1
*-*-*radiation test problem with 2 htstrs in a pipe
* Starting from Jay'sRadEncSlab; ISL added hydro Apr 2003
*
*****************
* namelist data *
*****************
*
 &inopts
 nhtstr=1, cpuflg=1, npower=1, ipowr=1, nEnclosure=1,
 &end
*
*        dstep          timet
             0    0.0000e+00
*       stdyst         transi         ncomp          njun          ipak
             0              1             7             2             1
*         epso           epss
    1.0000e-03     1.0000e-10
*       oitmax         sitmax        isolut        ncontr
            10             10             0             0
*         ntsv           ntcb          ntcf          ntrp          ntcp
             1              0             0             1             0
*
*************************
* component-number data *
*************************
*
* iorder*    666  777 888 s
* iorder*    11  22 33 901  e
*
****************************
* material-properties data *
****************************
*
* matb  *            51e
* ptbln *             2e
*       temp         rho           cp            k            emiss
*   prptb(1,i)    prptb(2,i)    prptb(3,i)    prptb(4,i)    prptb(5,i)
    2.0000e+02    5000.0         0.80e+03       14.0          0.67
    4.0000e+05    5000.0         0.80e+03       24.0          0.67
e
*
**************************
* control-parameter data *
**************************
*
*
* signal variables
*         idsv           isvn          ilcn          icn1          icn2
             1              0             0             0             0
*
```

```
* trips
*         ntse          ntct          ntsf          ntdp          ntsd
             0             0             0             0             0
*         idtp          isrt          iset          itst          idsg
            -2             2             0             1             1
*      setp(1)       setp(2)
    0.0000e+00    1.0000e-01
*      dtsp(1)       dtsp(2)
    0.0000e+00    0.0000e+00
*      ifsp(1)       ifsp(2)
             0             0
*
******************
* component data *
******************
*
*******   type           num            id       ctitle
fill                     666            666  inlet zero fill
*3        jun1          ifty           ioff
           666             6              0
*5       iftr    ifsv    nftb   ntsv   nfrf
            0       1       4      0      0
*6        twtold         rfmxv         concin           felv
         500.0          10.0e8          0.0              0.0
*9      dxin          volin         alpin         vlin     tlin
          1.0           0.1           1.0           1.0     613.0
*10       pin            pain         flowin         vvin      tvin
      14.5000e+06          0.0       0.907185          1.0      613.0
*13   vmscl    vvscl
       1.0      1.0
*14   tlscl   tvscl   pscl   pascl    conscl
       1.0       1.0   1.0     1.0      1.0
*Card Sets
*18   vmtbv
      0.0   0.907185   10.0   0.907185 s
    100.0   0.907185 1000.0   0.907185 e
*19   vvtbv
      0.0   0.53360    10.0   0.53360 s
    100.0   0.53360  1000.0   0.53360 e
*20  tltb
        0.0         644.261   100.0   644.261 s
      200.0         644.261  1.0E+20  644.261 e
*21  tvtb
        0.0         644.261  100.0   1366.48 s
      200.0         644.261  1.0E+20 644.761 e
*22  alptb
        0.0         1.0    100.0         1.0  s
      200.0         1.0   1.0E+20        1.0  e
*23  ptb
        0.0         14.5e6    100.0         14.5e6 s
      200.0         14.5e6   1.0E+20        14.5e6 e
*22  patb
        0.0         0.0       100.0         0.0    s
      200.0         0.0      1.0E+20        0.0    e
*
*******   type           num            id       ctitle
pipe                     777            777     bottom pipe
*       ncells         nodes          jun1          jun2          epsw
             2             0           666           777          0.0
*         ichf         iconc          iacc          ipow
             0             0             0             0
*        radin            th         houtl         houtv         toutl
    5.0000e-01    5.0000e-02    0.0000e+00    0.0000e+00    5.0000e+02
*        toutv
```

```
    5.0000e+02
*
* dx     * f 9.251     e
* vol    * f 0.5168    e
* fa     * f 0.055863  e
* fric   * r02 0.0  0.35 e
* grav   * f 0.0  e
* hd     * f 0.266695 e
* nff    * f           1e
* alp    * f   1.0 e
* vl     * f   1.0  e
* vv     * f   1.0  e
* tl     * f   613.0 e
* tv     * f   613.0 e
* p      * f   14.5e6 e
* pa     * f   0.0 e
*
*******   type          num           id        ctitle
break                   888          888         bottom
*         jun1         ibty         isat          ioff
           777            0            0             0
*         dxin        volin        alpin           tin           pin
           2.0          0.2           1.          613.     14.50e+06
*         pain       concin        rbmx          poff          belv
    0.0000e+00   0.0000e+00   0.0000e+00    0.0000e+00            0.
*
*
*******   type          num           id        ctitle
htstr                    11           11 powered-slab conductor
*2      nzhtstr        ittc        hscyl          ichf
              2           0            0             1
*3   nofuelrod        plane       liqlev        iaxcnd
              0           2            0             0
*4      nmwrx          nfci        nfcil          hdri          hdro
              0           0            0       0.25231       0.35231
*5     ifradi        ifrado
              0           1
*7     emcof1        emcof2       emcof3
            0.8         0.0          0.0
*8      width
           0.42
*9       nhot         nodes         fmOn         nzmax
              0           4            0             4
*10   dtxht(1)      dtxht(2)        dznht         hgapo
    5.0000e+00   1.0000e+01   5.0000e-02    0.0000e+00
* idbciN * 0 0e
* idbcoN * 2 2e
* qsurfi
  0.0   e
  0.0   e
* hcomon  hcelio  hceljo   hcelko
  777        1     0         0   e
  777        2     0         0   e
* dzhtstr 41* f 9.251      e
* rdx 42  *     1.0e
* radrd *  1.28595e-01    1.3970e-01  1.508e-01  1.619e-01 e
* matrd * f            51e
* nfax  * f            0e
* rftn  * f   613.0 e
* fpuo2 *     0.0000e+00e
* ftd   *     9.2500e-01e
* gmix  * f   0.0000e+00e
* gmles *     0.0000e+00e
* pgapt *     0.0000e+00e
```

```
* plvol *     2.0000e-05e
* pslen *     3.6576e+00e
* clenn *     3.9576e+00e
* burn  * f   2.6620e+03e
*
*
*******   type           num            id        ctitle
htstr                     22            22 non-powered-slab conductor
*2        nzhtstr         ittc       hscyl           ichf
             2             0             0             1
*3   nofuelrod         plane        liqlev        iaxcnd
             0             2             0             0
*4      nmwrx           nfci         nfcil          hdri          hdro
            0              0             0       0.25231       0.35231
*5     ifradi         ifrado
            1              0
*7     emcof1         emcof2        emcof3
          0.8            0.0           0.0
*8     width
          0.42
*9       nhot          nodes          fmOn         nzmax
            0              4             0             4
*10   dtxht(1)      dtxht(2)         dznht         hgapo         shelv
    5.0000e+00    1.0000e+01    5.0000e-02    0.0000e+00    0.0000e+00
* idbciN * 2 2 e
* idbcoN * 0 0 e
* hcomin  hcelii  hcelji   hcelki
  777        1     0         0   e
  777        2     0         0   e
* qsurfi
  0.0   e
  0.0   e
* dzhtstr 41* f 9.251     e
* rdx  42 *     1.0e
* radrd *  1.28595e-01    1.3970e-01  1.508e-01  1.619e-01 e
* matrd * f            51e
* nfax  * f            0e
* rftn  * f   613.0 e
* fpuo2 *     0.0000e+00e
* ftd   *     9.2500e-01e
* gmix  * f   0.0000e+00e
* gmles *     0.0000e+00e
* pgapt *     0.0000e+00e
* plvol *     2.0000e-05e
* pslen *     3.6576e+00e
* clenn *     3.9576e+00e
* burn  * f   2.6620e+03e
*
*
*******   type           num            id        ctitle
  power         901            901 power data input test1
*2 numpwr chanpow  ngtpow  nsvpow ncbpow
   1
*3 htnum
   11e
*       irpwty          ndgx          ndhx          nrts         nhist
             5             0           -11             5             0
*       izpwtr        izpwsv        nzpwtb        nzpwsv        nzpwrf
             0             1             1             0             0
*        ipwrad        ipwdep
         0             0
*        nzpwz         nzpwi        nfbpwt
             0             0             0
*        react         tneut        rpwoff        rrpwmx        rpwscl
```

```
    0.0000e+00    0.0000e+00    0.0000e+00    0.0000e+00    1.0000e+00
*       rpowri         zpwin        zpwoff        rzpwmx
          1.0    0.0000e+00    0.0000e+00    0.0000e+00
*       extsou          pldr         pdrat        fucrac
    0.0000e+00    0.0000e+00    1.3000e+00    7.0000e-01
* rdpwr * f   1.0000e+00e
* cpowr *     1.0000e+00e
* zpwtb * f   1.0000e+00e
*
*******   type           num            id        ctitle
radenc                    33            33        Radiation HT enclosure
*2      nzlevel          nhss
            2             3
*3       numhss         rnHSS-node   znHSS-level
            11            4             1
            22            1             1
            22            1             2
            11            4             2
            22            1             2
            22            1             1
*4       Upper Off-diagonal view fraction matrix array.
           0.95 0.05 e
                0.0 e
           0.95 0.05 e
                0.0 e
*5       Diagonal and upper off-diagonal for path length array.
         0.0  0.267  9.255 e
              0.0    9.251 e
                     0.0   e
         0.0  0.267  9.255 e
              0.0    9.251 e
                     0.0   e
*
end
*
******************
* time-step data *
******************
*
*        dtmin         dtmax          tend         rtwfp
    1.0000e-03         0.1          199.0    1.0000e+02
*        edint         gfint        dmpint        sedint
         20.0          1.0    1.0000e+03    5.0000e+01
*
******************
* time-step data *
******************
*
*      endflag
   -1.0000e+00
```

REPEAT-HTSTR Component Data

In order to repeat a heat structure component, the first number input for the second card must be negative.

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (HTSTR left justified).
NUM	Component ID number (must be unique for each component, $1 \leq \text{NUM} \leq 999$).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format I14) **NUMORG**

Variable	Description
NUMORG	NUMORG must be negative. Absolute value of numOrg is the ID number of the original HS whose data is to be repeated.

HTSTR Array Cards

Note: Use LOAD format. Each array has its element values defined by a Card Set of one or more cards.

Card Set Number	Variable	Dimension	Description
3	IDBCIN	NZHTSTR	Inner surface boundary condition for each axial level in the heat structure. 0 = Constant heat flux (positive direction is from solid to fluid) 1 = Constant heat transfer coefficient, and constant sink temperature 2 = Heat structure is coupled to the hydro component 3 = Heat flux is specified by heat flux vs. independent variable table (positive direction is from solid to fluid) 4 = Heat transfer coefficient is specified by table of heat transfer coefficient vs. independent variable; sink temperature is specified by sink temperature versus independent variable table. 5 = Constant fixed surface temperature. 6 = Constant fixed heat transfer coefficient, with fluid/sink temperature determined by the connecting Hydro component. 7 = Surface temperature is determined by a signal variable or control block. 8 = Heat transfer coefficient is determined by a signal variable or control block. 9 = Sink temperature is determined by a signal variable or control block. 10 = Surface heat flux is determined by a signal variable or control block. (Positive direction is from solid to fluid). 11 = Surface temperature is determined by a general table. 12 = Surface HTC is determined by a general table.
4	IDBCON	NZHTSTR	Outer surface boundary condition for each axial level in the heat structure. See above for input options.

Inner Surface Boundary Condition

Note: Include one of inside surface Card Sets for each of the NZHTSTR axial levels of HTSTR.

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCIN = 0 (**Card Set 3**) for this axial level.			
5	**QFLXBCI**	1	Inner surface heat flux for axial level.
Note: Input next Card only if IDBCIN = 1 (**Card Set 3**) for this axial level.			
6	**HTCLIQI, TFLUIDI**	2	Inner surface heat transfer coefficient and sink temperature for axial level.
Note: Input next Card only if IDBCIN = 2 (**Card Set 3**) for this axial level.			
7	**HCOMIN, HCELII, HCELJI, HCELKI**	4	HCOMIN: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELII,HCEJI,HCELKI: i-,j-,k-cell number of the fluid cell of component HCOMIN to which axial level of the HTSTR component is coupled. If HCOMIN is a 1D fluid component, only HCELII is used; it refers to the axial cell number in the fluid component. If NHCOMIN refers to a 3D vessel, HCELII refers to the radial cell number, HCELJI refers to the theta cell number, and HCELKI refers to the axial cell number.
Note: Input next card set only if IDBCIN = 3 (**Card Set 3**).			
8	**NUMBCI1**	1	Number of the general table for this surface boundary condition. IDBCIN = 3 implies the general table will be for a surface heat flux.

Card Set Number	Variable	Dimension	Description
Note: Input next card set only if IDBCIN = 4 (**Card Set 3**).			
9	**NUMBCI1, NUMBCI2**	2	NUMBCI1 = general table number for the HTC BC for this inner surface at this axial level. NUMBCI2 = general table number for the sink temperature BC for this inner surface at this axial level.
Note: Input next Card only if IDBCIN = 5 (**Card Set 3**) for this axial level.			
10	**TSURFI**	1	Inner surface temperature BC for this axial level.
Note: Input next Card only if IDBCIN = 6 (**Card Set 3**) for this axial level.			
11	**HTCLIQI, HTCVAPI, HCOMIN, HCELII, HCELJI, HCELKI**	6	HTCLIQI: Inside surface HTC for the liquid phase. HTCVAPI: Inside surface HTC for the vapor phase. HCOMIN: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELII,HCEJI,HCELKI: i-,j-,k-cell number of the fluid cell of component HCOMIN to which axial level of the HTSTR component is coupled. If HCOMIN is a 1D fluid component, only HCELII is used; it refers to the axial cell number in the fluid component. If NHCOMIN refers to a 3D vessel, HCELII refers to the radial cell number, HCELJI refers to the theta cell number, and HCELKI refers to the axial cell number. **Note:** Use **s;** input no more than 5 numbers per card.
Note: Input next Card only if IDBCIN = 7 (**Card Set 3**) for this axial level.			
12	**NUMBCI1**	1	Signal variable or control block id for the inner surface temperature BC for this axial level.

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCIN = 8, or 9 (**Card Set 3**) for this axial level.			
13	**NUMBCI1, HCOMIN, HCELII, HCELJI, HCELKI**	5	NUMBCI1: Signal variable or control block id for the inner surface heat transfer coefficient BC for this axial level if IDBCIN = 8. NUMBCI1: Signal variable or control block id for the inner surface sink temperature BC for this axial level if IDBCIN = 9. HCOMIN: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELII,HCEJI,HCELKI: i-,j-,k-cell number of the fluid cell of component HCOMIN to which axial level of the HTSTR component is coupled. If HCOMIN is a 1D fluid component, only HCELII is used; it refers to the axial cell number in the fluid component. If HCOMIN refers to a 3D vessel, HCELII refers to the radial cell number, HCELJI refers to the theta cell number and HCELKI refers to the axial cell number.
Note: Input next Card only if IDBCIN = 10 (**Card Set 3**) for this axial level.			
14	**NUMBCI1**	1	NUMBCI1: Signal variable or control block id for the inner surface heat flux BC for this axial level.
Note: Input next card set only if IDBCIN = 11 (**Card Set 3**).			
15	**NUMBCI1**	1	Number of the general table for this surface boundary condition. IDBCIN = 3 implies the general table will be for a surface heat flux. IDBCIN = 11 implies the general table will be for a surface wall temperature.

REPEAT-HTSTR Component

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCIN = 12 (**Card Set 3**) for this axial level.			
16	**NUMBCI1, HCOMIN, HCELII, HCELJI, HCELK1**	5	NUMBCI1: General table number for the inner surface HTC BC for this axial level. HCOMIN: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELII,HCEJI,HCELKI: i-,j-,k-cell number of the fluid cell of component HCOMIN to which axial level of the HTSTR component is coupled. If HCOMIN is a 1D fluid component, only HCELII is used; it refers to the axial cell number in the fluid component. If HCOMIN refers to a 3D vessel, HCELII refers to the radial cell number, HCELJI refers to the theta cell number and HCELKI refers to the axial cell number.

Outer Surface Boundary Condition

Note: Include one of the outside surface Card Sets for each of the NZHTSTR axial levels of HTSTR.

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCON = 0 (**Card Set 4**) for this axial level.			
17	**QFLXBCO**	1	Outer surface heat flux [W/m^2, (Btu/hr)/ft^2]for axial level.
Note: Input next Card only if IDBCON = 1 (**Card Set 4**) for this axial level.			
18	**HTCLIQO, TFLUIDO**	2	Outer surface heat transfer coefficient [W/(m^2 K), Btu/(ft^2 ^{o}F hr)] and sink temperature (K, ^{o}F)for axial level.

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCON = 2 (**Card Set 4**) for this axial level.			
19	**HCOMON, HCELIO, HCELJO, HCELKO**	4	HCOMON: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELIO,HCEJO,HCELKO: i-,j-,k-cell number of the fluid cell of component HCOMON to which axial level of the HTSTR component is coupled. If HCOMON is a 1D fluid component, only HCELIO is used; it refers to the axial cell number in the fluid component. If NHCOMON refers to a 3D vessel, HCELIO refers to the radial cell number, HCELJO refers to the theta cell number, and HCELKO refers to the axial cell number.
Note: Input next card set only if IDBCON = 3 (**Card Set 4**).			
20	**NUMBCI1**	1	Number of the general table for this surface boundary condition. IDBCON = 3 implies the general table will be for a surface heat flux. IDBCON = 11 implies the general table will be for a surface wall temperature.
Note: Input next card set only if IDBCON = 4 (**Card Set 4**).			
21	**NUMBCO1, NUMBCO2**	2	NUMBCO1 = general table number for the HTC BC for this outer surface at this axial level. NUMBCO2 = general table number for the sink temperature BC for this outer surface at this axial level.
Note: Input next Card only if IDBCON = 5 (**Card Set 4**) for this axial level.			
22	**TSURFO**	1	Outer surface temperature BC for this axial level.

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCON = 6 (**Card Set 4**) for this axial level.			
23	**HTCLIQO, HTCVAPO, HCOMON, HCELIO, HCELJO, HCELKO**	6	HTCLIQO: Outside surface HTC for the liquid phase. HTCVAPO: Outside surface HTC for the vapor phase. HCOMON: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELIO,HCEJO,HCELKO: i-,j-,k-cell number of the fluid cell of component HCOMON to which axial level of the HTSTR component is coupled. If HCOMON is a 1D fluid component, only HCELIO is used; it refers to the axial cell number in the fluid component. If NHCOMON refers to a 3D vessel, HCELIO refers to the radial cell number, HCELJO refers to the theta cell number, and HCELKO refers to the axial cell number. Note: use **s;** input no more than 5 numbers per card.
Note: Input next Card only if IDBCON = 7 (**Card Set 4**) for this axial level.			
24	**NUMBCO1**	1	Signal variable or control block id for the outer surface temperature BC for this axial level.

Card Set Number	Variable	Dimension	Description
Note: Input next Card only if IDBCON = 8, or 9 (**Card Set 4**) for this axial level.			
25	**NUMBCO1, HCOMON, HCELIO, HCELJO, HCELKO**	5	NUMBCO1: Signal variable or control block id for the outer surface heat transfer coefficient BC for this axial level if IDBCON = 8. NUMBCO1: Signal variable or control block id for the outer surface sink temperature BC for this axial level if IDBCON = 9. HCOMON: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELIO,HCEJO,HCELKO: i-,j-,k-cell number of the fluid cell of component HCOMON to which axial level of the HTSTR component is coupled. If HCOMON is a 1D fluid component, only HCELIO is used; it refers to the axial cell number in the fluid component. If HCOMON refers to a 3D vessel, HCELIO refers to the radial cell number, HCELJO refers to the theta cell number and HCELKO refers to the axial cell number.
Note: Input next Card only if IDBCON = 10 (**Card Set 4**) for this axial level.			
26	**NUMBCO1**	1	NUMBCO1: Signal variable or control block id for the outer surface heat flux BC for this axial level.
Note: Input next card set only if IDBCON = 11 (**Card Set 4**).			
27	**NUMBCO1**	1	Number of the general table for this surface boundary condition. IDBCON = 11 implies the general table will be for a surface wall temperature.
Note: Input next Card only if IDBCON = 12 (**Card Set 4**) for this axial level.			

REPEAT-HTSTR Component

Card Set Number	Variable	Dimension	Description
28	**NUMBCO1, HCOMON, HCELIO, HCELJO, HCELKO**	5	NUMBCO1: General table number for the outer surface HTC BC for this axial level. HCOMON: Component number of the hydraulic cell to which the axial level of the HTSTR component is coupled. HCELIO,HCEJO,HCELKO: i-,j-,k-cell number of the fluid cell of component HCOMON to which axial level of the HTSTR component is coupled. If HCOMON is a 1D fluid component, only HCELIO is used; it refers to the axial cell number in the fluid component. If HCOMON refers to a 3D vessel, HCELIO refers to the radial cell number, HCELJO refers to the theta cell number and HCELKO refers to the axial cell number.

JETP Component Data

When this component is used, more than one cell should be used to model the jet pump throat region. If only one cell is used, the code may significantly under-estimate the total core flow.

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (JETP left justified).
NUM	Component ID number (must be unique for each component, 1 ≤ NUM ≤ 999).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2A14) **EOS, PHASECHANGE**

Note: Only input this card when the number of inputs for FLUIDS (a NAMELIST variable) is more than one.

Variable	Description
EOS	EOS identifier for this component (i.e. “h2o” or “r5h2o”, etc.).
PHASECHANGE	Phase change flag. Input TRUE or true, if phase change is allowed for this component. Input FALSE or false, if phase change is not allowed for this component.

Card Number 3. (Format 3I14,2E14.4) **JCELL, NODES, ICHF, COST, EPSW**

Variable	Description
JCELL	Main-tube cell number that has the side tube connected to it.
NODES	Number of radial heat-transfer nodes in the wall. A value of zero specifies no wall heat transfer.

Card Number 3. (Format 3I14,2E14.4) **JCELL, NODES, ICHF, COST, EPSW** (Continued)

Variable	Description
ICHF	CHF-calculation option. 0 = convection heat transfer only, no boiling heat transfer (i.e. no wall nucleation is allowed although phase change can still occur); 1 = CHF from AECL-IPPE CHF Table, no critical quality calculated. 2 = CHF from AECL-IPPE CHF Table, critical quality from Biasi correlation. 3 = CHF from AECL-IPPE CHF Table, critical quality from CISE-GE correlation.
COST	Cosine of the angle from the low-numbered cell portion of the main tube to the side tube.
EPSW	Wall surface roughness (m, ft).

Card Number 4. (Format 5I14) **ICONC1, NCELL1, JUN1, JUN2, IPOW1**

Variable	Description
ICONC1	Solute in the main-tube coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC1 > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.
NCELL1	Number of fluid cells in the main tube.
JUN1	Junction number for the junction interface adjacent to cell 1.
JUN2	Junction number for the junction interface adjacent to cell NCELL1.
IPOW1	Power-to-the-fluid option in the main tube. 0 = no; 1 = yes.

Card Number 5. (Format 5I14) **IPWTR1, IPWSV1, NPWTB1, NPWSV1, NPWRF1**

Variable	Description
Note: If IPOW1 = 0 (Word 5 on **Card Number 4**), do not input this card.	
IPWTR1	Trip ID number that controls evaluation of the power-to-the-fluid table defined by **Card Set 50** (array POWTB1) for the main tube (|IPWTR1| ≤ 9999). [Input IPWTR1 = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation].
IPWSV1	The independent-variable ID number for the power-to-the-fluid table for the main tube. IPWSV1 > 0 defines the ID number for a signal-variable parameter; IPWSV1 < 0 defines the ID number for a control-block output parameter.
NPWTB1	The number of power-to-the-fluid table data pairs for the main tube (defined by the absolute value of NPWTB1). NPWTB1 > 0 defines the table independent-variable form to be the IPWSV1 parameter; NPWTB1 < 0 defines the table independent-variable form to be the sum of the change in the IPWSV1 parameter each last timestep times the trip set-status value ISET during that timestep (when the power-to-the-fluid table is trip controlled); NPWTB1 = 0 defines the power to the fluid to be the IPWSV1 parameter.
NPWSV1	The independent-variable ID number for the rate factor that is applied to the main-tube power-to-the-fluid table independent variable. NPWSV1 > 0 defines the ID number for a signal-variable parameter; NPWSV1 < 0 defines the ID number for a control-block output parameter; NPWSV1 = 0 (when NPWRF1 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-fluid table is trip controlled.
NPWRF1	The number of rate-factor table data pairs (defined by the absolute value of NPWRF1). The rate factor is applied as a factor to the main-tube power-to-the-fluid table independent variable when the rate factor is defined. No rate factor is defined when NPWSV1 and NPWRF1 are both zero. NPWRF1 > 0 defines the rate-factor table independent variable to be the NPWSV1 parameter; NPWRF1 < 0 defines it to be the sum of change in the NPWSV1 parameter over each timestep times the trip set-status value ISET during the timestep (when the main-tube power-to-the-fluid table is trip controlled); NPWRF1 = 0 defines the rate factor to be the NPWSV1 parameter.

JETP Component Data

Card Number 6. (Format 5I14) **IQPTR1, IQPSV1, NQPTB1, NQPSV1, NQPRF1**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 41**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Variable	Description
IQPTR1	Trip ID number that controls evaluation of the power-to-the-wall table defined by **Card Set 52** (array QP3TB1) for the main tube (|IQPTR1| ≤ 9999). [Input IQPTR1 = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation].
IQPSV1	The independent-variable ID number for the main-tube power-to-the-wall table. IQPSV1 > 0 defines the ID number for a signal-variable parameter; IQPSV1 < 0 defines the ID number for a control-block output parameter.
NQPTB1	The number of power-to-the-wall table data pairs for the main tube (defined by the absolute value of NQPTB1). NQPTB1 > 0 defines the table independent-variable form to be the IQPSV1 parameter; NQPTB1 < 0 defines the table independent-variable form to be the sum of the change in the IQPSV1 parameter over each timestep times the trip set-status value ISET during each timestep (when the power-to-the-wall table is trip controlled); NQPTB1 = 0 defines the power to the wall to be the IQPSV1 parameter.
NQPSV1	The independent-variable ID number for the rate factor that is applied to the main-tube power-to-the-wall table independent variable. NQPSV1 > 0 defines the ID number for a signal-variable parameter; NQPSV1 < 0 defines the ID number for a control-block output parameter; NQPSV1 = 0 (when NQPRF1 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-wall table is trip controlled.
NQPRF1	The number of rate-factor table data pairs (defined by the absolute value of NQPRF1). The rate factor is applied as a factor to the main-tube power-to-the-wall table independent variable when the rate factor is defined. No rate factor is defined when NQPSV1 and NQPRF1 are both zero. NQPRF1 > 0 defines the rate-factor table independent variable to be the NQPSV1 parameter; NQPRF1 < 0 defines it to be the sum of the change in the NQPSV1 parameter over each timestep times the trip set-status value ISET during that timestep (when the main-tube power-to-the-wall table is trip controlled); NQPRF1 = 0 defines the rate factor to be the NQPSV1 parameter.

Card Number 7. (Format 5E14.4) **RADIN1, TH1, HOUTL1, HOUTV1, TOUTL1**

Variable	Description
Note:	The four parameters, HOUTL, HOUTV, TOUTL, and TOUTV, allow flexibility in calculating possible heat losses from the outside of the main-tube wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.
RADIN1	Inner radius (m, ft) of the main-tube wall.
TH1	Wall thickness (m, ft) of the main tube.
HOUTL1	Heat-transfer coefficient (HTC) [W/(m^2 K), Btu/(ft^2 °F hr)] between outer boundary of the main-tube wall and the liquid outside the main-tube wall.
HOUTV1	HTC [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the main-tube wall and the gas outside the main-tube wall.
TOUTL1	Liquid temperature (K, °F) outside the main-tube wall.

Card Number 8. (Format 5E14.4) **TOUTV1, PWIN1, PWOFF1, RPWMX1, PWSCL1**

Variable	Description
TOUTV1	Gas temperature (K, °F) outside the main-tube wall.
PWIN1	Initial total power (W, Btu/hr) deposited in (to) the main-tube fluid [not used when IPOW1 = 0 (Word 5 on **Card Number 4**)]. The power is distributed uniformly along the JETP main-tube length.
PWOFF1	Total power (W, Btu/hr) to the main-tube fluid when the controlling trip is OFF after being ON [not used if IPOW1 = 0 (Word 5 on **Card Number 4**) or IPWTR1 = 0 (Word 1 on **Card Number 5**)]. If PWOFF1 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr), the power to the fluid is held constant at the last table-evaluated power when the trip was ON.
RPWMX1	The maximum rate of change of the main-tube power to the fluid [W/s, (Btu/hr)/s] [RPWMX1 $\geq$ 0.0 W/s {0.0 (Btu/hr)/s}] [not used if IPOW1 = 0 (Word 5 on **Card Number 4**)].

Card Number 8. (Format 5E14.4) **TOUTV1, PWIN1, PWOFF1, RPWMX1, PWSCL1** (Continued)

Variable	Description
PWSCL1	Scale factor (–) for the power-to-the-fluid table. The dependent variable in the table, defined by **Card Set 50** (array POWTB1), is multiplied by PWSCL1 to obtain absolute power (W, Btu/hr) deposited in the fluid [not used if IPOW1 = 0 (Word 5 on **Card Number 4**) or NPWTB1 = 0 (Word 3 on **Card Number 5**)].

Card Number 9. (Format 4E14.4, I14) **QPIN1, QPOFF1, RQPMX1, QPSCL1, NHCOM**

Variable	Description
Note:	If NODES = 0 (Word 2 on **Card Number 3**), do not input this card.
QPIN1	Initial power (W, Btu/hr) deposited in (to) the main-tube wall and distributed according to the QPPP array. If QPIN1 > 0.0, it is the total power to the entire wall. When QPIN1 < 0.0, the initial power to the wall in each cell is |QPIN1|, and the negative sign indicates the power to the wall is to be a cell-dependent array of NCELL1 (Word 2 on **Card Number 4**) power values. Each data pair of the power-to-the-wall table [for QPIN1 < 0.0] has 1 + NCELL1 values (an independent-variable value and NCELL1 power values for cells 1 through NCELL1). When the power-to-the-wall table is not being evaluated, the same power value of |QPIN1| or QPOFF1 [if QPOFF1 > -10^{19} W (-3.41×10^{19} Btu/hr)] is applied at each of the NCELL1 cells.
QPOFF1	Power (W, Btu/hr) to the main-tube wall when the controlling trip is OFF after being ON [not used if IQPTR1 = 0 (Word 1 on **Card Number 6**); use the last table-evaluated power when the trip was ON if QPOFF1 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr)].
RQPMX1	Maximum rate of change of the power to the wall for the main tube [W/s, (Btu/hr)/s] [RQPMX1 $\geq$ 0.0].
QPSCL1	Scale factor (–) for the power-to-the-wall table for the main tube. The dependent variable in the table defined by **Card Set 52** (array QP3TB1) is multiplied by QPSCL1 to obtain the absolute power (W, Btu/hr) to the wall.
NHCOM	Component number receiving outside wall energy.

Card Number 10. (Format 4I14) **ICONC2, NCELL2, JUN3, IPOW2**

Variable	Description
ICONC2	Solute in the side-tube coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC2 > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.
NCELL2	Number of fluid cells in the side tube.
JUN3	Junction number at the external-junction end of the side tube adjacent to cell NCELL2.
IPOW2	Power-to-the-fluid option in the side tube. 0 = no; 1 = yes.

Card Number 11. (Format 5I14) **IPWTR2, IPWSV2, NPWTB2, NPWSV2, NPWRF2**

Note: If IPOW2 = 0 (Word 4 on **Card Number 10**), do not input this card.

Variable	Description
IPWTR2	Trip ID number that controls evaluation of the power-to-the-fluid table defined by **Card Set 83** (array POWTB2) for the side tube (|IPWTR2| ≤ 9999). [input IPWTR2 = 0 if there is to be no trip control and the table is to be evaluated every timestep of the transient calculation].
IPWSV2	The independent-variable ID number of the power-to-the-fluid table for the side tube. IPWSV2 > 0 defines the ID number for a signal-variable parameter; IPWSV2 < 0 defines the ID number for a control-block output parameter.
NPWTB2	The number of power-to-the-fluid table data pairs for the side tube (defined by the absolute value of NPWTB2). NPWTB2 > 0 defines the table independent-variable form to be the IPWSV2 parameter; NPWTB2 < 0 defines the table's independent-variable form to be the sum of the change in the IPWSV2 para-meter over the last timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-fluid table is trip controlled); NPWTB2 = 0 defines the power to the fluid to be the IPWSV2 parameter.

Card Number 11. (Format 5I14) **IPWTR2, IPWSV2, NPWTB2, NPWSV2, NPWRF2** (Continued)

Variable	Description
	Note: If IPOW2 = 0 (Word 4 on **Card Number 10**), do not input this card.
NPWSV2	The independent-variable ID number for the rate factor that is applied to the side-tube power-to-the-fluid table independent variable. NPWSV2 > 0 defines the ID number for a signal-variable parameter; NPWSV2 < 0 defines the ID number for a control-block output parameter; NPWSV2 = 0 (when NPWRF2 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-fluid table is trip controlled.
NPWRF2	The number of rate-factor table data pairs (defined by the absolute value of NPWRF2). The rate factor is applied as a factor to the side-tube power-to-the-fluid table independent variable when the rate factor is defined. No rate factor is defined when NPWSV2 and NPWRF2 are both zero. NPWRF2 > 0 defines the rate-factor table independent variable to be the NPWSV2 parameter; NPWRF2 < 0 defines it to be the sum of the change in the NPWSV2 parameter over the last timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-fluid table is trip controlled); NPWRF2 = 0 defines the rate factor to be the NPWSV2 parameter.

Card Number 12. (Format 5I14) **IQPTR2, IQPSV2, NQPTB2, NQPSV2, NQPRF2**

Variable	Description
	Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 74**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.
IQPTR2	Trip ID number that controls evaluation of the power-to-the-wall table defined by **Card Set 85** (array QP3TB2) for the side tube (|IQPTR2| ≤ 9999). (Input IQPTR2 = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation).
IQPSV2	The independent-variable ID number for the side-tube power-to-the-wall table. IQPSV2 > 0 defines the ID number for a signal-variable parameter; IQPSV2 < 0 defines the ID number for a control-block output parameter.
NQPTB2	The number of power-to-the-wall table data pairs for the side tube (defined by the absolute value of NQPTB2). NQPTB2 > 0 defines the table independent-variable form to be the IQPSV2 parameter; NQPTB2 < 0 defines the table independent-variable form to be the sum of the change in the IQPSV2 parameter over each timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-wall table is trip controlled); NQPTB2 = 0 defines the power to the wall to be the IQPSV2 parameter.

Card Number 12. (Format 5I14) **IQPTR2, IQPSV2, NQPTB2, NQPSV2, NQPRF2** (Continued)

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 74**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Variable	Description
NQPSV2	The independent-variable ID number for the rate factor that is applied to the side-tube power-to-the-wall table independent variable. NQPSV2 > 0 defines the ID number for a signal-variable parameter; NQPSV2 < 0 defines the ID number for a control-block output parameter; NQPSV2 = 0 (when NQPRF2 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-wall table is trip controlled.
NQPRF2	The number of rate-factor table data pairs (defined by the absolute value of NQPRF2). The rate factor is applied as a factor to the side-tube power-to-the-wall table independent variable when the rate factor is defined. No rate factor is defined when NQPSV2 and NQPRF2 are both zero. NQPRF2 > 0 defines the rate-factor table independent variable to be the NQPSV2 parameter; NQPRF2 < 0 defines it to be the sum of the change in the NQPSV2 parameter over each timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-wall table is trip controlled); NQPRF2 = 0 defines the rate factor to be the NQPSV2 parameter.

Card Number 13. (Format 5E14.4) **RADIN2, TH2, HOUTL2, HOUTV2, TOUTL2**

Note: The four parameters, HOUTL2, HOUTV2, TOUTL2, and TOUTV2, allow flexibility in calculating possible heat losses from the outside of the side-tube wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
RADIN2	Inner radius (m, ft) of the side-tube wall.
TH2	Wall thickness (m, ft) of the side tube.
HOUTL2	Heat-transfer coefficient (HTC) [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the side-tube wall and the liquid outside the side-tube wall.
HOUTV2	HTC [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the side-tube wall and the gas outside the side-tube wall.

Card Number 13. (Format 5E14.4) **RADIN2, TH2, HOUTL2, HOUTV2, TOUTL2** (Continued)

Note:	The four parameters, HOUTL2, HOUTV2, TOUTL2, and TOUTV2, allow flexibility in calculating possible heat losses from the outside of the side-tube wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
TOUTL2	Liquid temperature (K, °F) outside the side-tube wall.

Card Number 14. (Format 5E14.4) **TOUTV2, PWIN2, PWOFF2, RPWX2, PWSCL2**

Variable	Description
TOUTV2	Gas temperature (K, °F) outside the side-tube wall.
PWIN2	Initial total power (W, Btu/hr) deposited in (to) the side-tube fluid [not used when IPOW2 = 0 (Word 4 on **Card Number 10**)]. The power is distributed uniformly along the side-tube length.
PWOFF2	Total power (W, Btu/hr) to the side-tube fluid when the controlling trip is OFF after being ON [not used when IPOW2 = 0 (Word 4 on **Card Number 10**) or IPWTR2 = 0 (Word 1 on **Card Number 11**)]. If PWOFF2 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr), the power to the fluid is held constant at the last table-evaluated power when the trip was ON.
RPWMX2	Maximum rate of change of the side-tube power to the fluid [W/s, (Btu/hr)/s] [RPWMX1 $\geq$ 0.0] [not used if IPOW2 = 0 (Word 4 on **Card Number 10**)].
PWSCL2	Scale factor (–) for the power-to-the-fluid table. The dependent variable in the table defined by **Card Set 77** (array POWTB2) is multiplied by PWSCL2 to obtain the absolute power (W, Btu/hr) to the fluid [not used if IPOW2=0 (Word 4 on **Card Number 10**) or NPWTB2 = 0 (Word 3 on **Card Number 11**)].

Card Number 15. (Format 4E14.4) **QPIN2, QPOFF2, RQPMX2, QPSCL2**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card.

Variable	Description
QPIN2	Initial power (W, Btu/hr) deposited in (to) the side-tube wall and distributed according to the QPPP array. If QPIN2 > 0.0, it is the total power to the entire wall. When QPIN2 < 0.0, the initial power to the wall in each cell is |QPIN2|, and the negative sign indicates the power to the wall is to be a cell-dependent array of NCELL2 (Word 2 on **Card Number 10**) power values. Each data pair of the power-to-the-wall table [for QPIN2 < 0.0] has 1+NCELL2 values (an independent-variable value and NCELL2 power values for cells 1 through NCELL2). When the power-to-the-wall table is not being evaluated, the same power value of |QPIN2| or QPOFF2 [if QPOFF2 > -10^{19} W (-3.41×10^{19} Btu/hr)] is applied at each of the NCELL2 cells.
QPOFF2	Power (W, Btu/hr) to the side-tube wall when the controlling trip is OFF after being ON [not used if IQPTR2 = 0 (Word 1 on **Card Number 11**); the last table-evaluated power when the trip was ON if QPOFF2 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr)].
RQPMX2	Maximum rate of change of the power to the wall for the side-tube [W/s, (Btu/hr)/s] [RQPMX2 $\geq$ 0.0].
QPSCL2	Scale factor (–) for the power-to-the-wall table for the side-tube. The dependent variable in table defined by **Card Set 85** (array QP3TB2) is multiplied by QPSCL2 to obtain the absolute power (W, Btu/hr) to the wall.

Card Number 16. (Format I14) **IENTRN**

Note: If NAMELIST variable IOFFTK = 0, do not input this card.

Variable	Description
IENTRN	Offtake-model option. 0 = off; 1 = on (side tube internal-junction mass flow determined using offtake model).

JETP Component Data

Card Number 17. (Format I14) **NJETP**

Variable	Description
NJETP	Number of actual jet pumps lumped together. The user inputs the geometry for a single pump.

Card Number 18. (Format 4E14.4) **EPSDFF, EPSDFR, EPSNZF, EPSNZR**

Variable	Description
EPSDFF	Relative form loss coefficient for diffuser forward flow. (Default = 5.5.)
EPSDFR	Relative form loss coefficient for diffuser reverse flow. (Default = 0.38.)
EPSNZF	Relative form loss coefficient for nozzle forward flow. (Default = 5.5.)
EPSNZR	Relative form loss coefficient for nozzle reverse flow. Note: The normal flow direction in the nozzle is reverse. (Default = 0.38.)

Card Number 19. (Format 2E14.4) **FINLET, FOTLET**

Variable	Description
FINLET	Form loss for positive suction flow. (Default = 0.04.)
FOTLET	Form loss for negative discharge flow. (Default = 0.45.)

JETP Array Cards

Note: Input each of the following arrays using LOAD format.

All junction variables must match at component interfaces.

Model no flow-area change between cell JCELL and cells JCELL±1 and between the internal-junction interface and the side-tube first cell. A VOL/DX flow-area change between cell JCELL and cells JCELL±1 and their interface FA and between side-tube cell 1 and the internal-junction interface will not have any evaluated effect on flow from the current JCELL-interface momentum equations evaluated by TRACE.

Primary Side Array Cards

Card Set Number	Variable	Dimension	Description
20	**DX**	NCELL1	Main-tube cell lengths (m, ft).
21	**VOL**	NCELL1	Main-tube cell volumes (m^3, ft^3).
22	**FA**	NCELL1+1	Main-tube cell-edge flow areas (m^2, ft^2).
23	**FRIC**	NCELL1+1	Main-tube additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
24	**FRICR**	NCELL1+1	Main-tube additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input.
25	**GRAV or ELEV**	NCELL1+1 (NCELL1 for ELEV)	Main-tube gravity or elevation terms [(– or m), (– or ft)]. GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.

Card Set Number	Variable	Dimension	Description
26	**HD**	NCELL1+1	Main-tube hydraulic diameters (m, ft). (See NAMELIST variable NDIA1 for additional input of heat-transfer diameters).
Note: If NAMELIST variable NDIA1 ≠ 2 do not input array HD-HT.			
27	**HD-HT**	NCELL1+1	Main-tube heat transfer diameters (m, ft).
Note: If NAMELIST variable ICFLOW = 0 or 1, do not input array ICFLG. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur...			
28	**ICFLG**	NCELL1+1	Main-tube cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.
29	**NFF**	NCELL1+1	Main-tube friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE.
Note: If NCCFL = 0 (Word 5 on **Main-Data Card 9**), do not input array LCCFL.			
30	**LCCFL**	NCELL1+1	Main-tube countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
31	**ALP**	NCELL1	Main-tube initial gas volume fractions (–).

Card Set Number	Variable	Dimension	Description
32	VL	NCELL1+1	Main-tube initial liquid velocities (m/s, ft/s).
33	VV	NCELL1+1	Main-tube initial gas velocities (m/s, ft/s).
34	TL	NCELL1	Main-tube initial liquid temperatures (K, °F).
35	TV	NCELL1	Main-tube initial gas temperatures (K, °F).
36	P	NCELL1	Main-tube initial pressures (Pa, psia).
37	PA	NCELL1	Main-tube initial noncondensable-gas partial pressures (Pa, psia).
Note: If NAMELIST variable NOLT1D = 1 do not input array ILEV.			
38	ILEV	NCELLS	Level tracking flags. ILEV = 1 indicates that the two-phase level exists in the current cell. ILEV = 0 indicates that the two-phase level does not exist in the current cell. If ILEV = -1, the level tracking calculation will be turned off for this cell.
Note: If NAMELIST variable MWFL = 0, do not input array WFMFL.			
39	WFMFL	NCELL1+1	Main-tube wall-friction multiplier factor for the liquid phase (0.9 ≤ WFMFL ≤ 1.1).
Note: If NAMELIST variable MWFV = 0, do not input array WFMFV			
40	WFMFV	NCELL1+1	Main-tube wall-friction multiplier factor for the gas phase (–) (0.9 ≤ WFMFL ≤ 1.1).
Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input arrays QPPP, MATID, TW, IDROD, and NHCEL.			
41	QPPP	NODES × NCELL1	A relative power shape (–) in the main-tube wall. Input values for cell 1, node 1 through NODES; then cell 2, node 1 through NODES; etc. If the array is filled with the same nonzero constant, a uniform volumetric heat source in the wall results. TRACE internally normalizes the power shape to have a volume-averaged value of unity {each QPPP(I) is normalized to have the value QPPP(I) × [Σ_K VOL(K)]/{Σ_K QPPP(K) × VOL(K)]}. Filling the array with zeros results in no power being deposited in the wall regardless of the value of QPIN1, QPTB1, etc.

JETP Component Data

Card Set Number	Variable	Dimension	Description
42	MATID	NODES-1	Wall-material ID array, which specifies material ID between radial nodes. Dimension is 1 if NODES = 1. 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 12 = inconel, type 600.
43	TW	NODES × NCELL1	Initial wall temperatures (K, °F) in the main tube, which are input in the same order as QPPP.
Note: If NHCOM > 0 (Word 5 on **Card Number 9**) input IDROD.			
44	IDROD	1	Vessel radial-theta cell number or input 0 when NHCOM is a 1D component.
Note: If NHCOM>0 (Word 5 on **Card Number 9**) input NHCEL.			
45	NHCEL	NCELL1	Connecting axial cell numbers in component NHCOM.
Note: If ICONC1 = 0 (Word 1 on **Card Number 4**), do not input array CONC.			
46	CONC	NCELL1	Initial solute mass to liquid-coolant mass ratio [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)] in the main tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: If ICONC1 = 0 or 1 (Word 1 on **Card Number 4**), do not input array S.			
47	S	NCELL1	Initial macroscopic density of plated-out solute (kg/m^3, lb_m/ft^3) in the main tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
48	XGNB	NCELL1	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).

Card Set Number	Variable	Dimension	Description
Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
49	**XLNB**	NCELL1	Mass fraction for liquid trace species.
Note: If IPOW1 = 0 (Word 5 on **Card Number 4**), do not input array POWTB1.			
50	**POWTB1**	2×|NPWTB1|	Power-to-the-fluid vs independent-variable-form table [(*,W) (*, Btu/hr)] for the main tube. Input |NPWTB1| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IPWSV1 (Word 2 on **Card Number 5**), power to the fluid]. The power is deposited directly into the main-tube fluid with a uniform power density along the main-tube length.
Note: If IPOW1 = 0 (Word 5 on **Card Number 4**), do not input array POWRF1.			
51	**POWRF1**	2×|NPWRF1|	Rate-factor table (*,–) for the main-tube power-to-the-fluid table independent variable. Input |NPWRF1| (Word 5 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by NPWSV1 (Word 4 on **Card Number 5**), rate factor to be applied to the power-to-the-fluid table independent variable].
Note: If NQPTB1 = 0 (Word 3 on **Card Number 6**) or if NODES = 0 (Word 2 on **Card Number 3**), do not input array QP3TB1.			
52	**QP3TB1**	2× |NQPTB1| when QPIN1 > 0.0; (1+NCELL1) ×|NQPTB1| when QPIN1 < 0.0.	Power-to-the-wall independent-variable-form table [(*,W) (*, Btu/hr)] for the main tube. Input |NQPTB1| (Word 3 on **Card Number 6**) table-defining data pairs having the following form [independent-variable form defined by IQPSV1 (Word 2 on **Card Number 6**), power to the wall]. If QPIN1 > 0.0, the dependent variable specifies the total power to the entire wall; if QPIN1 < 0.0, the dependent variable is a power shape that specifies the power to the wall at each cell from cell 1 to NCELL1.

Side Arm Array Cards

Note: If NCELL2 = 0 (Word 2 on **Card Number 10**), only input FA, FRIC, GRAV, HD, NFF, LCCFL, VL, and VV array cards.

Card Set Number	Variable	Dimension	Description
53	**DX**	NCELL2	Side-tube cell lengths (m, ft).
54	**VOL**	NCELL2	Side-tube cell volumes (m^3, ft^3).
55	**FA**	NCELL2+1	Side-tube cell-edge flow areas (m^2, ft^2).
56	**FRIC**	NCELL2+1	Side-tube additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input. Input FRIC > 0.0 for internal-junction interface 1 of the side tube when a VOL/DX flow-area change occurs between JCELL and cell 1 of the side tube.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
57	**FRICR**	NCELL2+1	Side-tube additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input. Input FRICR > 0.0 for internal-junction interface 1 of the side tube when a VOL/DX flow-area change occurs between JCELL and cell 1 of the side tube.
58	**GRAV or ELEV**	NCELL2+1 (NCELLS for ELEV)	Side-tube gravity elevation terms [(– or m), (– or ft)]. GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.
59	**HD**	NCELL2+1	Side-tube hydraulic diameters (m, ft) (see NAMELIST variable NDIA1 for additional input of heat-transfer diameters).
Note: If NAMELIST variable NDIA1 /= 2 do not input array HD-HT.			
60	**HD-HT**	NCELL2+1	Side-tube heat transfer diameters (m, ft).

Card Set Number	Variable	Dimension	Description
Note: If NAMELIST variable ICFLOW = 0 or 1, do not input array ICFLG.. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur..			
61	**ICFLG**	NCELL2+1	Side-tube cell-edge choked-flow model option. Cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.
62	**NFF**	NCELL2+1	Side-tube friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE. Input NFF $\geq$ 0 for the JCELL and JCELL+1 interfaces.
Note: If NCCFL = 0 (Word 5 **Main-Data Card 9**), do not input array LCCFL.			
63	**LCCFL**	NCELL2+1	Side-tube countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 $\leq$ N $\leq$ NCCFL (Word 5 on **Main-Data Card 9**)].
64	**ALP**	NCELL2	Side-tube initial gas volume fractions (–).
65	**VL**	NCELL2+1	Side-tube initial liquid velocities (m/s, ft/s).
66	**VV**	NCELL2+1	Side-tube initial gas velocities (m/s, ft/s).
67	**TL**	NCELL2	Side-tube initial liquid temperatures (K, °F).

JETP Component Data

Card Set Number	Variable	Dimension	Description
68	**TV**	NCELL2	Side-tube initial gas temperatures (K, °F).
69	**P**	NCELL2	Side-tube initial pressures (Pa, psia).
70	**PA**	NCELL2	Side-tube initial noncondensable-gas partial pressures (Pa, psia).
Note: If NAMELIST variable NOLT1D = 1 do not input array ILEV.			
71	**ILEV**	NCELL2	Level tracking flags. ILEV = 1.0 indicates that the two-phase level exists in the current cell. ILEV = 0.0 indicates that the two-phase level does not exist in the current cell. If ILEV = -1.0, the level tracking calculation will be turned off for this cell.
Note: If NAMELIST variable MWFL = 0, do not input array WFMFL.			
72	**WFMFL**	NCELL2+1	Side-tube wall-friction multiplier factor for the liquid phase (–) (0.9 ≤ WFMFL ≤ 1.1).
Note: If NAMELIST variable MWFV = 0, do not input array WFMFV.			
73	**WFMFV**	NCELL2+1	Side-tube wall-friction multiplier factor for the gas phase (–) (0.9 ≤ WFMFL ≤ 1.1).
Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input arrays QPPP, MATID, TW, IDROD, and NHCEL.			
74	**QPPP**	NODES × NCELL2	A relative power shape (–) in the side-tube wall. Input values for cell 1, node 1 through NODES; then cell 2, node 1 through NODES; etc. If the array is filled with the same nonzero constant, a uniform volumetric heat source in the wall results. TRACE internally normalizes the power shape to have a volume-average value of unity (each QPPP(I) is normalized to have the value QPPP(I) × [Σ_K VOL(K)]/[Σ_K QPPP(K) × VOL(K)]). Filling the array with zeros results in no power being deposited in the wall regardless of the values of QPIN2, QPTB2, etc.

Card Set Number	Variable	Dimension	Description
75	**MATID**	NODES-1	Wall-material ID array, which specifies material ID between radial nodes. Dimension is 1 if NODES = 1. 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 12 = inconel, type 600.
76	**TW**	NODES × NCELL2	Initial wall temperatures (K, °F) in the side tube, which are input in the same order as QPPP.
Note: If NHCOM > 0 (Word 5 on **Card Number 9**) then input array IDROD.			
77	**IDROD**	1	Vessel radial-theta cell number or input 0 when NHCOM is a 1D component.
Note: If NHCOM > 0 (Word 5 on **Card Number 9**) then input array NHCEL.			
78	**NHCEL**	NCELL2	Connecting axial cell numbers in component NHCOM.
Note: If ICONC2 = 0 (Word 1 on **Card Number 10**), do not input array CONC.			
79	**CONC**	NCELL2	Initial solute mass to liquid-coolant mass ratio [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)] in the side tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: If ICONC2 = 0 or 1 (Word 1 on **Card Number 10**), do not input array S.			
80	**S**	NCELL2	Initial macroscopic density of plated-out solute (kg/m^3, lb_m/ft^3) in the side tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
81	**XGNB**	NCELL2	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).

Card Set Number	Variable	Dimension	Description
Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
82	**XLNB**	NCELL2	Mass fraction for liquid trace species.
Note: If IPOW2 = 0 (Word 5 on **Card Number 10**), do not input array POWTB2.			
83	**POWTB2**	2×|NPWTB2|	Power-to-the-fluid vs. independent-variable-form table [(*,W), (*, Btu/hr)] for the side tube. Input |NPWTB2| (Word 3 on **Card Number 11**) table-defining data pairs having the following form [independent-variable form defined by IPWSV2 (Word 2 on **Card Number 11**), power to the fluid]. The power is deposited directly into the side-tube fluid with a uniform volumetric power density along the JETP side-tube length.
Note: If IPOW2 = 0 (Word 5 on **Card Number 10**), do not input array POWRF2.			
84	**POWRF2**	2×|NPWRF2|	Rate-factor table (*,–) for the side-tube power-to-the-fluid table independent variable. Input |NPWRF2| (Word 5 on **Card Number 11**) table-defining data pairs having the following form [independent-variable form defined by NPWSV2 (Word 4 on **Card Number 11**), rate factor to be applied to the power-to-the-fluid table independent variable].
Note: If NQPTB2 = 0 (Word 3 on **Card Number 12**) or if NODES = 0 (Word 2 on **Card Number 3**), do not input array QP3TB2.			
85	**QP3TB2**	2×|NQPTB2| when QPIN2>0.0; (1+NCELL2) ×|NQPTB2| when QPIN2<0.0.	Power-to-the-wall vs independent-variable form table [(*,W), (*, Btu/hr)] for the side tube. Input |NQPTB2| (Word 3 on **Card Number 12**) table-defining data pairs having the following form [independent-variable form defined by IQPSV2 (Word 2 on **Card Number 12**), power to the wall]. If QPIN2 > 0.0, the dependent variable specifies the total power to the entire wall; if QPIN2 < 0.0, the dependent variable is a power shape that specifies the power to the wall at each cell from cell NCELL1 + 2 to cell NCELL1 + 1 + NCELL2.

PIPE Component Data

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (PIPE left justified).
NUM	Component ID number (must be unique for each component, 1 ≤ NUM ≤ 999).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2A14) **EOS, PHASECHANGE**

Note: Only input this card when the number of inputs for FLUIDS (a NAMELIST variable) is more than one.

Variable	Description
EOS	EOS identifier for this component (i.e. “h2o” or “r5h2o”, etc.).
PHASECHANGE	Phase change flag. Input TRUE or true, if phase change is allowed for this component. Input FALSE or false, if phase change is not allowed for this component.

Card Number 3. (Format 4I14,E14.4) **NCELLS, NODES, JUN1, JUN2, EPSW**

Note: When NAMELIST parameter USESJC = 1, 2, or 3 NCELLS can be set to zero. When NCELLS = 0, the PIPE component is treated as a single junction (no volume but a junction). Then, the first four parameters of **Card Number 8** should be set to ‘0’, but NPIPES should be set to ‘1’. If USESJC=1, then NODES should be set to ‘0’

If JUN1 or JUN2 is set to zero, a deadend is created with flow area and velocities always set to zero

Variable	Description
NCELLS	Number of fluid cells in the PIPE component.

PIPE Component Data

Card Number 3. (Format 4I14,E14.4) **NCELLS, NODES, JUN1, JUN2, EPSW** (Continued)

Note: When NAMELIST parameter USESJC = 1, 2, or 3 NCELLS can be set to zero. When NCELLS = 0, the PIPE component is treated as a single junction (no volume but a junction). Then, the first four parameters of **Card Number 8** should be set to '0', but NPIPES should be set to '1'. If USESJC=1, then NODES should be set to '0'

If JUN1 or JUN2 is set to zero, a deadend is created with flow area and velocities always set to zero

Variable	Description
NODES	Number of radial heat-transfer nodes in the PIPE wall. A value of zero specifies no wall heat transfer.
JUN1	Junction number for the junction adjacent to cell 1.
JUN2	Junction number for the junction adjacent to cell NCELLS (Word 1 on this card).
EPSW	Wall-surface roughness (m, ft).

Card Number 4. (Format I14) **NSIDES**

Note: If NCELLS = 0 do not input this card. Input this card only if NAMELIST variable USESJC = 2 or 3. This will allow this component to have side junctions. See SJC model, Chapter 7.

Variable	Description
NSIDES	Number of side junctions connected to this PIPE component.

Note: If NSIDES > 0 then input the next three cards as sets of 1, 2, or 3 cards per NSIDES. Examples include:

If USESJC = 2 and JUNLK (Word 2 on **Card Number 5**) is > 0 only **Card Number 5** is needed.

If USESJC = 2 and JUNLK is 0 input **Card Number 5** and **Card Number 6** in pairs.

If USESJC = 3 and JUNLK > 0 input **Card Number 5** and **Card Number 7** in pairs.

If USESJC = 3 and JUNLK is 0 input **Card Number 5**, **Card Number 6**, and **Card Number 7** in sets.

Card Number 5. (Format 5I14) **NCLK, JUNLK, NCMPTO, NCLKTO, NLEVTO**

Note: If NCELLS or NSIDES = 0, or USESJC = 1 do not input this card. Otherwise input this card for each NSIDES.

Variable	Description
NCLK	"From" cell number in the PIPE component.
JUNLK	Junction number. Enter a zero to have the code spawn a Single Junction Component internally. Otherwise enter the junction number here. This same junction number must appear as a VESSEL source junction or a 1D component junction.
NCMPTO	Component number of "To" component of a leak path. Enter 0 if JUNLK ≠ 0.
NCLKTO	Cell number of "To" cell of a leak path Enter 0 if JUNLK ≠ 0.
NLEVTO	Axial level number of "To" cell of a leak path when "To" component is a VESSEL. Otherwise enter 0. Enter 0 if JUNLK ≠ 0.

Card Number 6. (Format 5E14.4) **FALK, CLOS, VLLK, VVLK, DELZLK**

Note: If NCELLS or NSIDES = 0 do not input this card. Input this card only if JUNLK = 0. If USESJC = 2 or 3, input this card for each NSIDES.

Variable	Description
FALK	Leak path flow area (m^2, ft^2).
CLOS	Leak path loss coefficient
VLLK	Leak path initial liquid velocity (m/s, ft/s).
VVLK	Leak path initial vapor velocity (m/s, ft/s).
DELZLK	Elevation difference between center of "From" cell and center of "To" cell (m, ft). DELZLK > 0 when the center of the "From" cell is higher than the center of the "To" cell DELZLK < 0 when the center of the "From" cell is lower than the center of the "To" cell

Card Number 7. (Format E14.4, I14) **THETA, IENTRN**

Note: If NCELLS or NSIDES = 0, or USESJC = 1 or 2 do not input this card.	
Variable	**Description**
THETA	Angle between the main direction of flow and the flow through the side junction.
IENTRN	Offtake-model option. 0 = off; 1 = on (side-junction mass flow determined using offtake model)

Card Number 8. (Format 5I14) **ICHF, ICONC, PIPETYPE, IPOW, NPIPES**

Note: If PIPETYPE= 1, the bulk of the tank should be modeled with one computational cell. One additional relatively small cell may be added at the bottom of the tank to improve the timing of release of nitrogen from the accumulator.	
Variable	**Description**
ICHF	CHF-calculation option. 0 = convection heat transfer only, no boiling heat transfer (i.e. no wall nucleation is allowed although phase change can still occur); 1 = CHF from AECL-IPPE CHF Table, no critical quality calculated. 2 = CHF from AECL-IPPE CHF Table, critical quality from Biasi correlation. 3 = CHF from AECL-IPPE CHF Table, critical quality from CISE-GE correlation.
ICONC	Solute in the liquid coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.

Card Number 8. (Format 5I14) **ICHF, ICONC, PIPETYPE, IPOW, NPIPES** (Continued)

Note: If PIPETYPE= 1, the bulk of the tank should be modeled with one computational cell. One additional relatively small cell may be added at the bottom of the tank to improve the timing of release of nitrogen from the accumulator.

Variable	Description
PIPETYPE	Pipe model option. 0 = normal pipe; no special model options; 1 = Accumulator (non-spherical) modeling option; calculate of water level, volumetric flow, and liquid volume discharge, and the implementation of an interface sharpener; 2 = same as (1) plus the application of a liquid-separator model at JUN2 (the gas phase is never allowed to flow across the JUN2 interface). Note that the PIPE representing the accumulator should be oriented such that JUN2 is the accumulator outlet junction. 3 = model pipe as a spherical accumulator. NCELLS (Word 1 on **Card Number 3**) must be set to one. 4 = model pipe as a CANDU horizontal pressure tube fuel bundle (not yet active) 5 = model falling film condensation heat transfer in vertical tube bundles 6 = model condensation phenomena in a suppression pool (not yet active) 7 = this PIPE is connected to HTSTR components that have the fine mesh model turned on. Setting this option will also indicate the existence of special optional input of importance to reflood calculations (see **Card Number 12**). 8 = model wall condensation phenomena as would be appropriate for a drywell
IPOW	Power deposited in (to) the coolant option. 0 = no; 1 = yes.
NPIPES	The number of parallel pipes of which this is one. Enter 1 for normal cases.

Card Number 9. (Format 5I14) **IPOWTR, IPOWSV, NPOWTB, NPOWSV, NPOWRF**

Variable	Description
	Note: If IPOW = 0 (Word 4 on **Card Number 8**), do not input this card.
IPOWTR	The trip ID number that controls the evaluation of the power-to-fluid table defined by **Card Set 46** (array POWTB) (|IPOWTR| ≤ 9999) (input IPOWTR = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation).
IPOWSV	The independent-variable ID number for the power-to-the-fluid table. IPOWSV > 0 defines the ID number for a signal-variable parameter; IPOWSV < 0 defines the ID number for a control-block output parameter.
NPOWTB	The number of power-to-the-fluid table data entries (defined by the absolute value of NPOWTB). NPOWTB > 0 defines the table independent-variable form to be the IPOWSV parameter; NPOWTB < 0 defines the table independent-variable form to be the sum of the change in the IPOWSV parameter over each timestep times the trip set-status value ISET during that timestep (when the power-to-the-fluid table is trip controlled); NPOWTB = 0 defines the power to the fluid to be the IPOWSV parameter.
NPOWSV	The independent-variable ID number for the rate factor that is applied to the power-to-the-fluid table independent variable. NPOWSV > 0 defines the ID number for a signal-variable parameter; NPOWSV < 0 defines the ID number for a control-block output parameter; NPOWSV = 0 (when NPOWRF ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-fluid table is trip controlled.
NPOWRF	The number of rate-factor table data pairs (defined by the absolute value of NPOWRF). The rate factor is applied to the power-to-the-fluid table independent variable when the rate factor is defined. No rate factor is defined when NPOWSV and NPOWRF are both zero. NPOWRF > 0 defines the rate-factor table independent variable to be the NPOWSV parameter; NPOWRF < 0 defines it to be the sum of the change in the NPOWSV parameter over each timestep times the trip set-status value ISET during that timestep (when the power-to-the-fluid table is trip controlled); NPOWRF = 0 defines the rate factor to be the NPOWSV parameter.

Card Number 10. (Format 5I14) **IQP3TR, IQP3SV, NQP3TB, NQP3SV, NQP3RF**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 37**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Variable	Description
IQP3TR	The trip ID number that controls the evaluation of the power-to-the-wall table defined by **Card Set 48** (array QP3TB) ($\|IQP3TR\| \leq 9999$) [input IQP3TR = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation].
IQP3SV	The independent-variable ID number of the power-to-the-wall table. IQP3SV > 0 defines the ID number for a signal-variable parameter; IQP3SV < 0 defines the ID number for a control-block output parameter.
NQP3TB	The number of power-to-the-wall table data pairs (defined by the absolute value of NQP3TB). NQP3TB > 0 defines the table independent-variable form to be the IQP3SV parameter; NQP3TB < 0 defines the table independent-variable form to be the sum of the change in the IQP3SV parameter over each timestep times the trip set-status value ISET during that timestep (when the power-to-the-wall table is trip controlled); NQP3TB = 0 defines the power to the wall to be the IQP3SV parameter.
NQP3SV	The independent-variable ID number for the rate factor that is applied to the power-to-the-wall table independent variable. NQP3SV > 0 defines the ID number for a signal-variable parameter; NQP3SV < 0 defines the ID number for a control-block output parameter; NQP3SV = 0 (when NQP3RF ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-wall table is trip controlled.
NQP3RF	The number of (x,y) rate-factor table data pairs (defined by the absolute value of NQP3RF). The rate factor is applied to the power-to-the-wall table independent variable when the rate factor is defined. No rate factor is defined when NQP3SV and NQP3RF are both zero. NQP3RF > 0 defines the rate-factor table independent variable to be the NQP3SV parameter; NQP3RF < 0 defines it to be the sum of the change in the NQP3SV parameter over each timestep times the trip set-status value ISET during that time (when the power-to-the-wall table is trip controlled); NQP3RF = 0 defines the rate factor to be the NQP3SV parameter.

Card Number 11. (Format I14) **NLLTB**

Note: Input this card only if PIPETYPE = 3 (Word 3 on **Card Number 8**).	
Variable	**Description**
NLLTB	The number of data pairs for the liquid volume fraction, liquid level fraction table.

Card Number 12. (Format I14, E14.4) **NGRIDSPACERS, UNHEATFR**

Note: Input this card only if PIPETYPE = 7 (Word 3 on **Card Number 8**).	
Variable	**Description**
NGRIDSPACERS	The number of grid spacers associated with this PIPE component.
UNHEATFR	Fraction of the HS surface that is not heated. Fraction of the HS surface that could support a liquid film even though the fuel rods are in post-CHF heat transfer regimes.

Card Number 13. (Format 5E14.4) **RADIN, TH, HOUTL, HOUTV, TOUTL**

Note: The four parameters, HOUTL, HOUTV, TOUTL, and TOUTV, allow flexibility in calculating possible heat losses from the outside of the PIPE wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.	
Variable	**Description**
RADIN	Inner radius (m, ft) of the PIPE wall.
TH	Wall thickness (m, ft).
HOUTL	Heat-transfer coefficient (HTC) (W/(m^2 K), Btu/(hr ft^2 °F)) between the outer boundary of the PIPE wall and the liquid outside the PIPE wall.
HOUTV	HTC (W/(m^2 K), Btu/(hr ft^2 °F)) between the outer boundary of the PIPE wall and the gas outside the PIPE wall.
TOUTL	Liquid temperature (K, °F) outside the PIPE wall.

Card Number 14. (Format 5E14.4) **TOUTV, POWIN, POWOFF, RPOWMX, POWSCL**

Variable	Description
TOUTV	Gas temperature (K, °F) outside the PIPE wall.
Note:	Words 2 - 5 are not used if IPOW = 0 (Word 4 on **Card Number 8**).
POWIN	Initial total power (W, Btu/hr) deposited in (to) the fluid. The power is distributed uniformly along the PIPE length.
POWOFF	Total power (W, Btu/hr) to the fluid when the controlling trip is OFF after being ON [not used when IPOWTR = 0 (Word 1 on **Card Number 9**)]. If POWOFF $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr), the power to the fluid is held constant at the last table-evaluated power when the trip was ON.
RPOWMX	The maximum rate of change of power to the fluid (W/s, Btu/(hr s)) [RPOWMX ≥ 0.0].
POWSCL	Scale factor (–) for the power-to-the-fluid table. The dependent variable in the table defined by **Card Set 46** (array POWTB) is multiplied by POWSCL to obtain the absolute power (W, Btu/hr) deposited in the fluid [not used if NPOWTB = 0 (Word 3 on **Card Number 9**)].

Card Number 15. (Format 4E14.4, I14) **QP3IN, QP3OFF, RQP3MX, QP3SCL, NHCOM**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card.

Variable	Description
QP3IN	Initial power (W, Btu/hr) deposited in (to) the wall and distributed according to the QPPP array. If QP3IN > 0.0, it is the total power to the entire wall. When QP3IN < 0.0, the power to the wall in each cell is |QP3IN|, and the negative sign indicates the power to the wall is to be a cell-dependent array of NCELLS (Word 1 on **Card Number 3**) power values. Each data pair of the power-to-the-wall table [for QP3IN < 0.0] has 1 + NCELLS values [an independent-variable value and NCELLS power values for cells 1 through NCELLS]. When the power-to-the-wall table is not being evaluated, the same power value of |QP3IN| or QP3OFF [if QP3OFF $> -10^{19}$ W (-3.41×10^{19} Btu/hr)] is applied at each of the NCELLS cells.
QP3OFF	Power (W, Btu/hr) to the wall when the controlling trip is OFF after being ON [not used when IQP3TR = 0; use the last table-evaluated power when the trip was ON if QP3OFF $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr)].

Card Number 15. (Format 4E14.4, I14) **QP3IN, QP3OFF, RQP3MX, QP3SCL, NHCOM** (Continued)

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card.	
Variable	**Description**
RQP3MX	Maximum rate of change of the power to the wall [W/s, Btu/(hr s)] [RQP3MX ≥ 0.0)].
QP3SCL	Scale factor (–) for the power-to-the-wall table. The dependent variable in the table, defined by **Card Set 48** (array QP3TB), is multiplied by QP3SCL to obtain the absolute power (W, Btu/hr) to the wall.
NHCOM	Component number the outside wall energy is delivered to.

PIPE Array Cards.

Note: Input each of the following arrays using LOAD format.

All junction variables must match at component interfaces.

Card Set Number	**Variable**	**Dimension**	**Description**
16	**DX**	NCELLS	Cell lengths (m, ft).
17	**VOL**	NCELLS	Cell volumes (m^3, ft^3).
18	**FA**	NCELLS+1	Cell-edge flow areas (m^2, ft^2).
Note: Setting FRIC > 10^{20} at a cell edge invokes the steam-separator model (only the gas phase is allowed to flow through the cell interface). Setting FRIC < -10^{20} invokes the liquid-separator model (only the liquid is allowed to flow through the cell interface). If the reverse additive loss-coefficient option (NFRC1 = 2 in the NAMELIST data) is chosen, steam-separator and liquid-separator models may be used separately in each forward and reverse direction.			
19	**FRIC**	NCELLS+1	Additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
20	**FRICR**	NCELLS+1	Additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input.

Card Set Number	Variable	Dimension	Description
21	**GRAV or ELEV**	NCELLS+1 (NCELLS for ELEV)	Gravity or elevation terms (– or m, ft). GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.
22	**HD**	NCELLS+1	Hydraulic diameters (m, ft).
Note: If NAMELIST variable NDIA1 ≠ 2 do not input array HD-HT.			
23	**HD-HT**	NCELLS+1	Heat transfer diameters (m, ft).
Note: If NAMELIST variable ICFLOW = 0 or 1 do not input array ICFLG. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur..			
24	**ICFLG**	NCELLS+1	Cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.
25	**NFF**	NCELLS+1	Friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE.

Card Set Number	Variable	Dimension	Description
Note: If NCCFL = 0 (Word 5 on **Main-Data Card 9**), do not input array LCCFL.			
26	**LCCFL**	NCELLS+1	Countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
27	**ALP**	NCELLS	Initial gas volume fractions (–).
28	**VL**	NCELLS+1	Initial liquid velocities (m/s, ft/s).
29	**VV**	NCELLS+1	Initial gas velocities (m/s, ft/s).
30	**TL**	NCELLS	Initial liquid temperatures (K, °F).
31	**TV**	NCELLS	Initial gas temperatures (K, °F).
32	**P**	NCELLS	Initial pressures (Pa, psia).
33	**PA**	NCELLS	Initial noncondensable-gas partial pressures (Pa, psia).
Note: If NAMELIST variable NOLT1D = 1 do not input array ILEV.			
34	**ILEV**	NCELLS	Level tracking flags. ILEV = 1 indicates that the two-phase level exists in the current cell. ILEV = 0 indicates that the two-phase level does not exist in the current cell. If ILEV = -1, the level tracking calculation will be turned off for this cell.
Note: If NAMELIST variable MWFL = 0, do not input array WFMFL.			
35	**WFMFL**	NCELLS+1	Wall-friction multiplier factor for the liquid phase (–) [0.9 ≤ WFMFL ≤ 1.1].
Note: If NAMELIST variable MWFV = 0, do not input array WFMFV.			
36	**WFMFV**	NCELLS+1	Wall-friction multiplier factor for the gas phase (–) [0.9 ≤ WFMFL ≤ 1.1].

Card Set Number	Variable	Dimension	Description
Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input arrays QPPP, MATID, TW, IDROD, and NHCEL.			
37	**QPPP**	NODES × NCELLS	A relative power profile (–) in the PIPE wall. Input values for cell 1, node 1 through NODES; then for cell 2, node 1 through NODES, etc. If the array is filled with the same nonzero constant, a uniform volumetric heat source in the wall results. TRACE internally normalizes the power profile to have a volume-averaged value of unity (each QPPPP(I) is normalized to have the value QPPP(I) × [VOL(K)] / [QPPP(K) × VOL(K)]. Filling the array with zeros results in no power being deposited in the PIPE wall regardless of the values of QP3IN, QP3TB, etc.
38	**MATID**	NODES–1	Wall-material ID array, which specifies material ID between radial nodes. Dimension is 1 if NODES = 1. 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 12 = inconel, type 600.
39	**TW**	NODES × NCELLS	Initial wall temperatures (K, °F) (input in the same order as QPPP).
Note: If NHCOM = 0; (Word 5 on **Card Number 15**) do not input array IDROD**.**			
40	**IDROD**	1	Vessel radial-theta cell number or input 0 when NHCOM is a 1D component.
Note: If NHCOM = 0; (Word 5 on **Card Number 15**) do not input array NHCEL.			
41	**NHCEL**	NCELLS	Connecting axial cell numbers in component NHCOM
Note: If ICONC = 0 (Word 2 on **Card Number 8**), do not input array CONC.			
42	**CONC**	NCELLS	Initial ratio of solute mass to liquid-coolant mass [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)]. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).

Card Set Number	Variable	Dimension	Description
Note: If ICONC = 0 or 1 (Word 2 on **Card Number 8**), do not input array S.			
43	**S**	NCELLS	Initial macroscopic density of plated-out solute (kg/m^3, lb_m/ft^3). Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
44	**XGNB**	NCELLS	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).
Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
45	**XLNB**	NCELLS	Mass fraction for liquid trace species.
Note: If IPOW = 0 (Word 4 on **Card Number 8**), do not input array POWTB.			
46	**POWTB**	2×|NPOWTB|	Power-to-the-fluid vs. independent-variable-form table [(*,W) (*, Btu/hr). Input |NPOWTB| (Word 3 on **Card Number 9**) table-defining data pairs having the following form [independent-variable form defined by IPOWSV (Word 2 on **Card Number 9**), power to the fluid]. The power is deposited directly in to the fluid in the PIPE with a uniform power density along the PIPE length.
Note: If IPOW = 0 (Words 4 on **Card Number 8**), do not input array POWRF.			
47	**POWRF**	2×|NPOWRF|	Rate-factor table (*,–) for the power-to-the-fluid table independent variable. Input |NPOWRF| (Word 5 on **Card Number 9**) table-defining data pairs having the following form [independent-variable form defined by NPOWSV (Word 4 on **Card Number 9**), rate factor to be applied to the power-to-the-fluid table independent variable].

Card Set Number	Variable	Dimension	Description
Note: If NQP3TB = 0 (Word 3 on **Card Number 10**), do not input array QP3TB.			
48	**QP3TB**	2 × |NQP3TB| when QP3IN > 0.0; (1+NCELLS) × |NQP3TB| when QP3IN < 0.0.	Power-to-the-wall vs independent-variable-form table [(*,W), (*,Btu/hr)]. Input |NQP3TB| (Word 3 on **Card Number 10**) table-defining data pairs having the following form [independent-variable form defined by IQP3SV (Word 2 on **Card Number 10**), power to the wall]. If QP3IN > 0.0, the dependent variable specifies the total power to the entire wall; if QP3IN < 0.0, the dependent variable is a power distribution that specifies the power to the wall at each cell from cell 1 to cell NCELLS.
Note: Input array LEVTB only if PIPETYPE = 3 (Word 3 on **Card Number 8**). PIPTETYPE = 3 designates a one celled spherical accumulator. A table of liquid volume fraction, liquid level fraction pairs is input. NLLTB is the number of data pairs for that table.			
49	**LEVTB**	2 × NLLTB	NLLTB pairs of accumulator liquid volume fraction versus liquid level fraction.
Note: Input array GRIDSPACERZ only if PIPETYPE = 7 (Word 3 on **Card Number 8**) and NGRIDSPACERS > 0 (Word 1 on **Card Number 12**).			
50	**GRIDSPACERZ**	NGRIDSPACERS	Grid spacer axial locations.

PLENUM Component Data

Note: No heat-transfer coupling of a **HTSTR ROD** and **SLAB** component to the hydraulic cell of a **PLENUM** component is allowed. **FILL**, **BREAK**, and **VESSEL** components cannot be connected to a **PLENUM** component junction.

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (PLENUM left justified).
NUM	Component ID number (must be unique for each component, 1 ≤ NUM ≤ 999).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 4I14) **NPLJN, ICONC, JUNS1, JUNS2**

Variable	Description
NPLJN	Number of junction interfaces on the boundary of the single-cell PLENUM component (NPLJN ≥ 1).
ICONC	Solute in the liquid coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.
JUNS1	The number of junctions on side 1 of the PLENUM cell that convect momentum across the cell [side 1 junctions are the first to the JUNS1th junction numbers; input 0 if no momentum is to be convected across the PLENUM cell].
JUNS2	The number of junctions on side 2 of the PLENUM cell that convect momentum across the cell [side 2 junctions are on the opposite side of the PLENUM cell from side 1 and the side 2 junctions are the (JUNS1 + 1)th to the (JUNS1 + JUNS2)th junction numbers; input 0 if no momentum is to be convected across the PLENUM cell and JUNS1 = 0].

PLENUM Array Cards.

Note: Input each of the following arrays using LOAD format.

Card Set Number	Variable	Dimension	Description
3	**JUNJ**	NPLJN	PLENUM junction numbers (–).
4	**DX**	NPLJN	Effective PLENUM cell length for each junction connected to the PLENUM cell (m, ft).
5	**VOL**	1	Cell volume (m^3, ft^3).
6	**ELEV**	1	Cell-centered elevation (m, ft). Used only when NAME-LIST variable IELV = 1. However, this Card Set must always be input.
7	**ALP**	1	Initial gas volume fraction (–).
8	**TL**	1	Initial liquid temperature (K, °F).
9	**TV**	1	Initial gas temperature (K, °F).
10	**P**	1	Initial pressure (Pa, psia).
11	**PA**	1	Initial noncondensable-gas partial pressure (Pa, psia).
Note: If ICONC = 0 (Word 2 on **Card Number 2**), do not input array BOR.			
12	**BOR**	1	Initial ratio of solute mass to liquid-coolant mass [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)]. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: If ICONC = 0 or 1 (Word 2 on **Card Number 2**), do not input array SOLID.			
13	**SOLID**	1	Initial macroscopic density of plated-out solute (kg/m^3, lb_m/ft^3). Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).

Card Set Number	Variable	Dimension	Description
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
14	**XGNB**	NCELLS	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).
Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
15	**XLNB**	NCELLS	Mass fraction for liquid trace species.

POWER Component Data

A sample input file which uses the POWER component is found at the end of the HTSTR component (see **HTSTR Component Data**)

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (POWER left justified).
NUM	Component ID number (must be unique for each component, $1 \leq \text{NUM} \leq 999$).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 5I14) **NUMPWR, CHANPOW, NGTPOW, NSVPOW, NCBPOW**

Variable	Description
NUMPWR	Number of HTSTR/CHAN components for which the power distribution is input by this POWER component.
CHANPOW	Power-to-component coupling flag 0 = POWER component powers HTSTR component (Default value). 1 = POWER component powers CHAN components.
NGTPOW	Number of general power/reactivity tables used to specify the power/reactivity versus time for this POWER component.
NSVPOW	Number of signal variables used to specify the power/reactivity versus time for this POWER component.
NCBPOW	Number of control blocks used to specify the power/reactivity versus time for this POWER component.

Card Set Number	Variable	Dimension	Description
3	**HTNUM**	NUMPWR	Component numbers of the HTSTR/CHAN components for which power distribution is being input by this POWER component. If all of the HTSTR/CHAN components powered by this POWER component have the same geometry, noding, and material types, then only one set of power distributions (i.e. RDPWR, ZPWTB, etc.) are expected in this input. If any one of the HTSTR/CHAN components have different geometry or noding or material type, then each radial and axial power distribution must be input for each HTSTR/CHAN component identified in this list. TRACE searching through the list of components in the HTNUM array to determine if geometry, noding, and material types are the same or different.

Card Number 4. (Format 5I14) **IRPWTY, NDGX, NDHX, NRTS, NHIST**

Variable	Description
IRPWTY	Neutronic point-reactor kinetics or reactor-core power option for defining programmed reactivity (–) or reactor-core power (W, Btu/hr). Input parameters required for each option value are shown in parentheses. **Add 10** to the value of IRPWTY if reactivity feedback is to be evaluated. For IRPWTY = 15, 16, or 17, reactivity feedback is evaluated and output but not used because the reactor-core power is being defined directly. 1 = point-reactor kinetics with constant REACT programmed reactivity (requires RPOWRI and REACT); 2 = point-reactor kinetics with table lookup of programmed reactivity (requires RPOWRI, IRPWSV, NRPWTB, and RPWTB); 3 = point-reactor kinetics with an initial zero programmed reactivity and trip-initiated constant REACT programmed reactivity (requires RPOWRI, IRPWTR, and REACT); 4 = point-reactor kinetics with an initial constant REACT programmed reactivity and trip-initiated table lookup of programmed reactivity (requires RPOWRI, REACT, IRPWTR, IRPWSV, NRPWTB, and RPWTB); 5 = constant reactor-core power (requires RPOWRI); 6 = table lookup of reactor-core power (requires IRPWSV, NRPWTB, and RPWTB) 7 = initial constant reactor-core power with trip-initiated table lookup of reactor-core power (requires RPOWRI, IRPWTR, IRPWSV, NRPWTB, and RPWTB).
NDGX	The number of delayed-neutron groups (if NDGX = 0 is input when IRPWTY = 1, 2, 3, 4, 11, 12, 13, or 14, TRACE defaults to 6 delayed-neutron groups with the delayed-neutron constants defined internally; input NDGX = 0 when IRPWTY = 5, 6, 7, 15, 16, or 17).

POWER Component Data

Card Number 4. (Format 5I14) **IRPWTY, NDGX, NDHX, NRTS, NHIST** (Continued)

Variable	Description
NDHX	The number of decay-heat groups. Input any positive value other than 69 or 71 for NDHX when the TRACE user wishes to specify their own decay-heat parameters. The options shown below for NDHX are available to define internal decay heat data. [For IRPWTY = 5, 6, 7, 15, 16, or 17: input NDHX = 0] 69 = define the ANS-79 decay-heat standard 71 = define the ANS-79 decay-heat standard plus the heavy-element decay for U^{239} and Np^{239} -11 = define the ANS-73 11 decay-heat group that was the default in TRAC-P/MOD1. -23 = define the ANS-79 decay-heat standard using only U^{235} data -25 = define the ANS-79 decay-heat standard using only U^{235} data plus the heavy-element decay for U^{239} and Np^{239} -92 = define the ANS-94 decay-heat standard -94 = define the ANS-94 decay-heat standard plus the heavy-element decay for U^{239} and Np^{239}
NRTS	The number of timesteps between file output edits of the reactor-core power and reactivity-feedback changes to the **trcout** file (NRTS = 10, default).
NHIST	The number of value pairs in the power-history table. NHIST = 0 when IRPWTY = 5, 6, 7, 15, 16, or 17. 0 = the user will input the delayed-neutron precursor concentrations (CDGN) and the decay-heat precursor concentrations (CDHN); **WARNING**: This option will result in power jumps at restart unless you are very careful with input of CDGN. 1 = CDGN and CDHN will be calculated assuming an infinite history of operation at the user input power level of RPOWRI; $\geq$2 = a power history table will be input and used to calculate initial values for CDGN and CDHN.

Card Number 5. (Format 5E14.4) **Q235, Q239, Q238, QAVG, R239PF**

Note: If IRPWTY = 1, 2, 3, 4, 11, 12, 13, or 14 (Word 1 on **Card Number 4**) and NDHX = 69 or 71 or <0 (but not –11) (Word 3 on **Card Number 4**), input **Card Number 5** through **Card Number 7**.

Variable	Description
Q235	Energy per fission from U^{235} (Mev per fission).

Card Number 5. (Format 5E14.4) **Q235, Q239, Q238, QAVG, R239PF** (Continued)

Note:	If IRPWTY = 1, 2, 3, 4, 11, 12, 13, or 14 (Word 1 on **Card Number 4**) and NDHX = 69 or 71 or <0 (but not –11) (Word 3 on **Card Number 4**), input **Card Number 5** through **Card Number 7**.
Variable	**Description**
Q239	Energy per fission from Pu^{239} (Mev per fission).
Q238	Energy per fission from U^{238} (Mev per fission).
QAVG	Average energy per fission (Mev per fission).
R239PF	Atoms of U^{239} produced per fission.

Card Number 6. (Format 4E14.4) **FISPHI, RANS, FP235, FP238**

Note:	It is assumed that FP235 + FP238 + FP239 = 1.0. FP235 and FP238 are used only if NHIST < 2 (Word 5 on **Card Number 4**).
Variable	**Description**
FISPHI	Fissions per initial fissile atom.
RANS	Multiplier (–) applied to the ANS 79 decay heat (RANS = 1.0, default).
FP235	Fraction of fission power (–) associated with U^{235} fissions at time zero.
FP238	Fraction of fission power (–) associated with U^{238} fissions at time zero.

Card Number 7. (Format 3E14.4) **Q241, FP239, FP241**

Note:	If NAMELIST variable R5dh = 0, do not input this Card.
Variable	**Description**
Q241	Energy per fission from Pu^{241} (Mev per fission).
FP239	Fraction of fission power (–) associated with Pu^{239} fissions at time zero.
FP241	Fraction of fission power (–) associated with Pu^{241} fissions at time zero.

POWER Component Data

Card Number 8. (Format 5I14) **IRPWTR, IRPWSV, NRPWTB, NRPWSV, NRPWRF**

Note:	If IRPWTY = 1, 5, 11, or 15 (Word 1 on **Card Number 4**), do not input this Card.

Variable	Description
IRPWTR	The trip ID number which controls the evaluation of the reactivity-power table ($0 < \|IRPWTR\| \leq 9999$ when IRPWTY = 3, 4, 7, 13, 14, or 17; IRPWTR = 0 otherwise).
IRPWSV	The reactivity-power table's abscissa-coordinate variable ID number. IRPWSV defines the independent-variable parameter for the reactivity-power table. IRPWSV > 0 defines the ID number for a signal-variable parameter; IRPWSV < 0 defines the ID number for a control-block output parameter ($0 < \|IRPWSV\| \leq 9999$ when IRPWTY = 2, 4, 6, 7, 12, 14, 16, or 17; IRPWSV = 0 otherwise).
NRPWTB	The number of reactivity-power table value pairs (defined by the absolute value of NRPWTB). NRPWTB > 0 defines the table's independent-variable form to be the IRPWSV parameter; NRPWTB < 0 defines the reactivity-power table independent-variable form to be the sum of the change in the IRPWSV parameter over each timestep times the trip set-status value ISET during that timestep (when the reactivity-power table is trip controlled); NRPWTB = 0 defines the reactivity-power table's reactivity or power to be the IRPWSV parameter.
NRPWSV	The rate-factor table's abscissa-coordinate variable ID number. NRPWSV defines the independent-variable parameter to determine the rate factor that is applied to the reactivity-power table's independent variable. NRPWSV > 0 defines the ID number for a signal-variable parameter; NRPWSV < 0 defines the ID number for a control-block output parameter; NRPWSV = 0 (when NRPWRF ≠ 0) defines the difference between the trip signal and the set-point value that turns the trip OFF when the reactivity-power table is trip controlled.
NRPWRF	The number of rate-factor table value pairs (defined by the absolute value of NRPWRF). The rate factor is applied to the reactivity-power table's independent variable when the rate factor is defined. No rate factor is defined when NRPWSV and NRPWRF (Words 4 and 5 on this Card) are both zero. NRPWRF > 0 defines the rate-factor table's abscissa coordinate to be the NRPWSV parameter; NRPWRF < 0 defines it to be the sum of the change in the NRPWSV parameter over each timestep times the trip set-status value ISET during that timestep (when the reactivity-power table is trip controlled); NRPWRF = 0 defines the rate factor to be the NRPWSV parameter.

Card Number 9. (Format 5I14) **IZPWTR, IZPWSV, NZPWTB, NZPWSV, NZPWRF**

Variable	Description
IZPWTR	The trip ID number that controls the evaluation of the axial-power-shape table ($0 < \|IZPWTR\| \leq 9999$) (input IZPWTR = 0 when the evaluation of the axial power-shape table is not trip controlled).
IZPWSV	The axial-power-shape table's abscissa-coordinate variable ID number. IZPWSV defines the independent variable-parameter for the axial-power-shape table. IZPWSV > 0 defines the ID number for a signal-variable parameter; IZPWSV < 0 defines the ID number for a control-block output parameter.
NZPWTB	The number of axial-power-shape table (x, f(z) shape) value pairs (defined by the absolute value of NZPWTB). Each pair consists of an abscissa-coordinate value x and NZPWZ (Word 1 on **Card Number 11**) ordinate-coordinate values of f(z) defining the axial-power shape. NZPWTB > 0 defines the table's independent-variable form to be the IZPWSV parameter; NZPWPB < 0 defines the axial-power-shape table independent-variable form to be the sum of the change in the IZPWSV parameter over each timestep times the trip set-status value ISET during that timestep (when the axial-power-shape table is trip controlled).
NZPWSV	The rate-factor table's abscissa-coordinate variable ID number. NZPWSV defines the independent-variable parameter to determine the rate factor that is applied to the axial-power-shape table's independent variable. NZPWSV > 0 defines the ID number for a signal-variable parameter; NZPWSV < 0 defines the ID number for a control-block output parameter; NZPWSV = 0 (when NZPWRF ≠ 0) defines the difference between the trip signal and the set-point value that turns the trip OFF when the axial-power-shape table is trip controlled.
NZPWRF	The number of rate-factor table value pairs (defined by the absolute value of NZPWRF). The rate factor is applied to the axial-power-shape table's independent variable when the rate factor is defined. No rate factor is defined when NZPWSV and NZPWRF (Words 4 and 5 on this Card) are both zero. NZPWRF > 0 defines the rate-factor table's abscissa coordinate to be the NZPWSV parameter; NZPWRF < 0 defines it to be the sum of the change in the NZPWSV parameter over each timestep times the trip set-status value ISET during that timestep (when the axial-power-shape table is trip controlled); NZPWRF = 0 defines the rate factor to be the NZPWSV parameter

Card Number 10. (Format 2I14,3E14) **IPWRAD, IPWDEP, PROMHEAT, DECAHEAT, WTBYPASS**

Variable	Description
IPWRAD	Spatial power-shape option. 0 = 1D axial power-shape table (default); 1 = 2D axial-r or axial-x power-shape table.
IPWDEP	Power-shape table-dependence option. -1 = the power-shape table dependence is defined for each node by a signal-variable or control-block identification number which defines the node power density and the resulting power shape is not normalized by TRACE to a spatially averaged value of unity; 0 = the power-shape table dependence is defined by signal-variable or control-block identification number IZPWSV (Word 2 on **Card Number 9**) (default); 1 = the power-shape table dependence is defined for each node by a signal-variable or control-block identification number which defines the node power density and the resulting power shape is normalized by TRACE to a spatially averaged value of unity.
PROMHEAT	Fraction of prompt fission power applied directly to moderator. ($0.0 \leq$ PROMHEAT ≤ 1.0)
DECAHEAT	Fraction of decay power applied directly to moderator. ($0.0 \leq$ DECAHEAT $\leq$ 1.0)
WTBYPASS	Fraction of the moderator heating that appears in the bypass. ($0.0 \leq$ WTBYPASS ≤ 1.0)

Card Number 11. (Format 5I14) **NZPWZ, NZPWI, NFBPWT, NRPWR, NRPWI**

Variable	Description
NZPWZ	Number of axial locations defining the axial-power shape (NZPWZ = 2); if NZPWZ < 2 is input, NZPWZ is redefined to be NZHTSTR or 0 if NZHTSTR = 0 (NZHTSTR is Word 1 on **Card Number 2** of HTSTR input) and **Card Set 27** (array ZPWZT) is not input.

Card Number 11. (Format 5I14) **NZPWZ, NZPWI, NFBPWT, NRPWR, NRPWI** (Continued)

Variable	Description
NZPWI	Axial-power shape integration option for the heat-transfer calculation. -1 = histogram with step changes at the axial locations defined by **Card Set 27** (array ZPWZT); 0 = histogram with step changes midway between the axial locations defined by ZPWZT; 1 = trapezoidal integration [with linear variation between the axial-power shape densities defined by **Card Set 29** (array ZPWTB) at the axial locations defined by ZPWZT].
NFBPWT	Option for replacing the radial, axial, and/or horizontal-plane power shapes with another user-defined shape for volume averaging the reactivity-feedback parameters over the core region. (Add 1 for defining radial (if HSCYL=1) or thickness (if HSCYL=0) shape, 2 for defining an axial shape, and 4 for defining a (r,θ) or (x,y) plane shape. For example, if radial and axial shapes are to be defined, a value of 3 (sum of 1 and 2) will be input).
NRPWR	Number of radial (if HSCYL=1) or thickness (if HSCYL=0) locations defining the 2D axial-r or axial-x power shape if IPWRAD = 1 (Word 1 on **Card Number 10**) and NRPWR >1; if IPWRAD = 1 and NRPWR < 2, the same definition applies and NRPWR is redefined to be NODES (Word 2 on **Card Number 9** of input for component number HTNID), array RPWRT (**Card Set 28**) is not input, and array RADRD (**Card Set 41** of input for component number HTNID) defines array RPWRT. If IPWRAD = 0, a 1D axial power shape and a 1D radial or Cartesian power shape are input, NRPWR is redefined by TRACE to be 1, and array RPWRT is not input.
NRPWI	Radial (if HSCYL=1) or thickness (if HSCYL=0) power-shape integration option for the heat-transfer calculation when IPWRAD = 1 (Word 1 on **Card Number 10**). -1 = histogram with step changes at the radial or thickness locations defined by array RPWRT (**Card Set 28**); 0 = histogram with step changes midway between the radial or thickness locations defined by array RPWRT; 1 = trapezoidal integration with linear variation between the radial or Cartesian geometry power-shape densities defined by array ZPWTB (**Card Set 29**) at the radial or thickness locations defined by array RPWRT.

POWER Component Data

Card Number 12. (Format 5E14) **REACT, TNEUT, RPWOFF, RRPWMX, RPWSCL**

Variable	Description
REACT	Initial programmed reactivity (–) (IRPWTY = 1, 2, 4, 11, 12, 14) or trip-initiated programmed reactivity (–) (IRPWTY = 3 or 13) (REACT = ρ_{PROG} = $(K_{eff} - 1)\ K_{eff}^{-1}$, where K_{eff} is the reactor-multiplication constant; both ρ_{PROG} and K_{eff} have no units).
TNEUT	The prompt-neutron lifetime (s) (TNEUT = 0.0 s defaults internally to TNEUT = 1.625×10^{-5} s).
RPWOFF	Programmed reactivity (–) (IRPWTY = 3, 4, 13, 14] or reactor-core power (W, Btu/hr) (IRPWTY = 7 or 17) when the reactivity/power controlling trip is OFF after being ON; the last value when the trip was ON is held constant when RPWOFF = -1.0×10^{19} W (-3.4121×10^{19} Btu/hr).
RRPWMX	The maximum rate of change of programmed reactivity (1/s) or reactor power [W/s, (Btu/hr)/s].
RPWSCL	Reactivity-power table's scale factor for programmed reactivity (–) or reactor-core power (–). The dependent variable in the table **Card Set 32** (array RPWTBR or RPWTBP) is multiplied by RPWSCL to obtain its absolute value of programmed reactivity (–) or reactor-core power (W, Btu/hr).

Card Number 13. (Format 4E14.4) **RPOWRI, ZPWIN, ZPWOFF, RZPWMX**

Variable	Description
RPOWRI	Initial total reactor-core power (W, Btu/hr) of the average HTSTR elements linked to this POWER component.
ZPWIN	The axial-power-shape table's abscissa-coordinate variable value (*) corresponding to the initial axial-power shape.
ZPWOFF	The axial-power-shape table's abscissa-coordinate variable value (*) corresponding to the axial-power shape to be used when the axial-power-shape table's controlling trip is OFF after being ON; use the last evaluated axial-power shape when the trip was ON when ZPWOFF = -1.0×10^{19} (*).
RZPWMX	The maximum rate of change of any z-location value in the axial-power shape (1/s).

Card Number 14. (Format 4E14.4) **EXTSOU, PLDR, PDRAT, FUCRAC**.

Variable	Description
EXTSOU	The fission power (W, Btu/hr) produced by external source neutrons in the reactor core (used only when the point-reactor kinetics equations are evaluated: IRPWTY = 1, 2, 3, 4, 11, 12, 13, or 14).
PLDR	Pellet-dish radius (m, ft) [no calculation of pellet dishing is performed if PLDR = 0.0 m (0.0 ft)] (currently not used in subroutine FRODN).
PDRAT	Element pitch-to-diameter (if hscyl=1) or element pitch-to-thickness ratio (if hscyl=0) (–) (currently not used in subroutines CHEN and CHF).
FUCRAC	Fraction of the fuel (–) which is not cracked [used only when NFCI = 1 (Word 2 on **Card Number 4** of HTSTR input)].

Note: If reactivity feedback is not evaluated, i.e., when IRPWTY < 11 (Word 1 on **Card Number 4**), do not input **Card Number 15** to **Card Number 21**.

Card Number 15. (Format 5I14) (**IRCJTB**(I,1), I = (1, 4)), **IBU**(1).

Note: This card defines the fuel-temperature reactivity-coefficient table.	
Variable	**Description**
IRCJTB(1,1)	The number of fuel-temperature T_f-dependent entries in the fuel temperature reactivity-coefficient table.
IRCJTB(2,1)	The number coolant-temperature T_c-dependent entries in the fuel temperature reactivity-coefficient table.
IRCJTB(3,1)	The number of gas volume-fraction α-dependent entries in the fuel temperature reactivity-coefficient table.
IRCJTB(4,1)	The number of solute-mass B_r or B_m-dependent entries in the fuel temperature reactivity-coefficient table.

POWER Component Data

Card Number 15. (Format 5I14) (**IRCJTB**(I,1), I = (1, 4)), **IBU**(1). (Continued)

Note: This card defines the fuel-temperature reactivity-coefficient table.	
Variable	**Description**
IBU(1)	The solute-units definition index for the fuel temperature reactivity coefficient: IBU(J) = –2 if $x = B_r$ and $B = B_r$, IBU(J) = –1 if $x = B_r$ and $B = B_m$, IBU(J) = 0 if $x = B_m$ and $B = B_r$, IBU(J) = 1 if $x = B_m$ and $B = B_m$, where $\partial K_{eff}/\partial x = fcn(T_f,T_c,\alpha,B)$. The two solute-mass concentrations are: B_m density which is the mass of solute in the coolant-channel volume (kg/ m^3, lb_m/ft^3) and B_r ratio which is the parts solute mass per million parts liquid-coolant mass (ppm).

Card Number 16. (Format 5I14) (**IRCJTB**(I,2), I = (1, 4)), **IBU**(2)

Note: This card defines the coolant-temperature reactivity-coefficient table.	
Variable	**Description**
IRCJTB(1,2)	The number of fuel-temperature T_f-dependent entries in the coolant temperature reactivity-coefficient table.
IRCJTB(2,2)	The number coolant-temperature T_c-dependent entries in the coolant temperature reactivity-coefficient table.
IRCJTB(3,2)	The number of gas volume-fraction α-dependent entries in the coolant temperature reactivity-coefficient table.
IRCJTB(4,2)	The number of solute-mass B_r or B_m-dependent entries in the coolant temperature reactivity-coefficient table.
IBU(2)	The solute-units definition index for the coolant temperature reactivity coefficient: IBU(J) = –2 if $x = B_r$ and $B = B_r$, IBU(J) = –1 if $x = B_r$ and $B = B_m$, IBU(J) = 0 if $x = B_m$ and $B = B_r$, IBU(J) = 1 if $x = B_m$ and $B = B_m$, where $\partial K_{eff}/\partial x = fcn(T_f,T_c,\alpha,B)$. The two solute-mass concentrations are: B_m density which is the mass of solute in the coolant-channel volume (kg/m^3, lb_m/ft^3) and B_r ratio which is the parts solute mass per million parts liquid-coolant mass (ppm).

Card Number 17. (Format 5I14) (**IRCJTB**(I,3), I = (1, 4)), **IBU**(3)

Note: This card defines the gas volume-fraction/moderator density reactivity-coefficient table.

Variable	Description
IRCJTB(1,3)	The number of fuel-temperature T_f-dependent entries in the gas volume fraction/moderator density reactivity-coefficient table.
IRCJTB(2,3)	The number coolant-temperature T_c-dependent entries in the gas volume fraction/moderator density reactivity-coefficient table.
IRCJTB(3,3)	The number of gas volume-fraction α-dependent entries in the gas volume fraction/moderator density reactivity-coefficient table [1 _ IRCJTB(3,3)].
IRCJTB(4,3)	The number of solute-mass B_r or B_m-dependent entries in the gas volume fraction/moderator density reactivity-coefficient table [1 _ IRCJTB(4,3)].
IBU(3)	The solute-units definition index for the Jth reactivity coefficient: IBU(J) = –2 if $x = B_r$ and $B = B_r$, IBU(J) = –1 if $x = B_r$ and $B = B_m$, IBU(J) = 0 if $x = B_m$ and $B = B_r$, IBU(J) = 1 if $x = B_m$ and $B = B_m$, where $\partial K_{eff}/\partial x = fcn(T_f,T_c,\alpha,B)$. The two solute-mass concentrations are: B_m density which is the mass of solute in the coolant-channel volume (kg/m^3, lb$_m$/ft^3) and B_r ratio which is the parts solute mass per million parts liquid-coolant mass (ppm).

Card Number 18. (Format 5I14) (**IRCJTB**(I,4), I = (1, 4)), **IBU**(4)

Note: This card defines the solute-mass concentration reactivity-coefficient table.

Variable	Description
IRCJTB(1,4)	The number of fuel-temperature T_f-dependent entries in the solute-mass concentration reactivity-coefficient table.
IRCJTB(2,4)	The number coolant-temperature T_c-dependent entries in the solute-mass concentration reactivity-coefficient table.
IRCJTB(3,4)	The number of gas volume-fraction α-dependent entries in the solute-mass concentration reactivity-coefficient table.

Card Number 18. (Format 5I14) (**IRCJTB**(I,4), I = (1, 4)), **IBU**(4) (Continued)

Note: This card defines the solute-mass concentration reactivity-coefficient table.	
Variable	**Description**
IRCJTB(4,4)	The number of solute-mass B_r or B_m-dependent entries in the solute-mass concentration reactivity-coefficient table.
IBU(4)	The solute-units definition index for the Jth reactivity coefficient: IBU(J) = –2 if $x = B_r$ and $B = B_r$, IBU(J) = –1 if $x = B_r$ and $B = B_m$, IBU(J) = 0 if $x = B_m$ and $B = B_r$, IBU(J) = 1 if $x = B_m$ and $B = B_m$, where $\partial K_{eff}/\partial x = fcn(T_f,T_c,\alpha,B)$. The two solute-mass concentrations are: B_m density which is the mass of solute in the coolant-channel volume (kg/m^3, lb_m/ft^3) and B_r ratio which is the parts solute mass per million parts liquid-coolant mass (ppm).

Card Number 19. (Format 3I14) (**IFBTYP**(J), J = (1, 3))

Note: If NAMELIST variable R5fdbk = 0, do not input this Card.	
Variable	**Description**
IFBTYP(1)	Units definition index for the dependent variable fuel temperature. (For now, only IFBTYP(1) = 0 is allowed)
IFBTYP(2)	Units definition index for the dependent variable moderator temperature. IFBTYP(2) = 0 is used to define void-weighted moderator temperature. IFBTYP(2) = 1 is used to define liquid moderator temperature.
IFBTYP(3)	Units definition index for the dependent variable moderator density. IFBTYP(3) = 0 is used to define void fraction. IFBTYP(3) = 1 is used to define void-weighted moderator density.

Card Number 20. (Format 5I14) **IRCJFM**(J), J = (1, 4), **ISNOTB**

Note: The reactivity-coefficient type form numbers are defined as follows: IRCJFM(J) = 0 for $\partial K_{eff}/\partial x$, IRCJFM(J) = 1 for $(1/K_{eff}) \bullet \partial K_{eff}/\partial x$, IRCJFM(J) = 2 for $x\, \partial K_{eff}/\partial x$, and IRCJFM(J) = 3 for $(x/K_{eff}) \bullet \partial K_{eff}/\partial x$, where $x = T_f$ for J = 1, $x = T_c$ for J = 2, $x = \alpha$ for J = 3, and $x = B_m$ [when IBU(4) = (0, 1)] or $x = B_r$ [when IBU(4) = (–2, –1)] for J = 4.	
Variable	**Description**
IRCJFM(1)	Form number for the fuel-temperature reactivity-coefficient type.
IRCJFM(2)	Form number for the coolant-temperature reactivity-coefficient type.
IRCJFM(3)	Form number for the gas volume-fraction reactivity-coefficient type.
IRCJFM(4)	Form number for the solute-mass concentration reactivity-coefficient type.
ISNOTB	Option to exclude burnable-poison pin and control-rod boron from the solute reactivity-feedback calculation. 0 = no (the solute is assumed to be orthoboric acid); 1 = yes.

Card Number 21. (Format 5E14.4) **POWEXP, BPP0, BPP1, BCR0, BCR1**

Variable	**Description**
POWEXP	Exponent value (–) to which the cell values of the power distribution are raised in defining the weighting factor for volume averaging the reactivity-feedback parameters over the powered reactor-core region (suggested value: 2.0).
BPP0	Zero-order coefficient (kg/m^3, lb$_m$/ft^3) of the first-order polynomial B_{mBPP} = BPP0 + BPP1 x T_c that defines the effective (smeared and shielded) core-averaged concentration of burnable-poison pin boron in the coolant-channel volume.
BPP1	First-order coefficient [kg/(m^3 K), lb$_m$/(ft^3 °F)] of the first-order polynomial B_{mBPP} = BPP0 + BPP1 x T_c that defines the effective (smeared and shielded) core-averaged concentration of burnable-poison pin boron in the coolant-channel volume. T_c is the core-averaged coolant temperature (K, °F).

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Card Number 21. (Format 5E14.4) **POWEXP, BPP0, BPP1, BCR0, BCR1** (Continued)

Variable	Description
BCR0	Zero-order coefficient (kg/m^3, lb_m/ft^3) of the first-order polynomial B_{mBCR} = BCR0 + BCR1 x ρ_{PROG} that defines the effective (smeared and shielded) core-averaged concentration of control-rod pin boron in the coolant-channel volume.
BCR1	First-order coefficient (kg/m^3, lb_m/ft^3) of the first-order polynomial B_{mBCR} = BCR0 + BCR1 x ρ_{PROG} that defines the effective (smeared and shielded) core-averaged concentration of control-rod pin boron in the coolant-channel volume. ρ_{PROG} is programmed reactivity and has no units.

POWER Array Cards.

Use LOAD format. Each array has its element values defined by a Card Set of one or more cards.

In the following array cards, dimension NODES refers to the value of NODES for each of the HTSTR components linked to this POWER component. If the radial and axial noding and material IDs for each of the HS components linked to this POWER component are the same, then only one RDPWR and RS array must be input for this POWER component. If there is any variation for the radial and axial noding or for the material IDs for the HTSTR components linked to this POWER component, then the RDPWR and RS arrays must be repeated for each of the HS components linked to this POWER component.

Card Set Number	Variable	Dimension	Description
Note: If IPWRAD = 1 (Word 1 on **Card Number 10**) or CHANPOW = 1 (Word 2 on **Card Number 2**), do not input array RDPWR.			
22	**RDPWR**	NODES	Relative radial (if HSCYL=1) or thickness (if HSCYL=0) power-density distribution (–) at the node locations defined by array RADRD (**Card Set 41** of input for HTSTR). If there is variation in the HTSTR component radial or axial noding or material IDs associated with this POWER component, then this array input must be input for each of the HTSTR components associated with this POWER component.

Card Set Number	Variable	Dimension	Description
Note: If NFBPWT (Word 3 on **Card Number 11**) is 0, do not input array RS. If CHANPOW = 1 (Word 2 on **Card Number 2**), do not input array RS or array CPOWR			
23	**RS**	NODES	Relative radial (if HSCYL=1) or thickness (if HSCYL=0) power-density distribution (–) at the node locations defined by array RADRD that will be used to volume average the reactivity-feedback parameters over the powered-core region. If there is variation in the HTSTR component radial or axial noding or material IDs associated with this POWER component, then this array must be input for each of the HTSTR components associated with this POWER component.
24	**CPOWR**	NUMPWR	Relative power-density distribution (–) in the average (power) element of each of the NUMPWR HTSTR elements linked to the POWER component, and coupled by heat-transfer to the (r,θ) or (x,y) mesh cells of a VESSEL-component level or to one or more 1D hydraulic components.
Note: If NFBPWT (Word 3 on **Card Number 11**) is less than 4 or CHANPOW = 1 (Word 2 on **Card Number 2**), do not input array HS.			
25	**HS**	NUMPWR	Relative power-density distribution (–) in the average (power) element of each of the HTSTR elements linked to the POWER component, and coupled by heat-transfer to the (r,θ) or (x,y) mesh cell of a VESSEL-component level or to one or more 1D hydraulic components. This will be used to volume average the reactivity-feedback parameters over the powered-core region.
Note: If CHANPOW = 1 (Word 2 on **Card Number 2**), do not input array RPFK. Input an RPKF card for each of the NUMPWR components linked to this POWER component, which has NHOT(i) > 0			
26	**RPKF**	NHOT(i), where i=1 to NUMPWR.	Power-peaking factors (relative to the average (power) HTSTR element) for each of the NHOT(i) supplemental elements.

POWER Component Data

Card Set Number	Variable	Dimension	Description
Note: If NZPWZ < 2 (Word 1 on **Card Number 11**) from input or NZPWTB = 0 (Word 3 on **Card Number 9**), do not input array ZPWZT.			
27	**ZPWZT**	NZPWZ	The axial locations (m, ft) where the axial-power shape's relative power densities are defined [define ZPWZT(1) = Z(1) and ZPWZT(NZPWZ) = Z(NZHTSTR) in order to have the power distribution span the axial range over which the HTSTR-element node rows are defined. If there is variation in the HS component radial or axial noding or material IDs associated with this POWER component, then this array input must be input for each of the HS components associated with this POWER component.
Note: If IPWRAD = 0 (Word 1 on **Card Number 10**) or NRPWR < 2 (Word 4 on **Card Number 11**) or NZPWTB = 0 (Word 3 on **Card Number 9**), do not input array RPWRT.			
28	**RPWRT**	NRPWR	The radial (if HSCYL=1) or thickness (if HSCYL=0) locations (m, ft) where the power shape's relative power densities are defined [define RPWRT(1) = RADRD(1) and RPWRT(NRPWR) = RADRD(NODES) in order to have the power distribution span the radial or Cartesian range over which the HTSTR-element node rows are defined (**Card Set 41**, array RADRD)].If there is variation in the HS component radial or axial noding or material IDs associated with this POWER component, then this array input must be input for each of the HS components associated with this POWER component.

Card Set Number	Variable	Dimension	Description
Note: If NZPWTB = 0 (Word 3 on **Card Number 9**), do not input array ZPWTB.			
29	ZPWTB	(1+NZPWZ * NRPWR) * |NZPWTB| where NZPWZ is NZHTSTR if NZPWZ < 2 & NZPWI=0, and NZPWZ= NZHTSTR+1 if NZPWZ < 2 & NZPWI is not 0.	One-dimensional axial (if IPWRAD = 0, Word 1 on **Card Number 10**) or 2D axial-r or axial-x (if IPWRAD = 1) power-shape vs independent-variable form table (*, –). Input |NZPWTB| table-defining data pairs having the following form [independent-variable form defined by IZPWSV (Word 2 on **Card Number 9**), NZPWZ x NRPWR (Words 1 and 4 on **Card Number 11**) power-density values]. NRPWR = 1 when IPWRAD = 0. NZPWTB = 1 and the power-density values are real values of the signal-variable or control-block identification numbers that TRACE uses to define the actual power-density values when IPWDEP = ±1 (Word 2 on **Card Number 10**). The relative power densities defining the power shape are specified at the NZPWZ axial locations of the ZPWZT array defined by **Card Set 27** and at the NRPWR radial (if HSCYL=1) or thickness (if HSCYL=0) locations of the RPWRT array defined by **Card Set 28**. There are |NZPWTB| power shapes being input with an independent-variable value and NZPWZ x NRPWR power-density values for each shape. If there is variation in the HS component radial or axial noding or material IDs associated with this POWER component, then this array input must be input for each of the HS components associated with this POWER component.
Note: If NZPWTB = 0 (Word 3 on **Card Number 9**) or NZPWRF = 0 (Word 5 on **Card Number 9**), do not input array ZPWRF.			
30	ZPWRF	2 * |NZPWRF|	Rate-factor table (*,-) for the axial-power-shape table's independent variable. Input |NZPWRF| (Word 5 on **Card Number 9**) table-defining data pairs having the following form [independent-variable form defined by NZPWSV (Word 4 on **Card Number 9**), rate factor].

Card Set Number	Variable	Dimension	Description
Note: If IRPWTY = 1, 5, 11, or 15 (Word 1 on **Card Number 4**) or NFBPWT = 0, 1, 4, or 5 (Word 3 on **Card Number 11**), do not input array ZS.			
31	**ZS**	NZPWZ where NZPWZ is NZHTSTR if NZPWZ < 2 is input	Relative axial-power-shape density (–) used to volume average the reactivity-feedback parameters over the powered-core region. If IPWRAD = 1 (Word 4 on **Card Number 10**) and array ZS is input, array RS (**Card Set 23**) must be input as well. If there is variation in the HS component radial or axial noding or material IDs associated with this POWER component, then this array input must be input for each of the HS components associated with this POWER component.
Note: If IRPWTY = 1, 5, 11, or 15 (Word 1 on **Card Number 4**) or NRPWTB = 0 (Word 3 on **Card Number 8**), do not input array RPWTBR or RPWTBP.			
32	**RPWTBR or RPWTBP**	2*|NRPWTB|	Programmed-reactivity (–) or reactor-core power (W or Btu/hr) vs independent-variable form (*) table [(*,– or W), (*,– or Btu/hr)]. Input |NRPWTB| (Word 3 on **Card Number 8**) table-defining data pairs having the following form [independent-variable form defined by IRPWSV (Word 2 on **Card Number 8**), programmed reactivity or reactor power as defined by IRPWTY].
Note: If NRPWTB = 0 (Word 3 on **Card Number 8**) or NRPWRF = 0 (Word 5 on **Card Number 8**), do not input array RPWRF.			
33	**RPWRF**	2 * |NRPWRF|	Rate-factor table (*,–) for the programmed-reactivity or reactor-power table's independent variable. Input |NRPWRF| (Word 5 on **Card Number 8**) table-defining data pairs having the following form [independent-variable form defined by NRPWSV (Words 4 on **Card Number 8**), rate factor to be applied to the programmed-reactivity or reactor-power table's independent variable].

Card Set Number	Variable	Dimension	Description
Note:			If IRPWTY < 11 (Word 1 on **Card Number 4**), do not input arrays RCTF, RCTC, RCAL, and RCBM. See User's Guide Volume 2 - Chapter 2 for detailed explanations and examples of the reactivity-coefficient tables RCTF, RCTC, RCAL, and RCBM.
34	RCTF	IRCJTB(1,1) + IRCJTB(2,1) + IRCJTB(3,1) + IRCJTB(4,1) + (IRCJTB(1,1) * IRCJTB(2,1) * IRCJTB(3,1) * IRCJTB(4,1))	The fuel-temperature reactivity-coefficient table. Input IRCJTB(1,1) T_f values, IRCJTB(2,1) T_c values, IRCJTB(3,1) α values, IRCJTB(4,1) B_r or B_m values, and IRCJTB(1,1) x IRCJTB(2,1) x IRCJTB(3,1) x IRCJTB(4,1) fuel-temperature reactivity-coefficient values that define the four dimensionally dependent table. (Note: This table and the following three tables are **not** entered with two-value pairs as is done for the one dimensionally dependent tables.).
35	RCTC	IRCJTB(1,2) + IRCJTB(2,2) + IRCJTB(3,2) + IRCJTB(4,2) + (IRCJTB(1,2) * IRCJTB(2,2) * IRCJTB(3,2) * IRCJTB(4,2))	The coolant-temperature reactivity-coefficient table.

Card Set Number	Variable	Dimension	Description
36	**RCAL**	IRCJTB(1,3) + IRCJTB(2,3) + IRCJTB(3,3) + IRCJTB(4,3) + (IRCJTB(1,3) * IRCJTB(2,3) * IRCJTB(3,3) * IRCJTB(4,3))	The gas volume-fraction reactivity-coefficient table.
37	**RCBM**	IRCJTB(1,4) + IRCJTB(2,4) + IRCJTB(3,4) + IRCJTB(4,4) + (IRCJTB(1,4) * IRCJTB(2,4) * IRCJTB(3,4) * IRCJTB(4,4))	The solute-mass concentration reactivity-coefficient table.
Note: If IRPWTY = 5, 6, 7, 15, 16, or 17 (Word 1 on **Card Number 4**), do not input arrays BETA, LAMDA, CDGN, LAMDH, EDH, CDHN, and PHIST. If NDGX = 0 (Word 2 on **Card Number 4**), do not input arrays BETA and LAMDA. The default 6-group delayed-neutron constants will be defined internally by TRACE.			
38	**BETA**	NDGX	The effective delayed-neutron neutron fraction (–).
39	**LAMDA**	NDGX	The delayed-neutron decay constant (1/s).

Card Set Number	Variable	Dimension	Description
Note: If NDGX > 0 and NHIST = 0 (Words 2 and 5 on **Card Number 4**) input array CDGN.			
40	**CDGN**	NDGX	The delayed-neutron precursor power (W, Btu/hr).
Note: If NDHX < 0 or NDHX = 69 or 71 (Word 3 on **Card Number 4**), do not input arrays LAMDH and EDH. If NDHX = 0, the default 69-group decay-heat constants will be defined internally by TRACE. If NDHX = 69 or 71, the ANS 79 decay-heat constants will be defined internally by TRACE. If NDHX = -92 or -94, the ANS 94 decay heat constants will be defined internally by TRACE.			
41	**LAMDH**	NDHX	The decay-heat decay constant (1/s).
42	**EDH**	NDHX	The effective decay-heat energy fraction (–).
Note: If NHIST = 0 (Word 5 on **Card Number 4**), input array CDHN.			
43	**CDHN**	NDHX	The decay-heat precursor power (W, Btu/hr).
Note: If NHIST = 0 or 1 (Word 5 on **Card Number 4**), do not input array PHIST.			
44	**PHIST**	2 * NHIST	Power-history table [(s,W), (s, Btu/hr)]. Input NHIST (Word 5 on **Card Number 4**) table-defining data pairs having the following form [time at the start of the transient minus the past time, reactor-core prompt-fission power at that past time]. The first data pair should be for the power level at the start of the transient; that is, the time at the start of the transient minus the past time, which in this case is 0.0 s, with the time difference for subsequent data pairs being positive valued and increasing monotonically for each data pair.
Note: If NDHX ≠ (69, 71, -92, or -94) and NDHX > 0 or NHIST < 1 (Words 3 and 5 on **Card Number 4**), do not input arrays FP235AR and FP239AR. It is assumed that FP235AR(i) + FP239AR(i) + FP238AR(i) = 1.0.			
45	**FP235AR**	max (1,NHIST-1)	Fraction (–) of fission power associated with U^{235} fission during the power-history table interval from i to i+1.

Card Set Number	Variable	Dimension	Description
46	**FP239AR**	max (1,NHIST-1)	Fraction (–) of fission power associated with Pu^{239} fission during the power-history table interval from i to i+1.
Note: If NDHX ≠ (-92, or -94) and NDHX > 0 or NHIST < 1 (Words 3 and 5 on **Card Number 4**), do not input arrays FP238AR and FP241AR. Also, if NAMELIST variable R5dh = 0, do not input arrays FP238AR and FP241AR.			
47	**FP238AR**	max (1,NHIST-1)	Fraction (–) of fission power associated with U^{238} fission during the power-history table interval from i to i+1.
48	**FP241AR**	max (1,NHIST-1)	Fraction (–) of fission power associated with Pu^{241} fission during the power-history table interval from i to i+1.
Note: Input GTBLNUMS if NGTPOW (Word 3 on **Card Number 2**) > 0.			
49	**GTBLNUMS**	NGTPOW	General table numbers that will be used to specify the power/reactivity for this POWER component.
Note: Input SVIDS if NSVPOW (Word 4 on **Card Number 2**) > 0.			
50	**SVIDS**	NSVPOW	Signal variable ids that will be used to specify the power/reactivity for this POWER component.
Note: Input CBIDS if NCBPOW (Word 5 on **Card Number 2**) > 0.			
51	**CBIDS**	NCBPOW	Control block ids that will be used to specify the power/reactivity for this POWER component.

PRIZER Component Data

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (PRIZER left justified).
NUM	Component ID number (must be unique for each component, 1 ≤ NUM ≤ 999).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2A14) **EOS, PHASECHANGE**

Note: Only input this card when the number of inputs for FLUIDS (a NAMELIST variable) is more than one.

Variable	Description
EOS	EOS identifier for this component (i.e. “h2o” or “r5h2o”, etc.).
PHASECHANGE	Phase change flag. Input TRUE or true, if phase change is allowed for this component. Input FALSE or false, if phase change is not allowed for this component.

Card Number 3. (Format 4I14) **NCELLS, NODES, JUN1, JUN2**

Variable	Description
NCELLS	Number of fluid cells in the PRIZER component.
NODES	Number of radial heat-transfer nodes in the PRIZER wall. A value of zero specifies no wall heat transfer.
Note: If JUN1 or JUN2 is set to zero, a deadend is created with flow area and velocities are always set to zero.	
JUN1	Junction number for the junction adjacent to cell 1.
JUN2	Junction number for the junction adjacent to cell NCELLS (Word 1 on this card).

Card Number 4. (Format 2I14,E14.4) **ICHF, ICONC, QP3IN**

Variable	Description
ICHF	CHF-calculation option. 0 = convection heat transfer only, no boiling heat transfer (i.e. no wall nucleation is allowed although phase change can still occur); 1 = CHF from AECL-IPPE CHF Table, no critical quality calculated. 2 = CHF from AECL-IPPE CHF Table, critical quality from Biasi correlation. 3 = CHF from AECL-IPPE CHF Table, critical quality from CISE-GE correlation.
ICONC	Solute in the liquid coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.
QP3IN	Initial power (W, Btu/hr) deposited in (to) the wall and distributed according to the QPPP array. If QP3IN > 0.0, it is the total power to the entire wall. When QP3IN < 0.0 the initial power to the wall in each cell is |QP3IN|, and the negative sign indicates the power to the wall is to be a cell-dependent array of NCELLS (Word 1 on Card Number 2) power values. Each data pair of the power-to-the-wall table [for QP3IN < 0.0] has 1 + NCELLS values (an independent-variable value and NCELLS power values for cells 1 through NCELLS). When the power-to-the-wall table is not being evaluated, the same power value of |QP3IN| or QP3OFF [if QP3OFF > -10^{19} W (-3.41×10^{19} Btu/hr)] is applied at each of the NCELLS cells.

Card Number 5. (Format 5E14.4) **RADIN, TH, HOUTL, HOUTV, TOUTL**

Note: The four parameters, HOUTL, HOUTV, TOUTL, and TOUTV, allow flexibility in calculating possible heat losses from the outside of the PRIZER wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
RADIN	Inner radius (m, ft) of the PRIZER wall.

Card Number 5. (Format 5E14.4) **RADIN, TH, HOUTL, HOUTV, TOUTL** (Continued)

Note: The four parameters, HOUTL, HOUTV, TOUTL, and TOUTV, allow flexibility in calculating possible heat losses from the outside of the PRIZER wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
TH	Wall thickness (m, ft).
HOUTL	Heat-transfer coefficient HTC [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the PRIZER wall and the liquid outside the PRIZER wall.
HOUTV	HTC [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the PRIZER wall and gas outside the PRIZER wall.
TOUTL	Liquid temperature (K, °F) outside the PRIZER wall.

Card Number 6. (Format 5E14.4) **TOUTV, QHEAT, PSET, DPMAX, ZHTR**

Variable	Description
TOUTV	Gas temperature (K, °F) outside the PRIZER wall.
QHEAT	Total heater power (W, Btu/hr).
PSET	Pressure setpoint (Pa, psia) for heater/sprayer control.
DPMAX	Pressure differential (Pa, psid) at which heater/sprayer has maximum power.
ZHTR	Water level (m, ft) for heater cutoff.

PRIZER Array Cards.

Note: Input each of the following arrays using LOAD format.

All junction variables (dimension NCELLS+1) must match at component interfaces.

Card Set Number	Variable	Dimension	Description
7	**DX**	NCELLS	Cell lengths (m, ft).
8	**VOL**	NCELLS	Cell volumes (m^3, ft^3).
9	**FA**	NCELLS+1	Cell-edge flow areas (m^2, ft^2).
Note: Setting FRIC > 10^{20} at a cell edge invokes the steam-separator model (only the gas phase is allowed to flow through the cell interface). Setting FRIC < -10^{20} invokes the liquid-separator model (only the liquid is allowed to flow through the cell interface). If the reverse additive loss-coefficient option (NFRC1 = 2 in the NAMELIST data) is chosen, steam-separator and liquid-separator models may be used separately in each forward and reverse direction.			
10	**FRIC**	NCELLS+1	Additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
11	**FRICR**	NCELLS+1	Additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input.
12	**GRAV or ELEV**	NCELLS+1	Gravity or elevation terms (– or m, ft). GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.
13	**HD**	NCELLS+1	Hydraulic diameters (m, ft) (see NAMELIST variable NDIA1 for additional input of heat-transfer diameters).
Note: If NAMELIST variable NDIA1 ≠ 2 do not input array HD-HT.			
14	**HD-HT**	NCELLS+1	Heat transfer diameters (m, ft).

Card Set Number	Variable	Dimension	Description
Note: If NAMELIST variable ICFLOW = 0 or 1 do not input array ICFLG. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur..			
15	**ICFLG**	NCELLS+1	Cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.
16	**NFF**	NCELLS+1	Friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE.
Note: If NCCFL = 0 (Word 5 **Main-Data Card 9**), do not input array LCCFL.			
17	**LCCFL**	NCELLS+1	Countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
18	**ALP**	NCELLS	Initial gas volume fractions (–).
19	**VL**	NCELLS+1	Initial liquid velocities (m/s, ft/s).
20	**VV**	NCELLS+1	Initial gas velocities (m/s, ft/s).
21	**TL**	NCELLS	Initial liquid temperatures (K, °F).
22	**TV**	NCELLS	Initial gas temperatures (K, °F).

Card Set Number	Variable	Dimension	Description
23	**P**	NCELLS	Initial pressures (Pa, psia).
24	**PA**	NCELLS	Initial noncondensable-gas partial pressures (Pa, psia).
Note: If NAMELIST variable NOLT1D = 0 or USESJC>0, do not input array ILEV			
25	**ILEV**	NCELLS	Level tracking flags. ILEV = 1 indicates that the two-phase level exists in the current cell. ILEV = 0 indicates that the two-phase level does not exist in the current cell. If ILEV = -1, the level tracking calculation will be turned off for this cell.
Note: If NAMELIST variable MWFL = 0, do not input array WFMFL.			
26	**WFMFL**	NCELLS+1	Wall-friction multiplier factor for the liquid phase (–) [0.9 ≤ WFMFL ≤ 1.1].
Note: If NAMELIST variable MWFV = 0, do not input array WFMFV.			
27	**WFMFV**	NCELLS+1	Wall-friction multiplier factor for the gas phase (–) [0.9 ≤ WFMFL ≤ 1.1].
Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input array QPPP.			
28	**QPPP**	NODES × NCELLS	A relative power profile (–) in the PRIZER wall. Input values for cell 1, node 1 through NODES; then for cell 2, node 1 through NODES, etc. If the array is filled with the same nonzero constant, a uniform volumetric heat source in the wall results. TRACE internally normalizes the power profile to have a volume-average value of unity (each QPPP(I) is normalized to have the value QPPP(I) x [VOL(K)] / [QPPP(K) x VOL(K)]). Filling the array with zeros results in no power being deposited in the PRIZER wall regardless of the values of QP3IN, QP3TB, etc.

Card Set Number	Variable	Dimension	Description
Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input array MATID.			
29	**MATID**	NODES–1	Wall-material ID array, which specifies material ID between radial nodes. Dimension is 1 if NODES = 1. 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 12 = inconel, type 600.
Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input array TW.			
30	**TW**	NODES × NCELLS	Initial wall temperatures (K, °F) (input in the same order as QPPP).
Note: If ICONC = 0 (Word 2 on **Card Number 4**), do not input array CONC.			
31	**CONC**	NCELLS	Initial ratio of solute mass to liquid-coolant mass [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)]. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: If ICONC = 0 or 1 (Word 2 on **Card Number 4**), do not input array SOLID.			
32	**SOLID**	NCELLS	Initial macroscopic density of plated-out solute (kg/m^3, lb_m/ft^3). Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
33	**XGNB**	NCELLS	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).
Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
34	**XLNB**	NCELLS	Mass fraction for liquid trace species.

PUMP Component Data

The pumping action occurs at face 2 in the **PUMP** except for the special case where NCELLS is set to zero. Setting NCELLS to zero makes a SJC component where-by a control system can be used to specify the liquid flow rate or velocity.

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (PUMP left justified).
NUM	Component ID number (must be unique for each component, $1 \leq$ NUM ≤ 999).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2A14) **EOS, PHASECHANGE**

Note: Only input this card when the number of inputs for FLUIDS (a NAMELIST variable) is more than one.

Variable	Description
EOS	EOS identifier for this component (i.e. “h2o” or “r5h2o”, etc.).
PHASECHANGE	Phase change flag. Input TRUE or true, if phase change is allowed for this component. Input FALSE or false, if phase change is not allowed for this component.

Card Number 3. (Format 4I14, E14.4) **NCELLS, NODES, JUN1, JUN2, EPSW**

Variable	Description
NCELLS	Number of fluid cells in the PUMP component (NCELLS ≥ 2).
NODES	Number of radial heat-transfer nodes in the PUMP wall. A value of zero specifies no wall heat transfer.
JUN1	Junction number for the junction adjacent to cell 1.

Card Number 3. (Format 4I14, E14.4) **NCELLS, NODES, JUN1, JUN2, EPSW** (Continued)

Variable	Description
JUN2	Junction number for the junction adjacent to cell NCELLS (Word 1 on this Card).
EPSW	Wall surface roughness (m, ft).

Card Number 4. (Format I14) **NSIDES**

Note: If NCELLS = 0 do not input this card. Input this card only if NAMELIST variable USESJC = 2 or 3. This will allow this component to have side junctions.

Variable	Description
NSIDES	Number of side junctions connected to this PUMP component.

Note: If NSIDES > 0 then input the next three cards as sets of 1, 2, or 3 cards per NSIDES. Examples include:

If USESJC = 2 and JUNLK (Word 2 on **Card Number 5**) is > 0 only **Card Number 5** is needed.

If USESJC = 2 and JUNLK is 0 input **Card Number 5** and **Card Number 6** in pairs.

If USESJC = 3 and JUNLK > 0 input **Card Number 5** and **Card Number 7** in pairs.

If USESJC = 3 and JUNLK is 0 input **Card Number 5**, **Card Number 6**, and **Card Number 7** in sets.

Card Number 5. (Format 5I14) **NCLK, JUNLK, NCMPTO, NCLKTO, NLEVTO**

Note: If NCELLS or NSIDES = 0, or USESJC = 1 do not input this card. Otherwise input this card for each NSIDES.

Variable	Description
NCLK	“From” cell number in the PUMP component.

Card Number 5. (Format 5I14) **NCLK, JUNLK, NCMPTO, NCLKTO, NLEVTO** (Continued)

Note: If NCELLS or NSIDES = 0, or USESJC = 1 do not input this card. Otherwise input this card for each NSIDES.

Variable	Description
JUNLK	Junction number. Enter a zero to have the code spawn a Single Junction Component internally. Otherwise enter the junction number here. This same junction number must appear as a VESSEL source junction or a 1D component junction.
NCMPTO	Component number of "To" component of a leak path. Enter 0 if JUNLK ≠ 0.
NCLKTO	Cell number of "To" cell of a leak path Enter 0 if JUNLK ≠ 0.
NLEVTO	Axial level number of "To" cell of a leak path when "To" component is a VESSEL. Otherwise enter 0. Enter 0 if JUNLK ≠ 0.

Card Number 6. (Format 5E14.4) **FALK, CLOS, VLLK, VVLK, DELZLK**

Note: If NCELLS or NSIDES = 0 do not input this card. Input this card only if JUNLK = 0. If USESJC = 2 or 3, input this card for each NSIDES.

Variable	Description
FALK	Leak path flow area (m^2, ft^2).
CLOS	Leak path loss coefficient
VLLK	Leak path initial liquid velocity (m/s, ft/s).
VVLK	Leak path initial vapor velocity (m/s, ft/s).
DELZLK	Elevation difference between center of "From" cell and center of "To" cell (m, ft). DELZLK > 0 when the center of the "From" cell is higher than the center of the "To" cell DELZLK < 0 when the center of the "From" cell is lower than the center of the "To" cell

Card Number 7. (Format E14.4, I14) **THETA, IENTRN**

Variable	Description
Note: If NCELLS or NSIDES = 0, or USESJC = 1 or 2 do not input this card.	
THETA	Angle between the main direction of flow and the flow through the side junction.
IENTRN	Offtake-model option. 0 = off; 1 = on (side-junction mass flow determined using offtake model)

Card Number 8. (Format 5I14) **ICHF, ICONC, IPMPTY, IRP, IPM**

Variable	Description
ICHF	CHF-calculation option. 0 = convection heat transfer only, no boiling heat transfer (i.e. no wall nucleation is allowed although phase change can still occur); 1 = CHF from AECL-IPPE CHF Table, no critical quality calculated. 2 = CHF from AECL-IPPE CHF Table, critical quality from Biasi correlation. 3 = CHF from AECL-IPPE CHF Table, critical quality from CISE-GE correlation.
ICONC	Solute in the liquid coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.

Card Number 8. (Format 5I14) **ICHF, ICONC, IPMPTY, IRP, IPM** (Continued)

Variable	Description
IPMPTY	Pump-type option. 0 = pump-impeller interface fluid velocity is specified by **Card Set 79** (array PMPTB) when trip IPMPTR is ON and by signal variable or control block NPMPSD (word 5 on **Card Number 21**) when trip IPMPTR is OFF. 1 = pump-impeller rotational speed is specified by **Card Set 79** (array PMPTB) when trip IPMPTR is ON and by OMEGAN (word 1 on **Card Number 21**) or signal variable or control block NPMPSD (word 5 on **Card Number 21**)] when trip IPMPTR is OFF. 2 = pump-impeller rotational speed is calculated from **Equation (4-21)** when trip IPMPTR (Word 1 on **Card Number 11**) is set ON and defined by OMEGAN or NPMPSD when trip IPMPTR is OFF. 3 = pump motor torque is controlled by the control system. This option requires the pump-motor torque table abscissa-coordinate variable ID number defined by IPMPSV (Word 2 on **Card Number 11**) and the number of motor torque action table data pairs defined by NPMPMT (**Card Number 12**). **Card Set 81** (array PMPMT) is required for this option. 10 = SJC pump where control blocks set the value of liquid and vapor velocity. 11 = SJC pump where control blocks set the value of liquid and vapor mass flow rate.
IRP	Reverse-rotation option (only used for IPMPTY = 2). 0 = no; 1 = yes.
IPM	Degradation option. 0 = use single-phase homologous curves; 1 = use combined single-phase and fully degraded two-phase homologous curves. 2 = read in head and torque two-phase degradation multipliers (only for Bingham and Westinghouse pumps. See OPTION, **Card Number 23**).

Card Number 9. (Format 2E14.4) **ICBVL, ICBVV**

Note: If IPMPTY<10 do not input this card.	
Variable	**Description**
ICBVL	If ipmpty=10, this control block sets the value of the liquid velocity (m/s) If ipmpty=11, this control block sets the value of the liquid mass flow rate (kg/s)
ICBVV	If ipmpty=10, this control block sets the value of the vapor velocity (m/s) If ipmpty=11, this control block sets the value of the vapor mass flow rate (kg/s)

Card Number 10. (Format 2E14.4) **VLLIM, VVLIM**

Note: If IPMPTY ≠ 11 do not input this card.	
Variable	**Description**
VLLIM	Bound on absolute value of the velocity associated with the liquid mass flow rate.
VVLIM	Bound on absolute value of the velocity associated with the vapor mass flow rate.

Card Number 11. (Format 5I14) **IPMPTR, IPMPSV, NPMPTB, NPMPSV, NPMPRF**

Note: If IPMPTY≥10 do not input this card.	
Variable	**Description**
IPMPTR	The trip ID number that controls the evaluation of the pump-impeller rotational speed (IPMPTR=0 implies a constant pump speed) (|IPMPTR| ≤ 9999). If the trip set status is OFF initially, the pump-impeller rotational speed is defined by a signal variable or control block with ID number NPMPSD (Word 5 on **Card Number 21**) or by a constant pump-impeller rotational speed OMEGAN (Word 1 on **Card Number 21** when NPMPSD = 0.
IPMPSV	The pump-speed or pump-motor torque table abscissa-coordinate variable ID number. IPMPSV defines the independent-variable parameter in the IPMPTY = 1 pump-speed table and IPMPTY=3 pump motorque table. IPMPSV > 0 defines the ID number for a signal-variable parameter; IPMPSV < 0 defines the ID number for a control-block output parameter [if IPMPTY = 2 (Word 3 on **Card Number 8**), input IPMPSV = 0].

Card Number 11. (Format 5I14) **IPMPTR, IPMPSV, NPMPTB, NPMPSV, NPMPRF** (Continued)

Note: If IPMPTY≥10 do not input this card.

Variable	Description
NPMPTB	The number of pump-speed table data pairs (defined by the absolute value of NPMPTB). NPMPTB > 0 defines the table independent-variable form to be the IPMPSV parameter; NPMPTB < 0 defines the table independent-variable form to be the sum of the change in the IPMPSV parameter over each timestep times the trip set-status value ISET during that timestep (when the pump-speed table is trip controlled); NPMPTB = 0 defines the pump-impeller rotational speed to be the IPMPSV parameter [if IPMPTY = 2 (Word 3 on **Card Number 8**), input NPMPTB = 0].
NPMPSV	The rate-factor table abscissa-coordinate variable ID number. NPMPSV defines the independent-variable parameter for the rate factor that is applied to the pump-speed table independent variable. NPMPSV > 0 defines the ID number for a signal-variable parameter; NPMPSV < 0 defines the ID number for a control-block output parameter; NPMPSV = 0 (when NPMPRF ≠ 0) defines the difference between the trip signal and the setpoint value that turns the trip OFF [if IPMPTY = 2 (Word 3 on **Card Number 8**), input NPMPSV = 0].
NPMPRF	The number of rate-factor table data pairs (defined by the absolute value of NPMPRF). The rate factor is applied to the pump-speed table independent variable when the rate factor is defined. No rate factor is defined when NPMPSV and NPMPRF are both zero. NPMPRF > 0 defines the rate-factor table's abscissa coordinate to be the NPMPSV parameter; NPMPRF < 0 defines it to be the sum of the change in the NPMPSV parameter over each timestep times the trip set-status value ISET during that timestep (when the pump-speed table is trip controlled); NPMPRF = 0 defines the rate factor to be the NPMPSV parameter [if IPMPTY = 2 (Word 3 on **Card Number 8**), input NPMPRF = 0].

Card Number 12. (Format I14) **NPMPMT**

Note: Input only when IPMPTY = 3

Variable	Description
NPMPMT	Number of pump motor torque data pairs for TABLE PMPMT.

Card Number 13. (Format 5I14) **IQP3TR, IQP3SV, NQP3TB, NQP3SV, NQP3RF**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 70**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Note:

Variable	Description
IQP3TR	The trip ID number that controls the evaluation of the power-to-the-wall table defined by Card Set 75 (array QP3TB) ($\vert IQP3TR\vert \leq 9999$) Input IQP3TR = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation.
IQP3SV	The independent-variable ID number for the power-to-the-wall table. IQP3SV > 0 defines the ID number for a signal-variable parameter; IQP3SV < 0 defines the ID number for a control-block output parameter.
NQP3TB	The number of power-to-the-wall table data pairs (defined by the absolute value of NQP3TB). NQP3TB > 0 defines the table independent-variable form to be the IQP3SV parameter; NQP3TB < 0 defines the table independent-variable form to be the sum of the change in the IQP3SV parameter over each timestep times the trip set-status value ISET during that timestep (when the power-to-the-wall table is trip controlled); NQP3TB = 0 defines the power to the wall to be the IQP3SV parameter.
NQP3SV	The independent-variable ID number for the rate factor that is applied to the power-to-the-wall table independent variable. NQP3SV > 0 defines the ID number for a signal-variable parameter; NQP3SV < 0 defines the ID number for a control-block output parameter; NQP3SV = 0 (when NQP3RF ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-wall table is trip controlled.
NQP3RF	The number of rate-factor table data pairs (defined by the absolute value of NQP3RF). The rate factor is applied to the power-to-the-wall tables (QP3TB) independent variable when the rate factor is defined. No rate factor is defined when NQP3SV and NQP3RF are both zero. NQP3RF > 0 defines the rate-factor table independent variable to be the NQP3SV parameter; NQP3RF < 0 defines it to be the change in the NQP3SV parameter over the last timestep times the trip set-status value ISET (when the power-to-the-wall table is trip controlled); NQP3RF = 0 defines the rate factor to be the NQP3SV parameter.

Card Number 14. (Format 5E14.4) **RADIN, TH, HOUTL, HOUTV, TOUTL**

Note: The four parameters, HOUTL, HOUTV, TOUTL, and TOUTV, allow flexibility in calculating possible heat losses from the outside of the PIPE wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
RADIN	Inner radius (m, ft) of the PUMP wall.
TH	Wall thickness (m, ft).
HOUTL	Heat-transfer coefficient (HTC) [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the PUMP wall and liquid outside the PUMP wall.
HOUTV	HTC [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the PUMP wall and the gas outside the PUMP wall.
TOUTL	Liquid temperature (K, °F) outside the PUMP wall.

Card Number 15. (Format 2E14.4) **TOUTV, EFFMI**

Variable	Description
TOUTV	Gas temperature (K, °F) outside the PUMP wall.
EFFMI	Effective moment of inertia (kg m^2, lb$_m$ ft^2). Input a negative value if an alternate effective moment of inertia EFFMI1 (Word 1 on **Card Number 18**) is to be used for pump-impeller rotational speeds below OMTEST (Word 5 on **Card Number 18**).

Card Number 16. (Format 5E14.4) **TFR0, TFR1, TFR2, TFR3, TFRB**

Variable	Description
TFR0	Zero-order coefficient in the PUMP frictional torque correlation [Pa m^3 (N m), lb$_f$ ft].
TFR1	First-order coefficient in the PUMP frictional torque correlation (Pa m^3, lb$_f$ ft).
TFR2	Second-order coefficient in the PUMP frictional torque correlation (Pa m^3, lb$_f$ ft).

Card Number 16. (Format 5E14.4) **TFR0, TFR1, TFR2, TFR3, TFRB** (Continued)

Variable	Description
TFR3	Third-order coefficient in the PUMP frictional torque correlation (Pa m^3, lb_f ft).
TFRB	Low-speed frictional torque break speed (PUMP speed below which TRACE switches to low-speed frictional torque correlation defined on the next card) (rad/s, rpm).

Card Number 17. (Format 4E14.4) **TFRL0, TFRL1, TFRL2, TFRL3**

Variable	Description
TFRL0	Zero-order coefficient in the low-speed PUMP frictional torque correlation (Pa m^3, lb_f ft).
TFRL1	First-order coefficient in the low-speed PUMP frictional torque correlation (Pa m^3, lb_f ft).
TFRL2	Second-order coefficient in the low-speed PUMP frictional torque correlation (Pa m^3, lb_f ft).
TFRL3	Third-order coefficient in the low-speed PUMP frictional torque correlation (Pa m^3, lb_f ft).

Card Number 18. (Format 5E14.4) **EFFMI1, AEFFMI, BEFFMI, CEFFMI, OMTEST**

Note: Input this card if variable EFFMI (Word 2 on **Card Number 15**) is negative	
Variable	**Description**
EFFMI1	The alternate effective moment of inertia that is used after the pump-impeller rotational speed falls below OMTEST (kg m^2, lb_m ft^2).
AEFFMI	The coefficient for the $(OMEGA/ROMEGA)^2$ term in the calculation of the variable moment of inertia (kg m^2, lb_m ft^2).
BEFFMI	The coefficient for the (OMEGA/ROMEGA) term in the calculation of the variable moment of inertia (kg m^2, lb_m ft^2).
CEFFMI	The constant term in the calculation of the variable moment of inertia (kg m^2, lb_m ft^2).

Card Number 18. (Format 5E14.4) **EFFMI1, AEFFMI, BEFFMI, CEFFMI, OMTEST** (Continued)

Note: Input this card if variable EFFMI (Word 2 on **Card Number 15**) is negative	
Variable	**Description**
OMTEST	The pump-impeller rotational speed below which EFFMI1 (the alternate effective moment of inertia) is used (rad/s, rpm).

Card Number 19. (Format I14) **IPMPS**

Note: Input this card if variable EFFMI (Word 2 on **Card Number 15**) is negative	
Variable	**Description**
IPMPS	Variable flag to indicate whether or not the pump-impeller rotational speed previously has dropped below OMTEST (Word 5 on **Card Number 18**). 0 = the pump-impeller rotational speed has been greater than OMTEST; 1 = the pump-impeller rotational speed at some time has dropped below OMTEST.

Card Number 20. (Format 5E14.4) **RHEAD, RTORK, RFLOW, RRHO, ROMEGA**

Variable	**Description**
RHEAD	Rated head {[(Pa m^3)/kg, m^2/s^2, or N m/kg], lb_f ft/lb_m}. Head is defined as $\Delta P/\rho$.
RTORK	Rated torque (Pa m^3, lb_f ft).
RFLOW	Rated volumetric flow (m^3/s, gpm).
RRHO	Rated density (kg/m^3, lb_m/ft^3).
ROMEGA	Rated pump-impeller rotational speed (rad/s, rpm).

Card Number 21. (Format 4E14.4,I14) **OMEGAN, OMGOFF, ROMGMX, OMGSCL, NPMPSD**

Variable	**Description**
OMEGAN	Initial pump-impeller rotational speed (rad/s, rpm) when NPMPSD = 0 (Word 5 on **Card Number 21**).

Card Number 21. (Format 4E14.4,I14) **OMEGAN, OMGOFF, ROMGMX, OMGSCL, NPMPSD**

Variable	Description
OMGOFF	Pump-impeller rotational speed (rad/s, rpm) when the controlling trip is OFF after being ON [maintain the last pump-impeller rotational speed evaluated when the trip was ON if OMGOFF $\leq -10^{19}$ rad/s (-9.55×10^{19} rpm)] [used only when IPMPTR $\neq$ 0 (**Card Number 11**)].
ROMGMX	The maximum rate of change of the pump-impeller rotational speed (rad/s^2, rpm/s).
OMGSCL	Scale factor for the pump-impeller rotational-speed table (–). The dependent variable in the table, defined by **Card Set 79** (array PMPTB), is multiplied by OMGSCL to obtain the absolute pump-impeller rotational speed (rad/s, rpm).
NPMPSD	The ID number of the signal-variable parameter or control-block parameter that defines the pump-impeller rotational speed initially when the controlling trip is OFF [input NPMPSD = 0 if the initial pump-impeller rotational speed is to be defined by OMEGAN (Word 1 on **Card Number 21**)].

Card Number 22. (Format 4E14.4, I14) **QP3IN, QP3OFF, RQP3MX, QP3SCL, NHCOM**

Note: If NODES=0, do not input this card.

Variable	Description
QP3IN	Initial power (W, Btu/hr) deposited in (to) the wall and distributed according to the QPPP array. If QP3IN > 0.0, it is the total power to the entire wall. When QP3IN < 0.0, the initial power to the wall in each cell is |QP3IN| and the negative sign indicates the power to the wall is to be a cell-dependent array of NCELLS (Word 1 on Card Number 2) power values. Each data pair of the power-to-the-wall table [for QP3IN < 0.0] has 1+NCELLS values [an independent-variable value and NCELLS power values for cells 1 through NCELLS]. When the power-to-the-wall table is not being evaluated, the same power value of |QP3IN| or QP3OFF [if QP3OFF > -10^{19} W (-3.41×10^{19} Btu/hr)] is applied at each of the NCELLS cells.
QP3OFF	Power (W, Btu/hr) to the wall when the controlling trip is OFF after being ON [not used when IQP3TR = 0 (Word 1 on **Card Number 13**); use the last table-evaluated power when the trip was ON if QP3OFF $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr)].
RQP3MX	The maximum rate of change of the power to the wall [W/s, (Btu/hr)/s] [RQP3MX $\geq$ 0.0].

Card Number 22. (Format 4E14.4, I14) **QP3IN, QP3OFF, RQP3MX, QP3SCL, NHCOM** (Continued)

Note: If NODES=0, do not input this card.

Variable	Description
QP3SCL	Scale factor (–) for the power-to-the-wall table. The dependent variable in the table, defined by **Card Set 82** (array QP3TB), is multiplied by QP3SCL to obtain the absolute power (W, Btu/hr) to the wall.
NHCOM	Component number receiving outside wall energy.

Card Number 23. (Format I14) **OPTION**

Variable	Description
OPTION	Pump-curve option. 0 = user-specified pump curves input defined by **Card Set 24** through **Card Set 45**; 1 = use built-in semiscale pump curves; 2 = use built-in LOFT pump curves. 3 = use built-in Bingham pump curves. 4 = use built-in Westinghouse pump curves.

Card Number 24 through **Card Set 45** are input only if OPTION = 0. If OPTION > 0, go to **Card Number 46**. The user is referred to the pump model description in **Chapter 4** for definitions of the terms used below. Each homologous curve is defined by four curve segments. Each curve segment is denoted by the number appended to the curve name. The segments are defined by **Table 4-1** in **Chapter 4**.

Under certain conditions for OPTION = 0, some curves will not be used. However, to avoid confusion, we recommend that all curves be defined. NDATA(i) must be greater than zero for at least i = 1, 4.

For IPMPTY = 1 and IPM = 0, curves HSP1 through HSP4 are required and the remaining curves are not used.

For IPMPTY = 1 and IPM = 1, curves HSP1 through HSP4, HTP1 through HTP4, and HDM are required, and the remaining curves are not used.

For IPMPTY = 2 and IPM = 0, curves HSP1 through HSP4 and TSP1 through TSP4 are required, and the remaining curves are not used.

For IPMPTY = 2 and IPM = 1, all curves are required.

For IPMPTY = 3, the default pump curves are used.

Card Number 24. (Format 5I14) **NDATA(I), I = 1, 5**

Variable	Description
NDATA(1)	Number of data pairs defining the HSP1 curve.
NDATA(2)	Number of data pairs defining the HSP2 curve.
NDATA(3)	Number of data pairs defining the HSP3 curve.
NDATA(4)	Number of data pairs defining the HSP4 curve.
NDATA(5)	Number of data pairs defining the HTP1 curve.

Card Number 25. (Format 5I14) **NDATA(I), I = 6, 10**

Variable	Description
NDATA(6)	Number of data pairs defining the HTP2 curve.
NDATA(7)	Number of data pairs defining the HTP3 curve.
NDATA(8)	Number of data pairs defining the HTP4 curve.
NDATA(9)	Number of data pairs defining the TSP1 curve.
NDATA(10)	Number of data pairs defining the TSP2 curve.

Card Number 26. (Format 5I14) **NDATA(I), I = 11, 15**

Variable	Description
NDATA(11)	Number of data pairs defining the TSP3 curve.
NDATA(12)	Number of data pairs defining the TSP4 curve.
NDATA(13)	Number of data pairs defining the TTP1 curve.
NDATA(14)	Number of data pairs defining the TTP2 curve.
NDATA(15)	Number of data pairs defining the TTP3 curve.

Card Number 27. (Format 3I14) **NDATA(I), I = 16, NHDM, NTDM**

Variable	Description
NDATA(16)	Number of data pairs defining the TTP4 curve.
NHDM	Number of data pairs defining the HDM curve.
NTDM	Number of data pairs defining the TDM curve.

PUMP Curve Cards

Input up to 18 Card Sets, one set for each curve listed in **Card Set 24** through **Card Set 27** that has a positive number of data pairs. Use LOAD format. Data are entered in pairs $(x,y)_i$, i = (1, NDATA), where x is the independent variable and y is the dependent variable. The x_i values must increase monotonically from –1.0 to 1.0 for the homologous curves and from 0.0 to 1.0 for the multiplier curves. If information for a particular curve does not exist or if you desire to input a curve that will not be used, we suggest that the four points (–1.0, 0.0, 1.0, 0.0) be input. The suggested two data pairs for HDM and TDM are (0.0, 0.0, 1.0, 0.0).

Card Set Number	Variable	Dimension	Description
Single-phase homologous head curves.			
28	**HSP1**	2×NDATA(1)	HSP1 curve
29	**HSP2**	2×NDATA(2)	HSP2 curve
30	**HSP3**	2×NDATA(3)	HSP3 curve
31	**HSP4**	2×NDATA(4)	HSP4 curve
Fully-degraded homologous head curves.			
32	**HTP1**	2×NDATA(5)	HTP1 curve
33	**HTP2**	2×NDATA(6)	HTP2 curve
34	**HTP3**	2×NDATA(7)	HTP3 curve
35	**HTP4**	2×NDATA(8)	HTP4 curve
Single-phase homologous torque curves.			
36	**TSP1**	2×NDATA(9)	TSP1 curve

Card Set Number	Variable	Dimension	Description
37	**TSP2**	2×NDATA(10)	TSP2 curve
38	**TSP3**	2×NDATA(11)	TSP3 curve
39	**TSP4**	2×NDATA(12)	TSP4 curve
Fully-degraded homologous torque curves.			
40	**TTP1**	2×NDATA(13)	TTP1 curve
41	**TTP2**	2×NDATA(14)	TTP2 curve
42	**TTP3**	2×NDATA(15)	TTP3 curve
43	**TTP4**	2×NDATA(16)	TTP4 curve
Head-degradation multiplier curve.			
44	**HDM**	2×NHDM	
Torque-degradation multiplier curve.			
45	**TDM**	2×NTDM	

Note: Input **Card Number 46** through **Card Set 48** only for Bingham or Westinghouse built-in pumps (see **Card Number 23**), and IPM=2 (Word 5 on **Card Number 8**)

Card Number 46. (Format 2I14), **NHDM, NTDM**

Variable	Description
NHDM	Number of data pairs defining the HDM curve.
NTDM	Number of data pairs defining the TDM curve.

Card Set Number	Variable	Dimension	Description
47	**HDM**	2×NHDM	Head-degradation multiplier curve.
48	**TDM**	2×NTDM	Torque-degradation multiplier curve.

PUMP Array Cards

Note: Input each of the following arrays using LOAD format.

All junction variables must match at component interfaces.

Card Set Number	Variable	Dimension	Description
49	**DX**	NCELLS	Cell lengths (m, ft).
50	**VOL**	NCELLS	Cell volumes (m^3, ft^3).
51	**FA**	NCELLS+1	Cell-edge flow areas (m^2, ft^2).
Note: Setting FRIC > 10^{20} at a cell edge invokes the steam-separator model (only the gas phase is allowed to flow through the cell interface). Setting FRIC < -10^{20} invokes the liquid-separator model (only the liquid is allowed to flow through the cell interface). If the reverse additive loss-coefficient option (NFRC1 = 2 in the NAMELIST data) is chosen, steam-separator and liquid-separator models may be used separately in each forward and reverse direction.			
52	**FRIC**	NCELLS+1	Additive loss coefficients (–) [FRIC(2) must be 0.0]. See NAMELIST variable IKFAC for optional K factors input.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
53	**FRICR**	NCELLS+1	Additive loss coefficients (–) [FRICR(2) must be 0.0] in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input.
54	**GRAV or ELEV**	NCELLS+1 (NCELLS for ELEV)	Gravity or elevation terms (– or m, ft). GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell centered elevation ELEV input.
55	**HD**	NCELLS+1	Hydraulic diameters (m, ft).
Note: If NAMELIST variable NDIA1 ≠ 2 do not input array HD-HT.			
56	**HD-HT**	NCELLS+1	Heat transfer diameters (m, ft).

Card Set Number	Variable	Dimension	Description
Note: If NAMELIST variable ICFLOW = 0 or 1 do not input array ICFLG. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur..			
57	**ICFLG**	NCELLS+1	Cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.
58	**NFF**	NCELLS+1	Friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE.
Note: If NCCFL = 0 (Word 5 on **Main-Data Card 9**) do not input array LCCFL.			
59	**LCCFL**	NCELLS+1	Countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
60	**ALP**	NCELLS	Initial gas volume fractions (–).
61	**VL**	NCELLS+1	Initial liquid velocities (m/s, ft/s).
62	**VV**	NCELLS+1	Initial gas velocities (m/s, ft/s).
63	**TL**	NCELLS	Initial liquid temperatures (K, °F).
64	**TV**	NCELLS	Initial gas temperatures (K, °F).
65	**P**	NCELLS	Initial pressures (Pa, psia).

Card Set Number	Variable	Dimension	Description
66	**PA**	NCELLS	Initial noncondensable-gas partial pressures (Pa, psia).
Note: If NAMELIST variable NOLT1D = 1 do not input array ILEV.			
67	**ILEV**	NCELLS	Level tracking flags. 1 = two-phase level exists in the current cell. 0 = two-phase level does not exist in the current cell. -1 = level tracking calculation will be turned off for this cell.
Note: If NAMELIST variable MWFL = 0, do not input array WFMFL.			
68	**WFMFL**	NCELLS+1	Wall-friction multiplier factor for the liquid phase (–) [0.9 ≤ WFMFL ≤ 1.1].
Note: If NAMELIST variable MWFV = 0, do not input array WFMFV.			
69	**WFMFV**	NCELLS+1	Wall-friction multiplier factor for the gas phase (–) [0.9 ≤ WFMFL ≤ 1.1].
Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input arrays QPPP, MATID, TW, IDROD, and NHCEL.			
70	**QPPP**	NODES × NCELL	A relative power profile (–) in the PUMP wall. Input values for cell 1, node 1 through NODES; then cell 2, node 1 through NODES; etc. If the array is filled with the same nonzero constant, a uniform volumetric heat source in the wall results. TRACE internally normalizes the power profile to have a volume-averaged value of unity {each QPPP(I) is normalized to have the value QPPP(I) $\times [\Sigma_K$ VOL(K)]/ $[\Sigma_K$ QPPP(K) × VOL(K)]}. Filling the array with zeros results in no power being deposited in the wall regardless of the values of QP3IN, QP3TB, etc.

PUMP Component Data

Card Set Number	Variable	Dimension	Description
71	MATID	NODES-1	Wall-material ID array, which specifies material ID between radial nodes. Dimension is 1 if NODES = 1. **IDMaterial Type** 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 12 = inconel, type 600.
72	TW	NODES × NCELL	Initial wall temperatures (K, °F) (input in the same order as QPPP).
Note: If NHCOM = 0 (Word 5 on **Card Number 22**) do not input array IDROD.			
73	IDROD	1	Vessel radial-theta cell number or input 0 when NHCOM is a 1D component.
Note: If NHCOM = 0 (Word 5 on **Card Number 22**) do not input array NHCEL.			
74	NHCEL	NCELLS	Connecting axial cell numbers in component NHCOM.
Note: If ICONC = 0 (Word 2 on **Card Number 8**) do not input array CONC.			
75	CONC	NCELLS	Initial ratio of solute mass to liquid coolant mass [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)]. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: If ICONC = 0 or 1 (Word 2 on **Card Number 8**), do not input array S.			
76	S	NCELLS	Initial macroscopic density of plated-out solute (kg/m^3, lb_m/ft^3). Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: IInput array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
77	XGNB	NCELLS	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).

Card Set Number	Variable	Dimension	Description
Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
78	**XLNB**	NCELLS	Mass fraction for liquid trace species.
Note: If NPMPTB = 0 (Word 3 on **Card Number 11**), do not input array PMPTB.			
79	**PMPTB**	2×|NPMPTB|	Pump-impeller rotational speed vs. independent-variable-form table [(*, rad/s), (*, rpm)]. Input |NPMPTB| (Word 3 on **Card Number 11**) table-defining data pairs having the following form [independent-variable form defined by IPMPSV (Word 2 on **Card Number 11**), pump-impeller rotational speed].
Note: If NPMPTB = 0 (Word 3 on **Card Number 11**) or NPMPRF = 0 (Word 5 on **Card Number 11**), do not input array PMPRF.			
80	**PMPRF**	2×|NPMPRF|	Rate-factor table (*,–) for the pump-impeller rotational-speed table's independent variable. Input |NPMPRF| (Word 5 on **Card Number 11**) table-defining data pairs having the following form [independent-variable form defined by NPMPSV (Word 4 on **Card Number 11**), rate factor to be applied to the pump-impeller rotational-speed table independent variable].
Note: If NPMPMT > 0 (**Card Number 12**) and IPMPTY = 3 (Word 3 on **Card Number 8**) input array PMPMT			
81	**PMPMT**	2×|NPMPMT |	Pump motor torque vs. independent-variable-form table (*, N-m or *, lb_f ft)
Note: If NQP3TB = 0 (Word 3 on **Card Number 13**), do not input array QP3TB.			
82	**QP3TB**	2×|NQP3TB| when QP3IN > 0.0; (1+NCELLS) × |NQP3TB| when QP3IN < 0.0.	Power-to-the-wall vs. independent-variable-form table [(*, W), (*, Btu/hr)]. Input |NQP3TB| (Word 3 on **Card Number 13**) table-defining data pairs having the following form [independent-variable form defined by IQP3SV (Word 2 on **Card Number 13**), power to the wall]. If QP3IN > 0.0, the dependent variable specifies the total power to the entire wall; if QP3IN < 0.0, the dependent variable is a power shape that specifies the power to the wall at each cell from cell 1 to cell NCELLS.

RADENC Component Data

A sample input file which uses the RADENC component is found at the end of the HTSTR component (see **Chapter 6**).

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	RADENC.
NUM	Component ID number (must be unique for each component, $1 \leq NUM \leq 999$ and greater than the ID numbers of all hydraulic components).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2I14) **NZLEVEL, NHSS**

Variable	Description
NZLEVEL	Number of axial levels for this radiation enclosure (NZLEVEL > 0)
NHSS	Number of heat transfer surfaces that define the radiation heat transfer for each axial level. (NHSS > 1)

Card Number 3. (Format 3I14) **NUMHSS, RNHSS, ZNHSS**

Note: This card defines the location parameters of each heat structure surface. This card set is repeated NHSS*NZLEVEL times. The input for this card is according to the following order:

((NUMHSS(i,k), RNHSS(i,k), ZNHSS(i,k)) for i = 1, NHSS) and k = 1, NZLEVEL

The first card is for radiation heat transfer enclosure level 1 and heat structure surface 1. The next card is for radiation heat transfer enclosure level 1 and heat structure surface 2. If NZLEVEL > 1 (Word 1 on **Card Number 2**), then the NHSS+1 **Card Number 3** input is for radiation heat transfer enclosure level 2 and heat structure surface 1.

Variable	Description
NUMHSS	Heat structure component number
RNHSS	Radial or thickness node index of heat structure surface. RNHSS = 1 indicates the heat structure surface is the inner surface of heat structure component NUMHSS. RNHSS = NODES of heat structure surface is outer surface of heat structure component NUMHSS.
ZNHSS	Axial level of heat structure component NUMHSS

RADENC Array Cards

Note: Input each of the following arrays using LOAD format.

Card Set Number	Parameter	Dimension	Description
4	**VIEWFACT**	NHSS * NHSS * NZLEVEL	VIEWFACT(i, j, k) is the view factor from surface i to surface j for level k. [$0 \le \text{VIEWFACT}(i, j, k) \le 1$]. See notes below.
5	**PATHL**	NHSS * NHSS * NZLEVEL	PATHL(i, j, k) is the path length from surface i to surface j for level k. [$0 \le \text{PATHL}(i, j, k)$]. See notes below.

Note: **Card Set 4** is repeated NZLEVEL*(NHSS-1) times. The complete view factor matrix is not required as input. For each axial level NHSS*(NHSS-1)/2 values must be input. The total number of inputs for the view factor matrix is NZLEVEL*NHSS*(NHSS-1)/2. Only the upper off-diagonal elements of the view factor matrix are required for input. The lower off-diagonal elements will be calculated based on reciprocity and diagonal elements will be calculated based on the view factor definition that the sum all view factors from a given surface is one. The VIEWFACT array is dimensioned by (NHSS, NHSS, NZLEVEL). VIEWFACT (i, j, k) is the view factor from surface i to surface j for level k.

The number of view factors input for the jth RADENC surface is NHSS - j. Note for j = NHSS no view factors are input. For **Card Set 4**, first input using load format VIEWFACT (j, j+1:NHSS, 1) for j = 1, then terminate with an **e**. Then input VIEWFACT(j, j+1:NHSS, 1), for j = 2 and terminate with an **e**. Continue until j = NHSS-1, then go to the next level. The following example is for a NHSS = 3 and NZLEVEL = 2.

***for level 1**

F12 F13 e

F23e

***for level 2**

F12 F13 e

F23 e

Where F12 is the factor from surface 1 to 2, F13 is the view factor from surface 1 to 3, and F23 is the view factor from surface 2 to 3. TRACE will internally calculate the lower off-diagonal elements of the view factor matrix (i.e., for this example, F21 = F12*A2/A1, F31*A3/A1, and F32 = F23*A3/A2) and the diagonal elements of the view factor matrix (i.e., for this example, F11 = 1 - F12-F13, F22 = 1 - F21-F23, and F33 = 1-F31-F32). Where A1 is the area of radiation heat transfer enclosure surface 1 and A2 is the area of radiation heat transfer enclosure surface 2 and A3 is the area of radiation heat transfer enclosure surface 3.

Note for NHSS = 2 only one view factor must be input per axial level (i.e., VIEWFACT(1.2,k))

Card Set 5 is repeated NZLEVEL*NHSS times. The complete path length matrix is not required as input. For each axial level NHSS*(NHSS+1)/2 values must be input. The total number of inputs for the path length matrix is NZLEVEL*NHSS*(NHSS+1)/2. Only the diagonal and upper off-diagonal elements of the path length matrix are required for input. The lower off-diagonal elements of the path length matrix are required for input. The lower off-diagonal elements will be calculated based on reciprocity. The PATHL array is dimensioned by (NHSS, NHSS, NZLEVEL). PATHL(i, j, k) is the path length from surface i to surface j for axial level k.

For the jth RADENC HS surface for a given axial level the number of path lengths input for that surface is NHSS - j + 1. Input using load format path(j, j:NHSS,1), for j = 1, then terminate with an **e**. Then input path (j, j:NHSS, 1) for j = 2 and terminate with an **e**. Continue until j = NHSS, then go to the next level. The following example is for a NHSS = 3 and NZLEVEL = 2.

*** for level 1**

PL11 PL12 PL13 e

PL22 PL23 e

PL33 e

*** for level 2**

PL11 PL12 PL13 e

PL22 PL23 e

PL33 e

Where PL12 is the path length from surface 1 to 2, etc. PL11 is average path length for radiation heat transfer if surface 1 can see itself. Note a zero path length paired with a non-zero view factor implies that the fluid between the two surfaces does not participate in the radiation heat transfer (i.e., no absorption or emission of radiation HT along that path length due to the presence of fluid such as steam, water droplets, etc.).

SEPD Component Data

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (SEPD left justified).
NUM	Component ID number (must be unique for each component, $1 \leq \text{NUM} \leq 999$).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2A14) **EOS, PHASECHANGE**

Note: Only input this card when the number of inputs for FLUIDS (a NAMELIST variable) is more than one.

Variable	Description
EOS	EOS identifier for this component (i.e. "h2o" or "r5h2o", etc.).
PHASECHANGE	Phase change flag. Input TRUE or true, if phase change is allowed for this component. Input FALSE or false, if phase change is not allowed for this component.

Card Number 3. (Format 3I14,2E14.4) **JCELL, NODES, ICHF, COST, EPSW**

Variable	Description
JCELL	Main-tube cell number that has the side tube connected to it.
NODES	Number of radial heat-transfer nodes in the wall. A value of zero specifies no wall heat transfer.

Card Number 3. (Format 3I14,2E14.4) **JCELL, NODES, ICHF, COST, EPSW** (Continued)

Variable	Description
ICHF	CHF-calculation option. 0 = convection heat transfer only, no boiling heat transfer (i.e. no wall nucleation is allowed although phase change can still occur); 1 = CHF from AECL-IPPE CHF Table, no critical quality calculated. 2 = CHF from AECL-IPPE CHF Table, critical quality from Biasi correlation. 3 = CHF from AECL-IPPE CHF Table, critical quality from CISE-GE correlation.
COST	Cosine of the angle from the low-numbered cell portion of the main tube to the side tube.
EPSW	Wall surface roughness (m, ft).

Card Number 4. (Format 3I14,2E14.4) **NSEPS, NDRYR, ISTAGE, XCO, XCU**

Variable	Description
NSEPS	Number of physical separators modeled. This value must always be greater than 0.
NDRYR	Dryer activation flag. NDRYR = 0 implies that dryers are not modeled. Dryers are modeled when NDRYR ≠ 0.
ISTAGE	Separator-type option. –3 = three-stage mechanistic separator that uses default geometric data (three-stage GE-BWR separator); –2 = two-stage mechanistic separator that uses default geometric data (two-stage GE-BWR separator); 0 = ideal separator, uses constant user-input values of XCO and XCU; 1 = separator carryover and carryunder determined by control-block variables ICBS1 and ICBS2 on **Card Number 7**. **Note:** The user must provide the performance data for the modeled separators; 2 = two-stage mechanistic separator where the user inputs the geometric data (two-stage GE-BWR separator); 3 = three-stage mechanistic separator where the user inputs the geometric data (three-stage GE-BWR separator).
XCO	Separator carryover (–), the liquid mass flow divided by the total mass flow evaluated at the JCELL + 1 interface. If XCO < 0.0, the default value of 0.03 is used.

Card Number 4. (Format 3I14,2E14.4) **NSEPS, NDRYR, ISTAGE, XCO, XCU** (Continued)

Variable	Description
XCU	Separator carryunder (–), the vapor mass flow divided by the total mass flow, evaluated at the NCELL1 + 2 internal-junction interface. If XCU < 0.0, the default value of 0.005 is used.

Card Number 5. (Format 2E14.4) **ALPSMN, ALPSMX**

Note: If ISTAGE = 0 input this card.

Variable	Description
ALPSMN	Minimum void fraction set for the separator barrel
ALPSMX	Maximum void fraction set for the separator barrel

Card Number 6. (Format 3E14.4) **VDRYL, DVRYU, DELDIM**

Note: If NDRYR = 0 (Word 2 on **Card Number 4**), do not input this card. If 0.0 is entered for VDRYL, DVRYU, or DELDIM then a default value is used. The default values are: 1000.0, 1001.0 and 1.0 for VDRYL, VDRYU and DELDIM, respectively.

Variable	Description
VDRYL	Vapor velocity in dryer below which dryer capacity is 1.0 (m/s, ft/s).
VDRYU	Vapor velocity in dryer above which dryer capacity is 0.0 (m/s, ft/s).
DELDIM	Range of dryer inlet liquid quality over which dryer capacity degrades from 1.0 to 0.0 at fixed inlet vapor velocity.

Card Number 7. (Format 2I14) **ICBS1, ICBS2**

Note: If ISTAGE = 0 (Word 3 on **Card Number 4**), do not input this card.	
Variable	**Description**
ICBS1	When ISTAGE=1, ICBS1 is the control-block ID number (ICBS1 < 0) which defines the separator carryover [the liquid mass flow divided by the total mass flow evaluated at the JCELL + 1 (Word 1 on **Card Number 3**) interface]. When ISTAGE = -3, -2, 2 or 3 (mechanistic separator), ICBS1 is the signal variable for the water level surrounding the separator barrel.
ICBS2	When ISTAGE=1, ICBS2 is the control-block ID number (ICBS2 < 0) which defines the separator carryunder [the vapor mass flow divided by the total mass flow evaluated at the NCELL1 + 2 (Word 2 on **Card Number 9**) internal-junction interface]. For other values of ISTAGE, this parameter has no meaning.

Card Number 8. (Format 5E14.4) **AI, AN, RH, THETA, RR1**

Note: If ISTAGE < 2 (Word 3 on **Card Number 4**), do not input this card.	
Variable	**Description**
AI	Standpipe flow area (m^2, ft^2). If AI $\leq$ 0.0 m^2 (0.0 ft^2), the default value of 1.8637×10^{-2} m^2 (2.0061×10^{-1} ft^2) is used.
AN	Nozzle-exit area (m^2, ft^2). If AN $\leq$ 0.0, the default value of 1.4411×10^{-2} m^2 (1.5512×10^{-1} ft^2) is used.
RH	Radius (m, ft) of separator hub at inlet. If RH $\leq$ 0.0, the default value of 8.09585×10^{-2} m (2.65612×10^{-1} ft) is used.
THETA	Angle (rad, deg) of separator swirling vane. If THETA $\leq$ 0.0, the default value of 8.3776×10^{-1} rad (4.8000×10^{1} deg) is used.
RR1	Radius (m, ft) of separator pickoff ring. If RR1 $\leq$ 0.0, the default value of 8.57208×10^{-2} m (2.81236×10^{-1} ft) is used.

Card Number 9. (Format 5I14) **ICONC1, NCELL1, JUN1, JUN2, IPOW1**

Variable	Description
ICONC1	Solute in the main-tube coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC1 > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.
NCELL1	Number of fluid cells in the main tube.
JUN1	Junction number for the junction interface adjacent to cell 1.
JUN2	Junction number for the junction interface adjacent to cell NCELL1.
IPOW1	Power-to-the-fluid option in the main tube. 0 = no; 1 = yes.

Card Number 10. (Format 5I14) **IPWTR1, IPWSV1, NPWTB1, NPWSV1, NPWRF1**

Note: If IPOW1 = 0 (Word 5 on **Card Number 9**), do not input this card.

Variable	Description
IPWTR1	Trip ID number that controls evaluation of the power-to-the-fluid table defined by **Card Set 52** (array POWTB1) for the main tube ($\|IPWTR1\| \leq 9999$). [Input IPWTR1 = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation].
IPWSV1	The independent-variable ID number for the power-to-the-fluid table for the main tube. IPWSV1 > 0 defines the ID number for a signal-variable parameter; IPWSV1 < 0 defines the ID number for a control-block output parameter.
NPWTB1	The number of power-to-the-fluid table data pairs for the main tube (defined by the absolute value of NPWTB1). NPWTB1 > 0 defines the table independent-variable form to be the IPWSV1 parameter; NPWTB1 < 0 defines the table independent-variable form to be the sum of the change in the IPWSV1 parameter each last timestep times the trip set-status value ISET during that timestep (when the power-to-the-fluid table is trip controlled); NPWTB1 = 0 defines the power to the fluid to be the IPWSV1 parameter.

Card Number 10. (Format 5I14) **IPWTR1, IPWSV1, NPWTB1, NPWSV1, NPWRF1** (Continued)

Note: If IPOW1 = 0 (Word 5 on **Card Number 9**), do not input this card.

Variable	Description
NPWSV1	The independent-variable ID number for the rate factor that is applied to the main-tube power-to-the-fluid table independent variable. NPWSV1 > 0 defines the ID number for a signal-variable parameter; NPWSV1 < 0 defines the ID number for a control-block output parameter; NPWSV1 = 0 (when NPWRF1 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-fluid table is trip controlled.
NPWRF1	The number of rate-factor table data pairs (defined by the absolute value of NPWRF1). The rate factor is applied as a factor to the main-tube power-to-the-fluid table independent variable when the rate factor is defined. No rate factor is defined when NPWSV1 and NPWRF1 are both zero. NPWRF1 > 0 defines the rate-factor table independent variable to be the NPWSV1 parameter; NPWRF1 < 0 defines it to be the sum of change in the NPWSV1 parameter over each timestep times the trip set-status value ISET during the timestep (when the main-tube power-to-the-fluid table is trip controlled); NPWRF1 = 0 defines the rate factor to be the NPWSV1 parameter.

Card Number 11. (Format 5I14) **IQPTR1, IQPSV1, NQPTB1, NQPSV1, NQPRF1**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 43**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Variable	Description
IQPTR1	Trip ID number that controls evaluation of the power-to-the-wall table defined by **Card Set 54** (array QP3TB1) for the main tube (|IQPTR1| ≤ 9999). [Input IQPTR1 = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation].
IQPSV1	The independent-variable ID number for the main-tube power-to-the-wall table. IQPSV1 > 0 defines the ID number for a signal-variable parameter; IQPSV1 < 0 defines the ID number for a control-block output parameter.
NQPTB1	The number of power-to-the-wall table data pairs for the main tube (defined by the absolute value of NQPTB1). NQPTB1 > 0 defines the table independent-variable form to be the IQPSV1 parameter; NQPTB1 < 0 defines the table independent-variable form to be the sum of the change in the IQPSV1 parameter over each timestep times the trip set-status value ISET during each timestep (when the power-to-the-wall table is trip controlled); NQPTB1 = 0 defines the power to the wall to be the IQPSV1 parameter.

Card Number 11. (Format 5I14) **IQPTR1, IQPSV1, NQPTB1, NQPSV1, NQPRF1** (Continued)

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 43**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Variable	Description
NQPSV1	The independent-variable ID number for the rate factor that is applied to the main-tube power-to-the-wall table independent variable. NQPSV1 > 0 defines the ID number for a signal-variable parameter; NQPSV1 < 0 defines the ID number for a control-block output parameter; NQPSV1 = 0 (when NQPRF1 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-wall table is trip controlled.
NQPRF1	The number of rate-factor table data pairs (defined by the absolute value of NQPRF1). The rate factor is applied as a factor to the main-tube power-to-the-wall table independent variable when the rate factor is defined. No rate factor is defined when NQPSV1 and NQPRF1 are both zero. NQPRF1 > 0 defines the rate-factor table independent variable to be the NQPSV1 parameter; NQPRF1 < 0 defines it to be the sum of the change in the NQPSV1 parameter over each timestep times the trip set-status value ISET during that timestep (when the main-tube power-to-the-wall table is trip controlled); NQPRF1 = 0 defines the rate factor to be the NQPSV1 parameter.

Card Number 12. (Format 5E14.4) **RADIN1, TH1, HOUTL1, HOUTV1, TOUTL1**

Note: The four parameters, HOUTL, HOUTV, TOUTL, and TOUTV, allow flexibility in calculating possible heat losses from the outside of the main-tube wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
RADIN1	Inner radius (m, ft) of the main-tube wall.
TH1	Wall thickness (m, ft) of the main tube.
HOUTL1	Heat-transfer coefficient (HTC) [W/(m^2 K), Btu/(ft °F hr)] between outer boundary of the main-tube wall and the liquid outside the main-tube wall.
HOUTV1	HTC [W/(m^2 K), Btu/(ft °F hr)] between the outer boundary of the main-tube wall and the gas outside the main-tube wall.

Card Number 12. (Format 5E14.4) **RADIN1, TH1, HOUTL1, HOUTV1, TOUTL1** (Continued)

	Note: The four parameters, HOUTL, HOUTV, TOUTL, and TOUTV, allow flexibility in calculating possible heat losses from the outside of the main-tube wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.
Variable	**Description**
TOUTL1	Liquid temperature (K, °F) outside the main-tube wall.

Card Number 13. (Format 5E14.4) **TOUTV1, PWIN1, PWOFF1, RPWMX1, PWSCL1**

Variable	Description
TOUTV1	Gas temperature (K, °F) outside the main-tube wall.
PWIN1	Initial total power (W, Btu/hr) deposited in (to) the main-tube fluid [not used when IPOW1 = 0 (Word 5 on **Card Number 9**)]. The power is distributed uniformly along the JETP main-tube length.
PWOFF1	Total power (W, Btu/hr) to the main-tube fluid when the controlling trip is OFF after being ON [not used if IPOW1 = 0 (Word 5 on **Card Number 9**) or IPWTR1 = 0 (Word 1 on **Card Number 10**)]. If PWOFF1 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr), the power to the fluid is held constant at the last table-evaluated power when the trip was ON.
RPWMX1	The maximum rate of change of the main-tube power to the fluid (W/s, [Btu/hr)/s] [RPWMX1 $\geq$ 0.0] [not used if IPOW1 = 0 (Word 5 on **Card Number 9**)].
PWSCL1	Scale factor (–) for the power-to-the-fluid table. The dependent variable in the table, defined by **Card Set 52** (array POWTB1), is multiplied by PWSCL1 to obtain absolute power (W, Btu/hr) deposited in the fluid [not used if IPOW1 = 0 (Word 5 on **Card Number 9**) or NPWTB1 = 0 (Word 3 on **Card Number 10**)].

Card Number 14. (Format 4E14.4, I14) **QPIN1, QPOFF1, RQPMX1, QPSCL1, NHCOM**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card.

Variable	Description
QPIN1	Initial power (W, Btu/hr) deposited in (to) the main-tube wall and distributed according to the QPPP array. If QPIN1 > 0.0, it is the total power to the entire wall. When QPIN1 < 0.0, the initial power to the wall in each cell is |QPIN1|, and the negative sign indicates the power to the wall is to be a cell-dependent array of NCELL1 (Word 2 on **Card Number 9**) power values. Each data pair of the power-to-the-wall table [for QPIN1 < 0.0] has 1 + NCELL1 values (an independent-variable value and NCELL1 power values for cells 1 through NCELL1). When the power-to-the-wall table is not being evaluated, the same power value of |QPIN1| or QPOFF1 [if QPOFF1 > -10^{19} W (-3.41×10^{19} Btu/hr)] is applied at each of the NCELL1 cells.
QPOFF1	Power (W, Btu/hr) to the main-tube wall when the controlling trip is OFF after being ON [not used if IQPTR1 = 0 (Word 1 on **Card Number 11**); use the last table-evaluated power when the trip was ON if QPOFF1 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr)].
RQPMX1	Maximum rate of change of the power to the wall for the main tube [W/s, (Btu/hr)/s] [RQPMX1 ≥ 0.0].
QPSCL1	Scale factor (–) for the power-to-the-wall table for the main tube. The dependent variable in the table defined by **Card Set 54** (array QP3TB1) is multiplied by QPSCL1 to obtain the absolute power (W, Btu/hr) to the wall.
NHCOM	Component number receiving outside wall energy.

Card Number 15. (Format 4I14) **ICONC2, NCELL2, JUN3, IPOW2**

Variable	Description
ICONC2	Solute in the side-tube coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC2 > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.
NCELL2	Number of fluid cells in the side tube.
JUN3	Junction number at the external-junction end of the side tube adjacent to cell NCELL2.

SEPD Component Data

Card Number 15. (Format 4I14) **ICONC2, NCELL2, JUN3, IPOW2** (Continued)

Variable	Description
IPOW2	Power-to-the-fluid option in the side tube. 0 = no; 1 = yes.

Card Number 16. (Format 5I14) **IPWTR2, IPWSV2, NPWTB2, NPWSV2, NPWRF2**

Note: If IPOW2 = 0 (Word 4 on **Card Number 15**), do not input this card.

Variable	Description
IPWTR2	Trip ID number that controls evaluation of the power-to-the-fluid table defined by **Card Set 85** (array POWTB2) for the side tube (|IPWTR2| ≤ 9999). [input IPWTR2 = 0 if there is to be no trip control and the table is to be evaluated every timestep of the transient calculation].
IPWSV2	The independent-variable ID number of the power-to-the-fluid table for the side tube. IPWSV2 > 0 defines the ID number for a signal-variable parameter; IPWSV2 < 0 defines the ID number for a control-block output parameter.
NPWTB2	The number of power-to-the-fluid table data pairs for the side tube (defined by the absolute value of NPWTB2). NPWTB2 > 0 defines the table independent-variable form to be the IPWSV2 parameter; NPWTB2 < 0 defines the table's independent-variable form to be the sum of the change in the IPWSV2 para-meter over the last timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-fluid table is trip controlled); NPWTB2 = 0 defines the power to the fluid to be the IPWSV2 parameter.
NPWSV2	The independent-variable ID number for the rate factor that is applied to the side-tube power-to-the-fluid table independent variable. NPWSV2 > 0 defines the ID number for a signal-variable parameter; NPWSV2 < 0 defines the ID number for a control-block output parameter; NPWSV2 = 0 (when NPWRF2 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-fluid table is trip controlled.
NPWRF2	The number of rate-factor table data pairs (defined by the absolute value of NPWRF2). The rate factor is applied as a factor to the side-tube power-to-the-fluid table independent variable when the rate factor is defined. No rate factor is defined when NPWSV2 and NPWRF2 are both zero. NPWRF2 > 0 defines the rate-factor table independent variable to be the NPWSV2 parameter; NPWRF2 < 0 defines it to be the sum of the change in the NPWSV2 parameter over the last timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-fluid table is trip controlled); NPWRF2 = 0 defines the rate factor to be the NPWSV2 parameter.

Card Number 17. (Format 5I14) **IQPTR2, IQPSV2, NQPTB2, NQPSV2, NQPRF2**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 76**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Variable	Description
IQPTR2	Trip ID number that controls evaluation of the power-to-the-wall table defined by **Card Set 87** (array QP3TB2) for the side tube ($\|IQPTR2\| \leq 9999$). (Input IQPTR2 = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation).
IQPSV2	The independent-variable ID number for the side-tube power-to-the-wall table. IQPSV2 > 0 defines the ID number for a signal-variable parameter; IQPSV2 < 0 defines the ID number for a control-block output parameter.
NQPTB2	The number of power-to-the-wall table data pairs for the side tube (defined by the absolute value of NQPTB2). NQPTB2 > 0 defines the table independent-variable form to be the IQPSV2 parameter; NQPTB2 < 0 defines the table independent-variable form to be the sum of the change in the IQPSV2 parameter over each timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-wall table is trip controlled); NQPTB2 = 0 defines the power to the wall to be the IQPSV2 parameter.
NQPSV2	The independent-variable ID number for the rate factor that is applied to the side-tube power-to-the-wall table independent variable. NQPSV2 > 0 defines the ID number for a signal-variable parameter; NQPSV2 < 0 defines the ID number for a control-block output parameter; NQPSV2 = 0 (when NQPRF2 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-wall table is trip controlled.
NQPRF2	The number of rate-factor table data pairs (defined by the absolute value of NQPRF2). The rate factor is applied as a factor to the side-tube power-to-the-wall table independent variable when the rate factor is defined. No rate factor is defined when NQPSV2 and NQPRF2 are both zero. NQPRF2 > 0 defines the rate-factor table independent variable to be the NQPSV2 parameter; NQPRF2 < 0 defines it to be the sum of the change in the NQPSV2 parameter over each timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-wall table is trip controlled); NQPRF2 = 0 defines the rate factor to be the NQPSV2 parameter.

Card Number 18. (Format 5E14.4) **RADIN2, TH2, HOUTL2, HOUTV2, TOUTL2**

Note: The four parameters, HOUTL2, HOUTV2, TOUTL2, and TOUTV2, allow flexibility in calculating possible heat losses from the outside of the side-tube wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
RADIN2	Inner radius (m, ft) of the side-tube wall.
TH2	Wall thickness (m, ft) of the side tube.
HOUTL2	Heat-transfer coefficient (HTC) [W/(m^2 K), Btu/(ft °F hr)] between the outer boundary of the side-tube wall and the liquid outside the side-tube wall.
HOUTV2	HTC [W/(m^2 K), Btu/(ft °F hr)] between the outer boundary of the side-tube wall and the gas outside the side-tube wall.
TOUTL2	Liquid temperature (K, °F) outside the side-tube wall.

Card Number 19. (Format 5E14.4) **TOUTV2, PWIN2, PWOFF2, RPWX2, PWSCL2**

Variable	Description
TOUTV2	Gas temperature (K, °F) outside the side-tube wall.
PWIN2	Initial total power (W, Btu/hr) deposited in (to) the side-tube fluid [not used when IPOW2 = 0 (Word 4 on **Card Number 15**)]. The power is distributed uniformly along the side-tube length.
PWOFF2	Total power (W, Btu/hr) to the side-tube fluid when the controlling trip is OFF after being ON [not used when IPOW2 = 0 (Word 4 on **Card Number 15**) or IPWTR2 = 0 (Word 1 on **Card Number 16**)]. If PWOFF2 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr), the power to the fluid is held constant at the last table-evaluated power when the trip was ON.
RPWMX2	Maximum rate of change of the side-tube power to the fluid [W/s, (Btu/hr)/s] [RPWMX1 $\geq$ 0.0] [not used if IPOW2 = 0 (Word 4 on **Card Number 15**)].

Card Number 19. (Format 5E14.4) **TOUTV2, PWIN2, PWOFF2, RPWX2, PWSCL2** (Continued)

Variable	Description
PWSCL2	Scale factor (–) for the power-to-the-fluid table. The dependent variable in the table defined by **Card Set 85** (array POWTB2) is multiplied by PWSCL2 to obtain the absolute power (W, Btu/hr) to the fluid [not used if IPOW2 = 0 (Word 4 on **Card Number 15**) or NPWTB2 = 0 (Word 3 on **Card Number 16**)].

Card Number 20. (Format 4E14.4) **QPIN2, QPOFF2, RQPMX2, QPSCL2**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card.

Variable	Description
QPIN2	Initial power (W, Btu/hr) deposited in (to) the side-tube wall and distributed according to the QPPP array. If QPIN2 > 0.0, it is the total power to the entire wall. When QPIN2 < 0.0, the initial power to the wall in each cell is |QPIN2|, and the negative sign indicates the power to the wall is to be a cell-dependent array of NCELL2 (Word 2 on **Card Number 15**) power values. Each data pair of the power-to-the-wall table [for QPIN2 < 0.0] has 1+NCELL2 values (an independent-variable value and NCELL2 power values for cells 1 through NCELL2). When the power-to-the-wall table is not being evaluated, the same power value of |QPIN2| or QPOFF2 [if QPOFF2 > -10^{19} W (-3.41×10^{19} Btu/hr)] is applied at each of the NCELL2 cells.
QPOFF2	Power (W, Btu/hr) to the side-tube wall when the controlling trip is OFF after being ON [not used if IQPTR2 = 0 (Word 1 on **Card Number 17**); the last table-evaluated power when the trip was ON if QPOFF2 ≤ -10^{19} W (-3.41×10^{19} Btu/hr)].
RQPMX2	Maximum rate of change of the power to the wall for the side-tube [W/s, (Btu/hr)/s] [RQPMX2 ≥ 0.0].
QPSCL2	Scale factor (–) for the power-to-the-wall table for the side-tube. The dependent variable in table defined by **Card Set 87** (array QP3TB2) is multiplied by QPSCL2 to obtain the absolute power (W, Btu/hr) to the wall.

SEPD Component Data

Card Number 21. (Format I14) **IENTRN**

Note: If NAMELIST variable IOFFTK = 0, do not input this card.	
Variable	**Description**
IENTRN	Offtake-model option. 0 = off; 1 = on (side tube internal-junction mass flow determined using offtake model).

SEPD Array Cards

Note: Input each of the following arrays using LOAD format.

All junction variables must match at component interfaces.

Model no flow-area change between cell JCELL and cells JCELL±1 and between the internal-junction interface and the side-tube first cell. A VOL/DX flow-area change between cell JCELL and cells JCELL±1 and their interface FA and between side-tube cell 1 and the internal-junction interface will not have any evaluated effect on flow from the current JCELL-interface momentum equations evaluated by TRACE.

Primary Side Array Cards

Card Set Number	Variable	Dimension	Description
22	DX	NCELL1	Main-tube cell lengths (m, ft).
23	VOL	NCELL1	Main-tube cell volumes (m^3, ft^3).
24	FA	NCELL1+1	Main-tube cell-edge flow areas (m^2, ft^2).
25	FRIC	NCELL1+1	Main-tube additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input.

Card Set Number	Variable	Dimension	Description
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
26	**FRICR**	NCELL1+1	Main-tube additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input.
27	**GRAV or ELEV**	NCELL1+1 (NCELL1 for ELEV)	Main-tube gravity or elevation terms [(– or m), (– or ft)]. GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.
28	**HD**	NCELL1+1	Main-tube hydraulic diameters (m, ft). (See NAMELIST variable NDIA1 for additional input of heat-transfer diameters).
Note: If NAMELIST variable NDIA1 ≠ 2 do not input array HD-HT.			
29	**HD-HT**	NCELL1+1	Main-tube heat transfer diameters (m, ft).
Note: If NAMELIST variable ICFLOW = 0 or 1, do not input array ICFLG.. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur..			
30	**ICFLG**	NCELLS+1	Main-tube cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.
31	**NFF**	NCELL1+1	Main-tube friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE.

Card Set Number	Variable	Dimension	Description
Note: If NCCFL = 0 (Word 5 on **Main-Data Card 9**), do not input array LCCFL.			
32	**LCCFL**	NCELL1+1	Main-tube countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
33	**ALP**	NCELL1	Main-tube initial gas volume fractions (–).
34	**VL**	NCELL1+1	Main-tube initial liquid velocities (m/s, ft/s).
35	**VV**	NCELL1+1	Main-tube initial gas velocities (m/s, ft/s).
36	**TL**	NCELL1	Main-tube initial liquid temperatures (K, °F).
37	**TV**	NCELL1	Main-tube initial gas temperatures (K, °F).
38	**P**	NCELL1	Main-tube initial pressures (Pa, psia).
39	**PA**	NCELL1	Main-tube initial noncondensable-gas partial pressures (Pa, psia).
Note: If NAMELIST variable NOLT1D = 1 do not input array ILEV.			
40	**ILEV**	NCELL1	Level tracking flags. ILEV = 1.0 indicates that the two-phase level exists in the current cell. ILEV = 0.0 indicates that the two-phase level does not exist in the current cell. If ILEV = -1.0, the level tracking calculation will be turned off for this cell.
Note: If NAMELIST variable MWFL = 0, do not input array WFMFL.			
41	**WFMFL**	NCELL1+1	Main-tube wall-friction multiplier factor for the liquid phase (0.9 ≤ WFMFL ≤ 1.1).
Note: If NAMELIST variable MWFV = 0, do not input array WFMFV			
42	**WFMFV**	NCELL1+1	Main-tube wall-friction multiplier factor for the gas phase (–) (0.9 ≤ WFMFL ≤ 1.1).

Card Set Number	Variable	Dimension	Description
Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input arrays QPPP, MATID, TW, IDROD, and NHCEL.			
43	**QPPP**	NODES × NCELL1	A relative power shape (–) in the main-tube wall. Input values for cell 1, node 1 through NODES; then cell 2, node 1 through NODES; etc. If the array is filled with the same nonzero constant, a uniform volumetric heat source in the wall results. TRACE internally normalizes the power shape to have a volume-averaged value of unity {each QPPP(I) is normalized to have the value QPPP(I) × [Σ_K VOL(K)]/{Σ_K QPPP(K) × VOL(K)]}. Filling the array with zeros results in no power being deposited in the wall regardless of the value of QPIN1, QPTB1, etc.
44	**MATID**	NODES-1	Wall-material ID array, which specifies material ID between radial nodes. Dimension is 1 if NODES = 1. 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 12 = inconel, type 600.
45	**TW**	NODES × NCELL1	Initial wall temperatures (K, °F) in the main tube, which are input in the same order as QPPP.
Note: If NHCOM > 0 (Word 5 on **Card Number 14**) input IDROD.			
46	**IDROD**	1	Vessel radial-theta cell number or input 0 when NHCOM is a 1D component.
Note: If NHCOM>0 (Word 5 on **Card Number 14**) input NHCEL.			
47	**NHCEL**	NCELL1	Connecting axial cell numbers in component NHCOM.
Note: If ICONC1 = 0 (Word 1 on **Card Number 9**), do not input array CONC.			
48	**CONC**	NCELL1	Initial solute mass to liquid-coolant mass ratio [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)] in the main tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).

SEPD Component Data

Card Set Number	Variable	Dimension	Description
Note: If ICONC1 = 0 or 1 (Word 1 on **Card Number 9**), do not input array S.			
49	**S**	NCELL1	Initial macroscopic density of plated-out solute (kg/ m^3, $lb_m/ft^{3)}$ in the main tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
50	**XGNB**	NCELL1	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).
Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
51	**XLNB**	NCELL1	Mass fraction for liquid trace species.
Note: If IPOW1 = 0 (Word 5 on **Card Number 9**), do not input array POWTB1.			
52	**POWTB1**	2×|NPWTB 1|	Power-to-the-fluid vs independent-variable-form table [(*, W) (*, Btu/hr)] for the main tube. Input |NPWTB1| (Word 3 on **Card Number 10**) table-defining data pairs having the following form [independent-variable form defined by IPWSV1 (Word 2 on **Card Number 10**), power to the fluid]. The power is deposited directly into the main-tube fluid with a uniform power density along the main-tube length.
Note: If IPOW1 = 0 (Word 5 on **Card Number 9**), do not input array POWRF1.			
53	**POWRF1**	2×|NPWRF 1|	Rate-factor table (*,–) for the main-tube power-to-the-fluid table independent variable. Input |NPWRF1| (Word 5 on **Card Number 10**) table-defining data pairs having the following form [independent-variable form defined by NPWSV1 (Word 4 on **Card Number 10**), rate factor to be applied to the power-to-the-fluid table independent variable].

Card Set Number	Variable	Dimension	Description
Note: If NQPTB1 = 0 (Word 3 on **Card Number 11**) or if NODES = 0 (Word 2 on **Card Number 3**), do not input array QP3TB1.			
54	**QP3TB1**	2× |NQPTB1| when QPIN1 > 0.0; (1+NCELL1) ×|NQPTB1| when QPIN1 < 0.0.	Power-to-the-wall independent-variable-form table [(*,W) (*,Btu/hr)] for the main tube. Input |NQPTB1| (Word 3 on **Card Number 11**) table-defining data pairs having the following form [independent-variable form defined by IQPSV1 (Word 2 on **Card Number 11**), power to the wall]. If QPIN1 > 0.0, the dependent variable specifies the total power to the entire wall; if QPIN1 < 0.0, the dependent variable is a power shape that specifies the power to the wall at each cell from cell 1 to NCELL1.

SEPD Component Data

Side Arm Array Cards

Note: If NCELL2 = 0 (Word 2 on **Card Number 15**), only input FA, FRIC, GRAV, HD, NFF, LCCFL, VL, and VV array cards.

Card Set Number	Variable	Dimension	Description
55	**DX**	NCELL2	Side-tube cell lengths (m, ft).
56	**VOL**	NCELL2	Side-tube cell volumes (m^3, ft^3).
57	**FA**	NCELL2+1	Side-tube cell-edge flow areas (m^2, ft^2).
58	**FRIC**	NCELL2+1	Side-tube additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input. Input FRIC > 0.0 for internal-junction interface 1 of the side tube when a VOL/DX flow-area change occurs between JCELL and cell 1 of the side tube.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			

Card Set Number	Variable	Dimension	Description
59	**FRICR**	NCELL2+1	Side-tube additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input. Input FRICR > 0.0 for internal-junction interface 1 of the side tube when a VOL/DX flow-area change occurs between JCELL and cell 1 of the side tube.
60	**GRAV or ELEV**	NCELL2+1 (NCELL2 for ELEV)	Side-tube gravity elevation terms [(– or m), (– or ft)]. GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.
61	**HD**	NCELL2+1	Side-tube hydraulic diameters (m, ft) (see NAMELIST variable NDIA1 for additional input of heat-transfer diameters).
Note: If NAMELIST variable NDIA1 /= 2 do not input array HD-HT.			
62	**HD-HT**	NCELL2+1	Side-tube heat transfer diameters (m, ft).
Note: If NAMELIST variable ICFLOW = 0 or 1, do not input array ICFLG. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur...			
63	**ICFLG**	NCELL2+1	Side-tube cell-edge choked-flow model option. Cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.

Card Set Number	Variable	Dimension	Description
64	**NFF**	NCELL2+1	Side-tube friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE. Input NFF ≥ 0 for the JCELL and JCELL+1 interfaces.
Note: If NCCFL = 0 (Word 5 **Main-Data Card 9**), do not input array LCCFL.			
65	**LCCFL**	NCELL2+1	Side-tube countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
66	**ALP**	NCELL2	Side-tube initial gas volume fractions (–).
67	**VL**	NCELL2+1	Side-tube initial liquid velocities (m/s, ft/s).
68	**VV**	NCELL2+1	Side-tube initial gas velocities (m/s, ft/s).
69	**TL**	NCELL2	Side-tube initial liquid temperatures (K, °F).
70	**TV**	NCELL2	Side-tube initial gas temperatures (K, °F).
71	**P**	NCELL2	Side-tube initial pressures (Pa, psia).
72	**PA**	NCELL2	Side-tube initial noncondensable-gas partial pressures (Pa, psia).

SEPD Component Data

Card Set Number	Variable	Dimension	Description
Note: If NAMELIST variable NOLT1D = 1 do not input array ILEV.			
73	**ILEV**	NCELL2	Level tracking flags. ILEV = 1.0 indicates that the two-phase level exists in the current cell. ILEV = 0.0 indicates that the two-phase level does not exist in the current cell. If ILEV = -1.0, the level tracking calculation will be turned off for this cell.
Note: If NAMELIST variable MWFL = 0, do not input array WFMFL.			
74	**WFMFL**	NCELL2+1	Side-tube wall-friction multiplier factor for the liquid phase (–) ($0.9 \leq$ WFMFL ≤ 1.1).
Note: If NAMELIST variable MWFV = 0, do not input array WFMFV.			
75	**WFMFV**	NCELL2+1	Side-tube wall-friction multiplier factor for the gas phase (–) ($0.9 \leq$ WFMFL ≤ 1.1).
Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input arrays QPPP, MATID, TW, IDROD, and NHCEL.			
76	**QPPP**	NODES × NCELL2	A relative power shape (–) in the side-tube wall. Input values for cell 1, node 1 through NODES; then cell 2, node 1 through NODES; etc. If the array is filled with the same nonzero constant, a uniform volumetric heat source in the wall results. TRACE internally normalizes the power shape to have a volume-average value of unity (each QPPP(I) is normalized to have the value QPPP(I) × [Σ_K VOL(K)]/[Σ_K QPPP(K) × VOL(K)]). Filling the array with zeros results in no power being deposited in the wall regardless of the values of QPIN2, QPTB2, etc.
77	**MATID**	NODES-1	Wall-material ID array, which specifies material ID between radial nodes. Dimension is 1 if NODES = 1. 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 12 = inconel, type 600.
78	**TW**	NODES × NCELL2	Initial wall temperatures (K, °F) in the side tube, which are input in the same order as QPPP.

Card Set Number	Variable	Dimension	Description
Note: If NHCOM > 0 (Word 5 on **Card Number 14**) then input array IDROD.			
79	**IDROD**	1	Vessel radial-theta cell number or input 0 when NHCOM is a 1D component.
Note: If NHCOM > 0 (Word 5 on **Card Number 14**) then input array NHCEL.			
80	**NHCEL**	NCELL2	Connecting axial cell numbers in component NHCOM.
Note: If ICONC2 = 0 (Word 1 on **Card Number 15**), do not input array CONC.			
81	**CONC**	NCELL2	Initial solute mass to liquid-coolant mass ratio [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)] in the side tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: If ICONC2 = 0 or 1 (Word 1 on **Card Number 15**), do not input array S.			
82	**S**	NCELL2	Initial macroscopic density of plated-out solute (kg/m^3, lb_m/ft^3) in the side tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
83	**XGNB**	NCELL2	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).
Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
84	**XLNB**	NCELL2	Mass fraction for liquid trace species.

Card Set Number	Variable	Dimension	Description
Note: If IPOW2 = 0 (Word 5 on **Card Number 15**), do not input array POWTB2.			
85	**POWTB2**	2×|NPWTB2|	Power-to-the-fluid vs. independent-variable-form table [(*,W), (*,Btu/hr)] for the side tube. Input |NPWTB2| (Word 3 on **Card Number 16**) table-defining data pairs having the following form [independent-variable form defined by IPWSV2 (Word 2 on **Card Number 16**), power to the fluid]. The power is deposited directly into the side-tube fluid with a uniform volumetric power density along the JETP side-tube length.
Note: If IPOW2 = 0 (Word 5 on **Card Number 15**), do not input array POWRF2.			
86	**POWRF2**	2×|NPWRF2|	Rate-factor table (*,–) for the side-tube power-to-the-fluid table independent variable. Input |NPWRF2| (Word 5 on **Card Number 16**) table-defining data pairs having the following form [independent-variable form defined by NPWSV2 (Word 4 on **Card Number 16**), rate factor to be applied to the power-to-the-fluid table independent variable].
Note: If NQPTB2 = 0 (Word 3 on **Card Number 17**) or if NODES = 0 (Word 2 on **Card Number 3**), do not input array QP3TB2.			
87	**QP3TB2**	2×|NQPTB2| when QPIN2>0.0; (1+NCELL2) ×|NQPTB2| when QPIN2<0.0.	Power-to-the-wall vs independent-variable form table [(*,W), (*,Btu/hr)] for the side tube. Input |NQPTB2| (Word 3 on **Card Number 17**) table-defining data pairs having the following form [independent-variable form defined by IQPSV2 (Word 2 on **Card Number 17**), power to the wall]. If QPIN2 > 0.0, the dependent variable specifies the total power to the entire wall; if QPIN2 < 0.0, the dependent variable is a power shape that specifies the power to the wall at each cell from cell NCELL1 + 2 to cell NCELL1 + 1 + NCELL2.

Separator Array Data

Note: If ISTAGE = 2 or 3 (Word 3 on **Card Number 4**), input **Card Set 88** through **Card Set 95**. Otherwise do not enter these cards.

Card Set Number	Variable	Dimension	Description
88	**RWS**	2 or 3	Inner radius (m, ft) of the wall.
89	**RRS**	2 or 3	Inner radius (m, ft) of the pickoff ring.
90	**ADS**	2 or 3	Flow area (m^2, ft^2) of the discharge passage.
91	**DDS**	2 or 3	Hydraulic diameter (m, ft) of the discharge passage.
92	**HBS**	2 or 3	Length (m, ft) of the barrel.
93	**HSK**	2 or 3	Axial distance (m, ft) between the discharge and the swirling vane.
94	**CKS**	2 or 3	Loss coefficient (–) in the discharge passage.
95	**EFFLD**	2 or 3	Effective L/D coefficient (–) at the pickoff ring.

TEE Component Data

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (TEE left justified).
NUM	Component ID number (must be unique for each component, $1 \leq NUM \leq 999$).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2A14) **EOS, PHASECHANGE**

Note: Only input this card when the number of inputs for FLUIDS (a NAMELIST variable) is more than one.

Variable	Description
EOS	EOS identifier for this component (i.e. “h2o” or “r5h2o”, etc.).
PHASECHANGE	Phase change flag. Input TRUE or true, if phase change is allowed for this component. Input FALSE or false, if phase change is not allowed for this component.

Card Number 3. (Format 3I14,2E14.4) **JCELL, NODES, ICHF, COST, EPSW**

Variable	Description
JCELL	Main-tube cell number that has the side tube connected to it.
NODES	Number of radial heat-transfer nodes in the wall. A value of zero specifies no wall heat transfer.

Card Number 3. (Format 3I14,2E14.4) **JCELL, NODES, ICHF, COST, EPSW** (Continued)

Variable	Description
ICHF	CHF-calculation option. 0 = convection heat transfer only, no boiling heat transfer (i.e. no wall nucleation is allowed although phase change can still occur); 1 = CHF from AECL-IPPE CHF Table, no critical quality calculated. 2 = CHF from AECL-IPPE CHF Table, critical quality from Biasi correlation. 3 = CHF from AECL-IPPE CHF Table, critical quality from CISE-GE correlation.
COST	Cosine of the angle from the low-numbered cell portion of the main tube to the side tube.
EPSW	Wall surface roughness (m, ft).

Card Number 4. (Format 5I14) **ICONC1, NCELL1, JUN1, JUN2, IPOW1**

Variable	Description
ICONC1	Solute in the main-tube coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC1 > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.
NCELL1	Number of fluid cells in the main tube.
JUN1	Junction number for the junction interface adjacent to cell 1.
JUN2	Junction number for the junction interface adjacent to cell NCELL1.
IPOW1	Power-to-the-fluid option in the main tube. 0 = no; 1 = yes.

Card Number 5. (Format 5I14) **IPWTR1, IPWSV1, NPWTB1, NPWSV1, NPWRF1**

Note: If IPOW1 = 0 (Word 5 on **Card Number 4**), do not input this card.	
Variable	**Description**
IPWTR1	Trip ID number that controls evaluation of the power-to-the-fluid table defined by **Card Set 47** (array POWTB1) for the main tube ($\|IPWTR1\| \le 9999$). [Input IPWTR1 = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation].
IPWSV1	The independent-variable ID number for the power-to-the-fluid table for the main tube. IPWSV1 > 0 defines the ID number for a signal-variable parameter; IPWSV1 < 0 defines the ID number for a control-block output parameter.
NPWTB1	The number of power-to-the-fluid table data pairs for the main tube (defined by the absolute value of NPWTB1). NPWTB1 > 0 defines the table independent-variable form to be the IPWSV1 parameter; NPWTB1 < 0 defines the table independent-variable form to be the sum of the change in the IPWSV1 parameter each last timestep times the trip set-status value ISET during that timestep (when the power-to-the-fluid table is trip controlled); NPWTB1 = 0 defines the power to the fluid to be the IPWSV1 parameter.
NPWSV1	The independent-variable ID number for the rate factor that is applied to the main-tube power-to-the-fluid table independent variable. NPWSV1 > 0 defines the ID number for a signal-variable parameter; NPWSV1 < 0 defines the ID number for a control-block output parameter; NPWSV1 = 0 (when NPWRF1 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-fluid table is trip controlled.
NPWRF1	The number of rate-factor table data pairs (defined by the absolute value of NPWRF1). The rate factor is applied as a factor to the main-tube power-to-the-fluid table independent variable when the rate factor is defined. No rate factor is defined when NPWSV1 and NPWRF1 are both zero. NPWRF1 > 0 defines the rate-factor table independent variable to be the NPWSV1 parameter; NPWRF1 < 0 defines it to be the sum of change in the NPWSV1 parameter over each timestep times the trip set-status value ISET during the timestep (when the main-tube power-to-the-fluid table is trip controlled); NPWRF1 = 0 defines the rate factor to be the NPWSV1 parameter.

Card Number 6. (Format 5I14) **IQPTR1, IQPSV1, NQPTB1, NQPSV1, NQPRF1**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 38**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Variable	Description
IQPTR1	Trip ID number that controls evaluation of the power-to-the-wall table defined by **Card Set 49** (array QP3TB1) for the main tube ($\|IQPTR1\| \leq 9999$). [Input IQPTR1 = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation].
IQPSV1	The independent-variable ID number for the main-tube power-to-the-wall table. IQPSV1 > 0 defines the ID number for a signal-variable parameter; IQPSV1 < 0 defines the ID number for a control-block output parameter.
NQPTB1	The number of power-to-the-wall table data pairs for the main tube (defined by the absolute value of NQPTB1). NQPTB1 > 0 defines the table independent-variable form to be the IQPSV1 parameter; NQPTB1 < 0 defines the table independent-variable form to be the sum of the change in the IQPSV1 parameter over each timestep times the trip set-status value ISET during each timestep (when the power-to-the-wall table is trip controlled); NQPTB1 = 0 defines the power to the wall to be the IQPSV1 parameter.
NQPSV1	The independent-variable ID number for the rate factor that is applied to the main-tube power-to-the-wall table independent variable. NQPSV1 > 0 defines the ID number for a signal-variable parameter; NQPSV1 < 0 defines the ID number for a control-block output parameter; NQPSV1 = 0 (when NQPRF1 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-wall table is trip controlled.
NQPRF1	The number of rate-factor table data pairs (defined by the absolute value of NQPRF1). The rate factor is applied as a factor to the main-tube power-to-the-wall table independent variable when the rate factor is defined. No rate factor is defined when NQPSV1 and NQPRF1 are both zero. NQPRF1 > 0 defines the rate-factor table independent variable to be the NQPSV1 parameter; NQPRF1 < 0 defines it to be the sum of the change in the NQPSV1 parameter over each timestep times the trip set-status value ISET during that timestep (when the main-tube power-to-the-wall table is trip controlled); NQPRF1 = 0 defines the rate factor to be the NQPSV1 parameter.

Card Number 7. (Format 5E14.4) **RADIN1, TH1, HOUTL1, HOUTV1, TOUTL1**

Variable	Description
Note:	The four parameters, HOUTL, HOUTV, TOUTL, and TOUTV, allow flexibility in calculating possible heat losses from the outside of the main-tube wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.
RADIN1	Inner radius (m, ft) of the main-tube wall.
TH1	Wall thickness (m, ft) of the main tube.
HOUTL1	Heat-transfer coefficient (HTC) [W/(m^2 K), Btu/(ft^2 °F hr)] between outer boundary of the main-tube wall and the liquid outside the main-tube wall.
HOUTV1	HTC [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the main-tube wall and the gas outside the main-tube wall.
TOUTL1	Liquid temperature (K, °F) outside the main-tube wall.

Card Number 8. (Format 5E14.4) **TOUTV1, PWIN1, PWOFF1, RPWMX1, PWSCL1**

Variable	Description
TOUTV1	Gas temperature (K, °F) outside the main-tube wall.
PWIN1	Initial total power (W, Btu/hr) deposited in (to) the main-tube fluid [not used when IPOW1 = 0 (Word 5 on **Card Number 4**)]. The power is distributed uniformly along the TEE main-tube length.
PWOFF1	Total power (W, Btu/hr) to the main-tube fluid when the controlling trip is OFF after being ON [not used if IPOW1 = 0 (Word 5 on **Card Number 4**) or IPWTR1 = 0 (Word 1 on **Card Number 5**)]. If PWOFF1 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr), the power to the fluid is held constant at the last table-evaluated power when the trip was ON.
RPWMX1	The maximum rate of change of the main-tube power to the fluid [W/s, Btu/(hr s)] [RPWMX1 $\geq$ 0.0 [not used if IPOW1 = 0 (Word 5 on **Card Number 4**)].

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Card Number 8. (Format 5E14.4) **TOUTV1, PWIN1, PWOFF1, RPWMX1, PWSCL1** (Continued)

Variable	Description
PWSCL1	Scale factor (–) for the power-to-the-fluid table. The dependent variable in the table, defined by Card Set 41 (array POWTB1), is multiplied by PWSCL1 to obtain absolute power (W, Btu/hr) deposited in the fluid [not used if IPOW1 = 0 (Word 5 on **Card Number 4**) or NPWTB1 = 0 (Word 3 on **Card Number 5**)].

Card Number 9. (Format 4E14.4, I14) **QPIN1, QPOFF1, RQPMX1, QPSCL1, NHCOM**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card.	
Variable	**Description**
QPIN1	Initial power (W, Btu/hr) deposited in (to) the main-tube wall and distributed according to the QPPP array. If QPIN1 > 0.0 W (0.0 Btu/hr), it is the total power to the entire wall. When QPIN1 < 0.0 W (0.0 Btu/hr), the initial power to the wall in each cell is |QPIN1|, and the negative sign indicates the power to the wall is to be a cell-dependent array of NCELL1 (Word 2 on **Card Number 4**) power values. Each data pair of the power-to-the-wall table [for QPIN1 < 0.0 W (0.0 Btu/hr)] has 1 + NCELL1 values (an independent-variable value and NCELL1 power values for cells 1 through NCELL1). When the power-to-the-wall table is not being evaluated, the same power value of |QPIN1| or QPOFF1 [if QPOFF1 > -10^{19} W (-3.41×10^{19} Btu/hr)] is applied at each of the NCELL1 cells.
QPOFF1	Power (W, Btu/hr) to the main-tube wall when the controlling trip is OFF after being ON [not used if IQPTR1 = 0 (Word 1 on **Card Number 6**); use the last table-evaluated power when the trip was ON if QPOFF1 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr)].
RQPMX1	Maximum rate of change of the power to the wall for the main tube [W/s, Btu/(hr s)] [RQPMX1 $\geq$ 0.0.
QPSCL1	Scale factor (–) for the power-to-the-wall table for the main tube. The dependent variable in the table defined by **Card Set 49** (array QP3TB1) is multiplied by QPSCL1 to obtain the absolute power (W, Btu/hr) to the wall.
NHCOM	Component number receiving outside wall energy.

Card Number 10. (Format 4I14) **ICONC2, NCELL2, JUN3, IPOW2**

Variable	Description
ICONC2	Solute in the side-tube coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC2 > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.
NCELL2	Number of fluid cells in the side tube. If zero, the side leg is a single junction with no input of volume array data.
JUN3	Junction number at the external-junction end of the side tube adjacent to cell NCELL2.
IPOW2	Power-to-the-fluid option in the side tube. 0 = no; 1 = yes.

Card Number 11. (Format 5I14) **IPWTR2, IPWSV2, NPWTB2, NPWSV2, NPWRF2**

Note: If IPOW2 = 0 (Word 4 on **Card Number 10**), do not input this card.

Variable	Description
IPWTR2	Trip ID number that controls evaluation of the power-to-the-fluid table defined by **Card Set 80** (array POWTB2) for the side tube (|IPWTR2| ≤ 9999). [input IPWTR2 = 0 if there is to be no trip control and the table is to be evaluated every timestep of the transient calculation].
IPWSV2	The independent-variable ID number of the power-to-the-fluid table for the side tube. IPWSV2 > 0 defines the ID number for a signal-variable parameter; IPWSV2 < 0 defines the ID number for a control-block output parameter.
NPWTB2	The number of power-to-the-fluid table data pairs for the side tube (defined by the absolute value of NPWTB2). NPWTB2 > 0 defines the table independent-variable form to be the IPWSV2 parameter; NPWTB2 < 0 defines the table's independent-variable form to be the sum of the change in the IPWSV2 para-meter over the last timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-fluid table is trip controlled); NPWTB2 = 0 defines the power to the fluid to be the IPWSV2 parameter.

Card Number 11. (Format 5I14) **IPWTR2, IPWSV2, NPWTB2, NPWSV2, NPWRF2** (Continued)

Note: If IPOW2 = 0 (Word 4 on **Card Number 10**), do not input this card.

Variable	Description
NPWSV2	The independent-variable ID number for the rate factor that is applied to the side-tube power-to-the-fluid table independent variable. NPWSV2 > 0 defines the ID number for a signal-variable parameter; NPWSV2 < 0 defines the ID number for a control-block output parameter; NPWSV2 = 0 (when NPWRF2 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-fluid table is trip controlled.
NPWRF2	The number of rate-factor table data pairs (defined by the absolute value of NPWRF2). The rate factor is applied as a factor to the side-tube power-to-the-fluid table independent variable when the rate factor is defined. No rate factor is defined when NPWSV2 and NPWRF2 are both zero. NPWRF2 > 0 defines the rate-factor table independent variable to be the NPWSV2 parameter; NPWRF2 < 0 defines it to be the sum of the change in the NPWSV2 parameter over the last timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-fluid table is trip controlled); NPWRF2 = 0 defines the rate factor to be the NPWSV2 parameter.

Card Number 12. (Format 5I14) **IQPTR2, IQPSV2, NQPTB2, NQPSV2, NQPRF2**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 71**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Variable	Description
IQPTR2	Trip ID number that controls evaluation of the power-to-the-wall table defined by **Card Set 82** (array QP3TB2) for the side tube (|IQPTR2| ≤ 9999). (Input IQPTR2 = 0 if there is to be no trip control and the table is to be evaluated every timestep during the transient calculation).
IQPSV2	The independent-variable ID number for the side-tube power-to-the-wall table. IQPSV2 > 0 defines the ID number for a signal-variable parameter; IQPSV2 < 0 defines the ID number for a control-block output parameter.
NQPTB2	The number of power-to-the-wall table data pairs for the side tube (defined by the absolute value of NQPTB2). NQPTB2 > 0 defines the table independent-variable form to be the IQPSV2 parameter; NQPTB2 < 0 defines the table independent-variable form to be the sum of the change in the IQPSV2 parameter over each timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-wall table is trip controlled); NQPTB2 = 0 defines the power to the wall to be the IQPSV2 parameter.

Card Number 12. (Format 5I14) **IQPTR2, IQPSV2, NQPTB2, NQPSV2, NQPRF2** (Continued)

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 71**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Variable	Description
NQPSV2	The independent-variable ID number for the rate factor that is applied to the side-tube power-to-the-wall table independent variable. NQPSV2 > 0 defines the ID number for a signal-variable parameter; NQPSV2 < 0 defines the ID number for a control-block output parameter; NQPSV2 = 0 (when NQPRF2 ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-wall table is trip controlled.
NQPRF2	The number of rate-factor table data pairs (defined by the absolute value of NQPRF2). The rate factor is applied as a factor to the side-tube power-to-the-wall table independent variable when the rate factor is defined. No rate factor is defined when NQPSV2 and NQPRF2 are both zero. NQPRF2 > 0 defines the rate-factor table independent variable to be the NQPSV2 parameter; NQPRF2 < 0 defines it to be the sum of the change in the NQPSV2 parameter over each timestep times the trip set-status value ISET during that timestep (when the side-tube power-to-the-wall table is trip controlled); NQPRF2 = 0 defines the rate factor to be the NQPSV2 parameter.

Card Number 13. (Format 5E14.4) **RADIN2, TH2, HOUTL2, HOUTV2, TOUTL2**

Note: The four parameters, HOUTL2, HOUTV2, TOUTL2, and TOUTV2, allow flexibility in calculating possible heat losses from the outside of the side-tube wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
RADIN2	Inner radius (m, ft) of the side-tube wall.
TH2	Wall thickness (m, ft) of the side tube.
HOUTL2	Heat-transfer coefficient (HTC) [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the side-tube wall and the liquid outside the side-tube wall.
HOUTV2	HTC [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the side-tube wall and the gas outside the side-tube wall.

Card Number 13. (Format 5E14.4) **RADIN2, TH2, HOUTL2, HOUTV2, TOUTL2** (Continued)

Variable	Description
	Note: The four parameters, HOUTL2, HOUTV2, TOUTL2, and TOUTV2, allow flexibility in calculating possible heat losses from the outside of the side-tube wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.
TOUTL2	Liquid temperature (K, °F) outside the side-tube wall.

Card Number 14. (Format 5E14.4) **TOUTV2, PWIN2, PWOFF2, RPWMX2, PWSCL2**

Variable	Description
TOUTV2	Gas temperature (K, °F) outside the side-tube wall.
PWIN2	Initial total power (W, Btu/hr) deposited in (to) the side-tube fluid [not used when IPOW2 = 0 (Word 4 on **Card Number 10**)]. The power is distributed uniformly along the side-tube length.
PWOFF2	Total power (W, Btu/hr) to the side-tube fluid when the controlling trip is OFF after being ON [not used when IPOW2 = 0 (Word 4 on **Card Number 10**) or IPWTR2 = 0 (Word 1 on **Card Number 11**)]. If PWOFF2 $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr), the power to the fluid is held constant at the last table-evaluated power when the trip was ON.
RPWMX2	Maximum rate of change of the side-tube power to the fluid [W/s, Btu/(hr s)] [RPWMX1 $\geq$ 0.0 [not used if IPOW2 = 0 (Word 4 on **Card Number 10**)].
PWSCL2	Scale factor (–) for the power-to-the-fluid table. The dependent variable in the table defined by **Card Set 80** (array POWTB2) is multiplied by PWSCL2 to obtain the absolute power (W, Btu/hr) to the fluid [not used if IPOW2=0 (Word 4 on **Card Number 10**) or NPWTB2 = 0 (Word 3 on **Card Number 11**)].

Card Number 15. (Format 4E14.4) **QPIN2, QPOFF2, RQPMX2, QPSCL2**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card.	
Variable	**Description**
QPIN2	Initial power (W, Btu/hr) deposited in (to) the side-tube wall and distributed according to the QPPP array. If QPIN2 > 0.0, it is the total power to the entire wall. When QPIN2 < 0.0, the initial power to the wall in each cell is |QPIN2|, and the negative sign indicates the power to the wall is to be a cell-dependent array of NCELL2 (Word 2 on **Card Number 10**) power values. Each data pair of the power-to-the-wall table [for QPIN2 < 0.0 has 1+NCELL2 values (an independent-variable value and NCELL2 power values for cells 1 through NCELL2). When the power-to-the-wall table is not being evaluated, the same power value of |QPIN2| or QPOFF2 [if QPOFF2 > -10^{19} W (-3.41×10^{19} Btu/hr)] is applied at each of the NCELL2 cells.
QPOFF2	Power (W, Btu/hr) to the side-tube wall when the controlling trip is OFF after being ON [not used if IQPTR2 = 0 (Word 1 on **Card Number 12**); the last table-evaluated power when the trip was ON if QPOFF2 ≤ -10^{19} W (-3.41×10^{19} Btu/hr)].
RQPMX2	Maximum rate of change of the power to the wall for the side-tube [W/s, (Btu/hr)/s] [RQPMX2 ≥ 0.0].
QPSCL2	Scale factor (–) for the power-to-the-wall table for the side-tube. The dependent variable in table defined by **Card Set 82** (array QP3TB2) is multiplied by QPSCL2 to obtain the absolute power (W, Btu/hr) to the wall.

Card Number 16. (Format I14) **IENTRN**

Note: If NAMELIST variable IOFFTK = 0, do not input this card.	
Variable	**Description**
IENTRN	Offtake-model option. 0 = off; 1 = on (side tube internal-junction mass flow determined using offtake model).

TEE Array Cards

Note: Input each of the following arrays using LOAD format.

All junction variables must match at component interfaces.

Model no flow-area change between cell JCELL and cells JCELL±1 and between the internal-junction interface and the side-tube first cell. A VOL/DX flow-area change between cell JCELL and cells JCELL±1 and their interface FA and between side-tube cell 1 and the internal-junction interface will not have any evaluated effect on flow from the current JCELL-interface momentum equations evaluated by TRACE.

Primary Side Array Cards

Card Set Number	Variable	Dimension	Description
17	DX	NCELL1	Main-tube cell lengths (m, ft).
18	VOL	NCELL1	Main-tube cell volumes (m^3, ft^3).
19	FA	NCELL1+1	Main-tube cell-edge flow areas (m^2, ft^2).
20	FRIC	NCELL1+1	Main-tube additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
21	FRICR	NCELL1+1	Main-tube additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input.
22	GRAV or ELEV	NCELL1+1 (NCELL1 for ELEV)	Main-tube gravity or elevation terms [(– or m), (– or ft)]. GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.
23	HD	NCELL1+1	Main-tube hydraulic diameters (m, ft). (See NAMELIST variable NDIA1 for additional input of heat-transfer diameters).

Card Set Number	Variable	Dimension	Description
Note: If NAMELIST variable NDIA1 ≠ 2 do not input array HD-HT.			
24	**HD-HT**	NCELL1+1	Main-tube heat transfer diameters (m, ft).
Note: If NAMELIST variable ICFLOW = 0 or 1, do not input array ICFLG.. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur..			
25	**ICFLG**	NCELL1+1	Main-tube cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.
26	**NFF**	NCELL1+1	Main-tube friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE.
Note: If NCCFL = 0 (Word 5 on **Main-Data Card 9**), do not input array LCCFL.			
27	**LCCFL**	NCELLS+1	Main-tube countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
28	**ALP**	NCELL1	Main-tube initial gas volume fractions (–).
29	**VL**	NCELL1+1	Main-tube initial liquid velocities (m/s, ft/s).
30	**VV**	NCELL1+1	Main-tube initial gas velocities (m/s, ft/s).
31	**TL**	NCELL1	Main-tube initial liquid temperatures (K, °F).

TEE Component Data

Card Set Number	Variable	Dimension	Description
32	**TV**	NCELL1	Main-tube initial gas temperatures (K, °F).
33	**P**	NCELL1	Main-tube initial pressures (Pa, psia).
34	**PA**	NCELL1	Main-tube initial noncondensable-gas partial pressures (Pa, psia).
Note: If NAMELIST variable NOLT1D = 1 do not input array ILEV.			
35	**ILEV**	NCELLS	Level tracking flags. 1 = the two-phase level exists in the current cell. 0 = the two-phase level does not exist in the current cell. -1 = the level tracking calculation will be turned off for this cell.
Note: If NAMELIST variable MWFL = 0, do not input array WFMFL.			
36	**WFMFL**	NCELL1+1	Main-tube wall-friction multiplier factor for the liquid phase (–) ($0.9 \leq$ WFMFL ≤ 1.1).
Note: If NAMELIST variable MWFV = 0, do not input array WFMFV.			
37	**WFMFV**	NCELL1+1	Main-tube wall-friction multiplier factor for the gas phase (–) ($0.9 \leq$ WFMFL ≤ 1.1).
Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input arrays QPPP, MATID, TW, IDROD, and NHCEL.			
38	**QPPP**	NODES × NCELL1	A relative power shape (–) in the main-tube wall. Input values for cell 1, node 1 through NODES; then cell 2, node 1 through NODES; etc. If the array is filled with the same nonzero constant, a uniform volumetric heat source in the wall results. TRACE internally normalizes the power shape to have a volume-averaged value of unity {each QPPP(I) is normalized to have the value QPPP(I) × [Σ_K VOL(K)]/{Σ_K QPPP(K) × VOL(K)]}. Filling the array with zeros results in no power being deposited in the wall regardless of the value of QPIN1, QPTB1, etc.

Card Set Number	Variable	Dimension	Description
39	**MATID**	NODES-1	Wall-material ID array, which specifies material ID between radial nodes. Dimension is 1 if NODES = 1. 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 12 = inconel, type 600.
40	**TW**	NODES × NCELL1	Initial wall temperatures (K, °F) in the main tube, which are input in the same order as QPPP.
Note: If NHCOM > 0 (Word 5 on **Card Number 9**) input IDROD.			
41	**IDROD**	1	Vessel radial-theta cell number or input 0 when NHCOM is a 1D component.
Note: If NHCOM>0 (Word 5 on **Card Number 9**) input NHCEL.			
42	**NHCEL**	NCELLS	Connecting axial cell numbers in component NHCOM.
Note: If ICONC1 = 0 (Word 1 on **Card Number 4**), do not input array CONC.			
43	**CONC**	NCELL1	Initial solute mass to liquid-coolant mass ratio [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)] in the main tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: If ICONC1 = 0 or 1 (Word 1 on **Card Number 4**), do not input array S.			
44	**S**	NCELL1	Initial macroscopic density of plated-out solute (kg/ m^3, $lb_m/ft^{3)}$ in the main tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
45	**XGNB**	NCELL1	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).

TEE Component Data

Card Set Number	Variable	Dimension	Description
			Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.
46	**XLNB**	NCELL1	Mass fraction for liquid trace species.
			Note: If IPOW1 = 0 (Word 5 on **Card Number 4**), do not input array POWTB1.
47	**POWTB1**	2×|NPWTB1|	Power-to-the-fluid vs independent-variable-form table [(*,W) (*,Btu/hr)] for the main tube. Input |NPWTB1| (Word 3 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by IPWSV1 (Word 2 on **Card Number 5**), power to the fluid]. The power is deposited directly into the main-tube fluid with a uniform power density along the main-tube length.
			Note: If IPOW1 = 0 (Word 5 on **Card Number 4**), do not input array POWRF1.
48	**POWRF1**	2×|NPWRF1|	Rate-factor table (*,–) for the main-tube power-to-the-fluid table independent variable. Input |NPWRF1| (Word 5 on **Card Number 5**) table-defining data pairs having the following form [independent-variable form defined by NPWSV1 (Word 4 on **Card Number 5**), rate factor to be applied to the power-to-the-fluid table independent variable].
			Note: If NQPTB1 = 0 (Word 3 on **Card Number 6**) or if NODES = 0 (Word 2 on **Card Number 3**), do not input array QP3TB1.
49	**QP3TB1**	2× |NQPTB1| when QPIN1 > 0.0; (1+NCELL1) ×|NQPTB1| when QPIN1 < 0.0.	Power-to-the-wall independent-variable-form table [(*,W) (*,Btu/hr)] for the main tube. Input |NQPTB1| (Word 3 on **Card Number 6**) table-defining data pairs having the following form [independent-variable form defined by IQPSV1 (Word 2 on **Card Number 6**), power to the wall]. If QPIN1 > 0.0, the dependent variable specifies the total power to the entire wall; if QPIN1 < 0.0, the dependent variable is a power shape that specifies the power to the wall at each cell from cell 1 to NCELL1.

Side Arm Array Cards

Note: If NCELL2 = 0 (Word 2 on Card Number 9), only input FA, FRIC, GRAV, HD, NFF, LCCFL, VL, and VV array cards.

Card Set Number	Variable	Dimension	Description
50	**DX**	NCELL2	Side-tube cell lengths (m, ft).
51	**VOL**	NCELL2	Side-tube cell volumes (m^3, ft^3).
52	**FA**	NCELL2+1	Side-tube cell-edge flow areas (m^2, ft^2).
53	**FRIC**	NCELL2+1	Side-tube additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input. Input FRIC > 0.0 for internal-junction interface 1 of the side tube when a VOL/DX flow-area change occurs between JCELL and cell 1 of the side tube.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
54	**FRICR**	NCELL2+1	Side-tube additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input. Input FRICR > 0.0 for internal-junction interface 1 of the side tube when a VOL/DX flow-area change occurs between JCELL and cell 1 of the side tube.
55	**GRAV or ELEV**	NCELL2+1 (NCELLS for ELEV)	Side-tube gravity elevation terms [(– or m), (– or ft)]. GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.
56	**HD**	NCELL2+1	Side-tube hydraulic diameters (m, ft) (see NAMELIST variable NDIA1 for additional input of heat-transfer diameters).
Note: If NAMELIST variable NDIA1 /= 2 do not input array HD-HT.			
57	**HD-HT**	NCELL2+1	Side-tube heat transfer diameters (m, ft).

Card Set Number	Variable	Dimension	Description
Note: If NAMELIST variable ICFLOW = 0 or 1, do not input array ICFLG. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur...			
58	**ICFLG**	NCELL2+1	Side-tube cell-edge choked-flow model option. Cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.
59	**NFF**	NCELL2+1	Side-tube friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE. Input NFF ≥ 0 for the JCELL and JCELL+1 interfaces.
Note: If NCCFL = 0 (Word 5 **Main-Data Card 9**), do not input array LCCFL.			
60	**LCCFL**	NCELL2+1	Side-tube countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
61	**ALP**	NCELL2	Side-tube initial gas volume fractions (–).
62	**VL**	NCELL2+1	Side-tube initial liquid velocities (m/s, ft/s).
63	**VV**	NCELL2+1	Side-tube initial gas velocities (m/s, ft/s).
64	**TL**	NCELL2	Side-tube initial liquid temperatures (K, °F).

Card Set Number	Variable	Dimension	Description
65	**TV**	NCELL2	Side-tube initial gas temperatures (K, °F).
66	**P**	NCELL2	Side-tube initial pressures (Pa, psia).
67	**PA**	NCELL2	Side-tube initial noncondensable-gas partial pressures (Pa, psia).
Note: If NAMELIST variable NOLT1D = 1 do not input array ILEV.			
68	**ILEV**	NCELL2	Level tracking flags. 1 = the two-phase level exists in the current cell. 0 = the two-phase level does not exist in the current cell. -1 = the level tracking calculation will be turned off for this cell.
Note: If NAMELIST variable MWFL = 0, do not input array WFMFL.			
69	**WFMFL**	NCELL2+1	Side-tube wall-friction multiplier factor for the liquid phase (–) ($0.9 \leq$ WFMFL ≤ 1.1).
Note: If NAMELIST variable MWFV = 0, do not input array WFMFV.			
70	**WFMFV**	NCELL2+1	Side-tube wall-friction multiplier factor for the gas phase (–) ($0.9 \leq$ WFMFL ≤ 1.1).
Note: If NODES = 0 (Word 2 on **Card Number 3**) do not input arrays QPPP, MATID, TW, IDROD, and NHCEL.			
71	**QPPP**	NODES × NCELL2	A relative power shape (–) in the side-tube wall. Input values for cell 1, node 1 through NODES; then cell 2, node 1 through NODES; etc. If the array is filled with the same nonzero constant, a uniform volumetric heat source in the wall results. TRACE internally normalizes the power shape to have a volume-average value of unity (each QPPP(I) is normalized to have the value QPPP(I) × [Σ_K VOL(K)]/[Σ_K QPPP(K) × VOL(K)]). Filling the array with zeros results in no power being deposited in the wall regardless of the values of QPIN2, QPTB2, etc.

Card Set Number	Variable	Dimension	Description
72	MATID	NODES-1	Wall-material ID array, which specifies material ID between radial nodes. Dimension is 1 if NODES = 1. 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 12 = inconel, type 600.
73	TW	NODES × NCELL2	Initial wall temperatures (K, °F) in the side tube, which are input in the same order as QPPP.
Note: If NHCOM > 0 (Word 5 on **Card Number 9**) then input array IDROD.			
74	IDROD	1	Vessel radial-theta cell number or input 0 when NHCOM is a 1D component.
Note: If NHCOM > 0 (Word 5 on **Card Number 9**) then input array NHCEL.			
75	NHCEL	NCELL2	Connecting axial cell numbers in component NHCOM.
Note: If ICONC2 = 0 (Word 1 on **Card Number 10**) do not input array CONC.			
76	CONC	NCELL2	Initial solute mass to liquid-coolant mass ratio [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)] in the side tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: If ICONC2 = 0 or 1 (Word 1 on **Card Number 10**) do not input array S.			
77	S	NCELL2	Initial macroscopic density of plated-out solute (kg/m^3, lb_m/ft^3) in the side tube. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
78	XGNB	NCELL2	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).

Card Set Number	Variable	Dimension	Description
			Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.
79	**XLNB**	NCELL2	Mass fraction for liquid trace species.
			Note: If IPOW2 = 0 (Word 5 on **Card Number 10**), do not input array POWTB2.
80	**POWTB2**	2×|NPWTB2|	Power-to-the-fluid vs independent-variable-form table [(*,W), (*,Btu/hr)] for the side tube. Input |NPWTB2| (Word 3 on **Card Number 11**) table-defining data pairs having the following form [independent-variable form defined by IPWSV2 (Word 2 on **Card Number 11**), power to the fluid]. The power is deposited directly into the side-tube fluid with a uniform volumetric power density along the TEE side-tube length.
			Note: If IPOW2 = 0 (Word 5 on **Card Number 10**), do not input array POWRF2.
81	**POWRF2**	2×|NPWRF2|	Rate-factor table (*,–) for the side-tube power-to-the-fluid table independent variable. Input |NPWRF2| (Word 5 on **Card Number 11**) table-defining data pairs having the following form [independent-variable form defined by NPWSV2 (Word 4 on **Card Number 11**), rate factor to be applied to the power-to-the-fluid table independent variable].
			Note: If NQPTB2 = 0 (Word 3 on **Card Number 12**) or if NODES = 0 (Word 2 on **Card Number 3**), do not input array QP3TB2.
82	**QP3TB2**	2×|NQPTB2| when QPIN2>0.0; (1+NCELL2) ×|NQPTB2| when QPIN2<0.0.	Power-to-the-wall vs independent-variable form table [(*,W), (*,Btu/hr)] for the side tube. Input |NQPTB2| (Word 3 on **Card Number 12**) table-defining data pairs having the following form [independent-variable form defined by IQPSV2 (Word 2 on **Card Number 12**), power to the wall]. If QPIN2 > 0.0, the dependent variable specifies the total power to the entire wall; if QPIN2 < 0.0, the dependent variable is a power shape that specifies the power to the wall at each cell from cell NCELL1 + 2 to cell NCELL1 + 1 + NCELL2.

TURB Component Data

Each turbine stage is modeled as a separate TURB component.

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (TURB left justified).
NUM	Component ID number (must be unique for each component, $1 \leq$ NUM ≤ 999).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2A14) **EOS, PHASECHANGE**

Variable	Description
Note: Only input this card when the number of inputs for FLUIDS (a NAMELIST variable) is more than one.	
EOS	EOS identifier for this component (i.e. “h2o” or “r5h2o”, etc.).
PHASECHANGE	Phase change flag. Input TRUE or true, if phase change is allowed for this component. Input FALSE or false, if phase change is not allowed for this component.

Card Number 3. (Format 3I14,2E14.4) **JCELL, NODES, ICHF, COST, EPSW**

Variable	Description
JCELL	Main-tube cell number that has the side tube connected to it.
NODES	Number of radial heat-transfer nodes in the wall. Currently, NODES = 0 is required.

Card Number 3. (Format 3I14,2E14.4) **JCELL, NODES, ICHF, COST, EPSW**

Variable	Description
ICHF	CHF-calculation option. 0 = convection heat transfer only, no boiling heat transfer (i.e. no wall nucleation is allowed although phase change can still occur); 1 = CHF from AECL-IPPE CHF Table, no critical quality calculated. 2 = CHF from AECL-IPPE CHF Table, critical quality from Biasi correlation. 3 = CHF from AECL-IPPE CHF Table, critical quality from CISE-GE correlation.
COST	Cosine of the angle from the low-numbered cell portion of the main tube to the side tube.
EPSW	Wall surface roughness (m, ft).

Card Number 4. (Format 5I14) **ICONC1, NCELL1, JUN1, JUN2, IPOW1**

Variable	Description
ICONC1	Solute in the main-tube coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC1 > 0. 0 = no; 0 is required
NCELL1	Number of fluid cells in the main tube.
JUN1	Junction number for the junction interface adjacent to cell 1.
JUN2	Junction number for the junction interface adjacent to cell NCELL1.
IPOW1	Power-to-the-fluid option in the main tube. 0 = no; Only “0’ is allowed.

Card Number 5. (Format 2E14.4) **RADIN1, TH1**

Note: Since NODES = 0 (Word 2 on **Card Number 3**), RADIN1 and TH1 are required but not used.

Variable	Description
RADIN1	Inner radius (m, ft) of the main-tube wall. Required but not used.
TH1	Wall thickness (m, ft). Required but not used.

Card Number 6. (Format E14.4) **TOUTV1**

Note: Since NODES = 0 (Word 2 on **Card Number 3**) is required TOUTV1 is not used.

Variable	Description
TOUTV1	Outside vapor temperature (K, ^{o}F). Required but not used.

Card Number 7. (Format 4I14) **ICONC2, NCELL2, JUN3, IPOW2**

Variable	Description
ICONC2	Solute in the side-tube coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC2 > 0. 0 = no; 0 is required.
NCELL2	Number of fluid cells in the side tube.
JUN3	Junction number at the external-junction end of the side tube adjacent to cell NCELL2.
IPOW2	Power-to-the-fluid option in the side tube. 0 = no; 0 is required.

Card Number 8. (Format 2E14.4) **RADIN2, TH2**

Note: Since NODES = 0 (Word 2 on **Card Number 3**) , RADIN2 and TH2 are required but not used.

Variable	Description
RADIN2	Inner radius (m, ft) of the side-tube wall. Required but not used.
TH2	Wall thickness (m, ft). Required but not used.

Card Number 9. (Format E14.4) **TOUTV2**

Note: Since NODES = 0 (Word 2 on **Card Number 3**) TOUTV2 is read but not used.	
Variable	**Description**
TOUTV2	Outside vapor temperature (K, ^{o}F). Required but not used.

Card Number 10. (Format 5E14.4) **EFF, SEPEFF, OMEGT, INERT, RMDOT**

Variable	**Description**
EFISHR	Turbine efficiency, between 0.0 and 1.0.
SEPEFF	Separator efficiency between 0.0 and 1.0. It is recommended that the user set SEPEFF = 0.0 and ITSEP = 0 and use the TRACE default model for the drains and steam taps by setting IKFAC = 1 in the NAMELIST and FRIC to 1.0e+21 and -1.0 e+21 for steam and liquid drains respectively. This model works the best and is the most stable.
OMEGT	Initial angular velocity of rotor (rad/s, rpm)
INERT	Inertia of rotor ($kg \cdot m^2$, $lb_m \cdot ft^2$).
RMDOT	Rated mass flow rate (kg/s, lb_m/hr)

Card Number 11. (Format 5I14) **ITSEP, NSTAGE, JROT, SATFLAG, ITURTR**

Variable	**Description**
ITSEP	ITSEP = 0, no TRAC-B sidearm separation model, = 1, TRAC-B sidearm model. Recommend ITSEP = 0.
NSTAGE	Number of stages lumped in series. Recommend modeling each stage (NSTAGE=1) since there is no effect on time step in TRACE.
JROT	Turbine rotor number (shaft number) used by this **TURB** component. A number of **TURB**s can use the same rotor. The maximum number of rotors in the problem is 10. The rotors are numbered sequentially 1 through n.

Card Number 11. (Format 5I14) **ITSEP, NSTAGE, JROT, SATFLAG, ITURTR** (Continued)

Variable	Description
SATFLAG	SATFLAG = 0 or 1. Default is zero, user can set SATFLAG =1 to get saturation values out at the exit, or set SATFLAG = 0 and calculate the junction area small enough for the nozzle to approach sonic velocity which results in a flow quality calculated < 1.0 to give sat values for mass and energy flux.
ITURTR	ITURTR = 0 or 1, Default is 0 and it is recommended. ITURTR=1 calculates a nozzle junction area by inputting flow and the pressure drop across the junction as initial conditions. Recommend not using since this model was tricky in TRAC-B and will be the same in TRACE. Better to size nozzle area with a number of short steady state runs by making the junction area smaller, so that the gas velocity approaches sound speed.

Card Number 12. (Format 3E14.4) **OMEGTR, CTRQTB, TORQTR**

Variable	Description
OMEGTR	Rated angular velocity (rad/s, rpm)
CTRQTB	Bearing and windage frictional coefficient
TORQTR	Rated turbine torque ($Pa \cdot m^3$, $lb_f \cdot ft$).

TURB Array Cards

Input the following Card Sets, one set for each of the following arrays. Use LOAD format. Each array has its element values defined by a Card Set of one or more cards.

Primary Side Array Cards

Card Set Number	Variable	Dimension	Description
13	**DX**	NCELL1	Main-tube cell lengths (m, ft).

Card Set Number	Variable	Dimension	Description
14	**VOL**	NCELL1	Main-tube cell volumes (m^3, ft^3).
15	**FA**	NCELL1+1	Main-tube cell-edge flow areas (m^2, ft^2).
16	**FRIC**	NCELL1+1	Main-tube additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
17	**FRICR**	NCELL1+1	Main-tube additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input.
18	**GRAV or ELEV**	NCELL1+1 (NCELL1 for ELEV)	Main-tube gravity or elevation terms [(– or m), (– or ft)]. GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.
19	**HD**	NCELL1+1	Main-tube hydraulic diameters (m, ft). (See NAMELIST variable NDIA1 for additional input of heat-transfer diameters).
Note: If NAMELIST variable NDIA1 ≠ 2 do not input array HD-HT.			
20	**HD-HT**	NCELL1+1	Main-tube heat transfer diameters (m, ft).
Note: If NAMELIST variable ICFLOW = 0 or 1, do not input array ICFLG.. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur..			
21	**ICFLG**	NCELL1+1	Main-tube cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.

Card Set Number	Variable	Dimension	Description
22	**NFF**	NCELL1+1	Main-tube friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE.
Note: If NCCFL = 0 (Word 5 on **Main-Data Card 9**), do not input array LCCFL.			
23	**LCCFL**	NCELL1+1	Main-tube countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
24	**ALP**	NCELL1	Main-tube initial gas volume fractions (–).
25	**VL**	NCELL1+1	Main-tube initial liquid velocities (m/s, ft/s).
26	**VV**	NCELL1+1	Main-tube initial gas velocities (m/s, ft/s).
27	**TL**	NCELL1	Main-tube initial liquid temperatures (K, °F).
28	**TV**	NCELL1	Main-tube initial gas temperatures (K, °F).
29	**P**	NCELL1	Main-tube initial pressures (Pa, psia).
30	**PA**	NCELL1	Main-tube initial noncondensable-gas partial pressures (Pa, psia).

Card Set Number	Variable	Dimension	Description
Note: If NAMELIST variable NOLT1D = 1 do not input array ILEV.			
31	**ILEV**	NCELL1	Level tracking flags. ILEV = 1 indicates that the two-phase level exists in the current cell. ILEV = 0 indicates that the two-phase level does not exist in the current cell. ILEV = -1, the level tracking calculation will be turned off for this cell.
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
32	**XGNB**	NCELL1	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).
Note: Input array XL only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
33	**XLNB**	NCELL1	Mass fraction for liquid trace species.

Side-Tube Array Cards

Card Set Number	Variable	Dimension	Description
34	**DX**	NCELL2	Side-tube cell lengths (m, ft).
35	**VOL**	NCELL2	Side-tube cell volumes (m^3, ft^3).
36	**FA**	NCELL2+1	Side-tube cell-edge flow areas (m^2, ft^2).

Card Set Number	Variable	Dimension	Description
37	**FRIC**	NCELL2+1	Side-tube additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input. Input FRIC > 0.0 for internal-junction interface 1 of the side tube when a VOL/DX flow-area change occurs between JCELL and cell 1 of the side tube.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
38	**FRICR**	NCELL2+1	Side-tube additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input. Input FRICR > 0.0 for internal-junction interface 1 of the side tube when a VOL/DX flow-area change occurs between JCELL and cell 1 of the side tube.
39	**GRAV or ELEV**	NCELL2+1 (NCELLS for ELEV)	Side-tube gravity elevation terms [(– or m), (– or ft)]. GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.
40	**HD**	NCELL2+1	Side-tube hydraulic diameters (m, ft) (see NAMELIST variable NDIA1 for additional input of heat-transfer diameters).
Note: If NAMELIST variable NDIA1 ≠ 2 do not input array HD-HT.			
41	**HD-HT**	NCELLS+1	Side-tube heat transfer diameters (m, ft).
Note: If NAMELIST variable ICFLOW = 0 or 1, do not input array ICFLG.. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur..			
42	**ICFLG**	NCELL2+1	Side-tube cell-edge choked-flow model option. Cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.

TURB Component Data

Card Set Number	Variable	Dimension	Description
43	**NFF**	NCELL2+1	Side-tube friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE. Input NFF ≥ 0 for the JCELL and JCELL+1 interfaces.
Note: If NCCFL = 0 (Word 5 **Main-Data Card 9**), do not input array LCCFL.			
44	**LCCFL**	NCELL2+1	Side-tube countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
45	**ALP**	NCELL2	Side-tube initial gas volume fractions (–).
46	**VL**	NCELL2+1	Side-tube initial liquid velocities (m/s, ft/s).
47	**VV**	NCELL2+1	Side-tube initial gas velocities (m/s, ft/s).
48	**TL**	NCELL2	Side-tube initial liquid temperatures (K, °F).
49	**TV**	NCELL2	Side-tube initial gas temperatures (K, °F).
50	**P**	NCELL2	Side-tube initial pressures (Pa, psia).
51	**PA**	NCELL2	Side-tube initial noncondensable-gas partial pressures (Pa, psia).

Card Set Number	Variable	Dimension	Description
Note: If NAMELIST variable NOLT1D = 1 do not input array ILEV.			
52	**ILEV**	NCELL2	Level tracking flags. ILEV = 1.0 indicates that the two-phase level exists in the current cell. ILEV = 0.0 indicates that the two-phase level does not exist in the current cell. ILEV = -1.0, the level tracking calculation will be turned off for this cell.
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
53	**XGNB**	NCELL2	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).
Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
54	**XLNB**	NCELL2	Mass fraction for liquid trace species.

VALVE Component Data

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (VALVE left justified).
NUM	Component ID number (must be unique for each component, $1 \leq NUM \leq 999$).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2A14) **EOS, PHASECHANGE**

Note: Only input this card when the number of inputs for FLUIDS (a NAMELIST variable) is more than one.

Variable	Description
EOS	EOS identifier for this component (i.e. "h2o" or "r5h2o", etc.).
PHASECHANGE	Phase change flag. Input TRUE or true, if phase change is allowed for this component. Input FALSE or false, if phase change is not allowed for this component.

Card Number 3. (Format 4I14,E14.4) **NCELLS, NODES, JUN1, JUN2, EPSW**

Note: When NAMELIST parameter USESJC = 1, 2, or 3, NCELLS can be set to zero so that VALVE component can be used as a single junction component (variable flow area but no volume). If NCELLS is set to 0, IVPS (Word 4 on **Card Number 8**) should be set to 1.

Variable	Description
NCELLS	Number of fluid cells ($NCELLS \geq 2$ or if USESJC = 1 or 2, $NCELLS \geq 0$).
NODES	Number of radial heat-transfer nodes in the VALVE wall. A value of zero specifies no wall heat transfer.
JUN1	Junction number for junction interface adjacent to cell 1.

Card Number 3. (Format 4I14,E14.4) **NCELLS, NODES, JUN1, JUN2, EPSW**

Note: When NAMELIST parameter USESJC = 1, 2, or 3, NCELLS can be set to zero so that VALVE component can be used as a single junction component (variable flow area but no volume). If NCELLS is set to 0, IVPS (Word 4 on **Card Number 8**) should be set to 1.

Variable	Description
JUN2	Junction number for junction interface adjacent to cell NCELLS.
EPSW	Wall surface roughness (m, ft).

Card Number 4. (Format I14) **NSIDES**

Note: If NCELLS = 0 do not input this card. Input this card only if NAMELIST variable USESJC = 2 or 3. This will allow this component to have side junctions.

Variable	Description
NSIDES	Number of side junctions connected to this PIPE component.

Note: If NSIDES > 0 then input the next three cards as sets of 1, 2, or 3 cards per NSIDES. Examples include:

If USESJC = 2 and JUNLK (Word 2 on **Card Number 5**) is > 0 only **Card Number 5** is needed.

If USESJC = 2 and JUNLK is 0 input **Card Number 5** and **Card Number 6** in pairs.

If USESJC = 3 and JUNLK > 0 input **Card Number 5** and **Card Number 7** in pairs.

If USESJC = 3 and JUNLK is 0 input **Card Number 5**, **Card Number 6**, and **Card Number 7** in sets.

Card Number 5. (Format 5I14) **NCLK, JUNLK, NCMPTO, NCLKTO, NLEVTO**

Note: If NCELLS or NSIDES = 0, or USESJC = 1 do not input this card. Otherwise input this card for each NSIDES.

Variable	Description
NCLK	“From” cell number in the PIPE component.
JUNLK	Junction number. Enter a zero to have the code spawn a Single Junction Component internally. Otherwise enter the junction number here. This same junction number must appear as a VESSEL source junction or a 1D component junction.
NCMPTO	Component number of "To" component of a leak path. Enter 0 if JUNLK $\neq$ 0.
NCLKTO	Cell number of "To" cell of a leak path Enter 0 if JUNLK $\neq$ 0.
NLEVTO	Axial level number of "To" cell of a leak path when "To" component is a VESSEL. Otherwise enter 0. Enter 0 if JUNLK $\neq$ 0.

Card Number 6. (Format 5E14.4) **FALK, CLOS, VLLK, VVLK, DELZLK**

Note: If NCELLS or NSIDES = 0 do not input this card. Input this card only if JUNLK = 0. If USESJC = 2 or 3, input this card for each NSIDES.

Variable	Description
FALK	Leak path flow area (m^2, ft^2).
CLOS	Leak path loss coefficient
VLLK	Leak path initial liquid velocity (m/s, ft/s).
VVLK	Leak path initial vapor velocity (m/s, ft/s).
DELZLK	Elevation difference between center of "From" cell and center of "To" cell (m, ft). DELZLK > 0 when the center of the "From" cell is higher than the center of the "To" cell DELZLK < 0 when the center of the "From" cell is lower than the center of the "To" cell

Card Number 7. (Format E14.4, I14) **THETA, IENTRN**

Note: If NCELLS or NSIDES = 0, or USESJC = 1 or 2 do not input this card.	
Variable	**Description**
THETA	Angle between the main direction of flow and the flow through the side junction.
IENTRN	Offtake-model option. 0 = off; 1 = on (side-junction mass flow determined using offtake model)

Card Number 8. (Format 5I14) **ICHF, ICONC, IVTY, IVPS, NVTB2**

Note: For valve-type option IVTY = 5 or 6, variables NVTB2 (Word 5 on this card) and IVSV, NVTB1, NVSV, and NVRF (Words 2 to 5 on **Card Number 9**) are defined to be zero or left blank, and the **Card Set 56** through **Card Set 58** (arrays VTB1, VTB2, and VRF) are not input.	
Variable	**Description**
ICHF	CHF calculation option 0 = convection heat transfer only, no boiling heat transfer (i.e. no wall nucleation is allowed although phase change can still occur); 1 = CHF from AECL-IPPE CHF Table, no critical quality calculated. 2 = CHF from AECL-IPPE CHF Table, critical quality from Biasi correlation. 3 = CHF from AECL-IPPE CHF Table, critical quality from CISE-GE correlation.
ICONC	Solute in the liquid coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.
IVTY	Valve Type (See **Table 6-6** and **Table 6-7**).
IVPS	Mesh-cell interface number where the VALVE flow area is adjusted (1 < IVPS < NCELLS + 1 unless a BREAK is connected to a VALVE junction; then IVPS can equal that junction interface 1 or NCELLS + 1).

Card Number 8. (Format 5I14) **ICHF, ICONC, IVTY, IVPS, NVTB2 (Continued)**

Note: For valve-type option IVTY = 5 or 6, variables NVTB2 (Word 5 on this card) and IVSV, NVTB1, NVSV, and NVRF (Words 2 to 5 on **Card Number 9**) are defined to be zero or left blank, and the **Card Set 56** through **Card Set 58** (arrays VTB1, VTB2, and VRF) are not input.

Variable	Description
NVTB2	The number of data pairs in the second valve table (defined by the absolute value of NVTB2). Input NVTB2 = 0 when IVTY = 0, 1, 2, 5, 6, 7, 8, 9 or 10 (Word 3 on this card). For IVTY = 3 or 4: NVTB2 > 0 defines the table independent-variable form to be the IVSV (Word 2 on **Card Number 9**) parameter; NVTB2 < 0 defines the second valve table independent-variable form to be the sum of the change in the IVSV parameter over each timestep times the trip set-status value ISET during that timestep (when the valve table is trip controlled); NVTB2 = 0 [when NVTB1 = 0 (Word 3 on **Card Number 9**)] defines the valve flow-area fraction or relative valve-stem position to be the IVSV parameter value. When NVTB2 = 0 and NVTB1 ≠ 0, no second valve table is defined. Only the first valve table is used. When NVTB2 ≠ 0, then NVTB1 ≠ 0, then NVTB2 and NVTB1 must have the same numerical sign, and the first valve table is evaluated when the controlling trip is set to $ON_{Forward}$, and the second valve table is evaluated when the trip is set to $ON_{Reverse}$. NVTB1 = 0, and NVTB2 ≠ 0 is invalid. For IVTY = -1 or 11 NVTB2 > 0 defines table input for valve C_v data. The table input is fractional area or stem position (if NVTB1 > 0) versus the valve C_v value. NFF (**Card Set 34**) can not be -1 or -100 for the valve face (IVPS, Word 4 of this card). NVTB2 sets of data must be input for valve table VTB2 (**Card Set 54**). NVTB2 < 0 or NVTB2 = 0 means no C_v data are provided

VALVE Component Data

Table 6-6. Valve Types

IVTY	Description
-1	Valve area fraction controlled by a control system. (Initial area fraction is obtained from FAVLVE on **Card Number 14**). If the control block output is in terms of valve stem position, a table of fractional stem position versus area is required [set NVTB1 > 0 (Word 3 on **Card Number 9**) and input valve table VTB1 (**Card Set 55**)]. Valve flow coefficient (C_v) data can be input with this valve type. C_v input requires that the user set NVTB2 > 0 (Word 5 on **Card Number 8**) and supply **Card Number 24** and VTB2 (**Card Set 56**). Reverse C_v flow coefficients can be input via valve table VLTB (**Card Set 54**).
0	constant flow area;
1	flow-area fraction vs independent-variable-form table is evaluated;
2	relative valve-stem position (0.0 means fully closed, 1.0 means fully opened) vs independent-variable-form table is evaluated;
3	constant flow area until trip IVTR (Word 1 on **Card Number 9**) is set ON, then flow-area fraction vs. independent-variable-form table is evaluated. This valve type requires two tables - one to define the flow area fraction when the trip status is $ON_{forward}$ and one to define the flow area fraction when the trip status is $ON_{reverse}$.
4	constant relative valve-stem position until trip IVTR (Word 1 on **Card Number 9**) is set ON, then relative valve-stem position vs. independent-variable-form table is evaluated. This valve type requires two tables - one to define the stem position when the trip status is $ON_{forward}$ and one to define the stem position when the trip status is $ON_{reverse}$.
5	valve is to be operated by a special turbine-component signal where an increase in generator power demand opens the valve;
6	similar to IVTY = 5 except that an increase in generator power demand closes the valve.
7	Multiple banks of safety relief valves (SRV) with automatic depression system (ADS) trip. Each valve bank opens and closes independently based on its own pressure set points. Pressure is monitored in cell (IVPS-1). Trip results in valve area = AVLVE to simulate ADS activation. Valve bank areas, pressure set points, and activation status must be specified on VTB1 cards (**Card Set 56**).

Table 6-6. Valve Types (Continued)

IVTY	Description
8	Motor-controlled valve (TRAC-B style). Opens and closes based on the pressure in cell ISENS (Word 2 on **Card Number 18**). A minimum flow area ALEAKB (Word 1 on **Card Number 16**) may be specified to simulate leakage. MODEM (Word 1 on **Card Number 18**) indicates valve operation (opening, closing, or stationary), and XPOS (Word 5 on **Card Number 14**) is the relative position of the valve stem. BOSP, EOSP, BCSP, and ECSP (Words 2, 3, 4, and 5 on **Card Number 16**) are pressure setpoints controlling valve motion. IVPG (Word 4 on **Card Number 18**) controls the manner in which valve area is related to stem position. IVPG = 1, Valve area is directly proportional to stem position. IVPG = 2, Valve area is S-shaped function of stem position. (Guillotine cut of circular cross section.) IVPG = 3, Valve area is user-specified function of stem position. This function is specified by the VLTB table (**Card Set 55**). This valve option can not be used when USESJC = 1 and this component is used as a SJC (because the valve needs a mesh volume to properly set ISENS).
9	Check valve (includes delta pressure needed to overcome any spring loading).
10	Inertial swing check valve (solves the rotational momentum equation to determine valve flapper position vs. time).
11	Motor-controlled valve (RELAP5 style). Most of the input is the normal valve input but the meaning of some of the variables has changed as shown in **Table 6-7**. At least one new card is needed to specify the latching capabilities of the open and close trips. (see **Card Number 23**) Also, a table of fractional stem position versus area may be input [set NVTB1 > 0 (Word 3 on **Card Number 9**) and input valve table VTB1 (**Card Set 55**)]. In addition, valve flow coefficient (C_v) data can be input with this valve type. C_v input requires that the user set NVTB2 > 0 (Word 5 on **Card Number 8**), and supply both **Card Number 24** and VTB2 (**Card Set 56**). Reverse C_v flow coefficients are input in valve table VLTB (**Card Set 54**).

Table 6-7. Meaning of RELAP5 Motor Valve Input variables (IVTY = 11).

Variable	CTM code Variable
Open Trip number	IVTR (Word 1 on **Card Number 9**)
Close Trip number	IVTROV (Word 1 on **Card Number 11**)
Opening change rate (1/s)	RVMX (Word 1 on **Card Number 12**)
Initial position	FAVLVE (Word 4 on **Card Number 14**)

Table 6-7. Meaning of RELAP5 Motor Valve Input variables (IVTY = 11). (Continued)

Variable	CTM code Variable
Valve table number	NVTB1 (Word 3 on **Card Number 9**). If NVTB1 > 0, input **Card Set 56**. Input stem position vs. area fraction.
Closing change rate (1/s)	RVOV (Word 2 on **Card Number 12**)

Card Number 9. (Format 5I14) **IVTR, IVSV, NVTB1, NVSV, NVRF** (See note in **Card Number 8** above).

Variable	Description
IVTR	Trip ID number for valve-type options when IVTY = 3 or 4 (Word 3 on **Card Number 8**) (|IVTR| ≤ 9999) or the component number of turbine stage 1 for valve-type options when IVTY = 5 or 6 (1 ≤ IVTR ≤ 999).
IVSV	The independent variable ID number for the valve table. IVSV > 0 defines the ID number for a signal-variable parameter; IVSV < 0 defines the ID number for a control-block output parameter. For IVTY = 7, this variable can be used to override the upstream pressure of the valve location otherwise used to determine the opening and closing of the SRV banks defined in **Card Set 55**.

Card Number 9. (Format 5I14) **IVTR, IVSV, NVTB1, NVSV, NVRF** (See note in **Card Number 8** above).

Variable	Description
NVTB1	The number of data pairs in the first valve table (defined by the absolute value of NVTB1). Input NVTB1 = 0 when IVTY = 0, 5, 6, 8, 9, or 10 (Word 3 on **Card Number 8**). For IVTY = 1 to 4: NVTB1 > 0 defines the valve table independent-variable form to be the IVSV (Word 2 on this card) parameter; NVTB1 < 0 defines the table independent-variable form to be the sum of the change in the IVSV parameter over each timestep times the trip set-status value ISET during that timestep (when the valve table is trip controlled); NVTB1 = 0 defines the valve flow-area fraction or relative valve-stem position (depending on the value of IVTY) to be the IVSV parameter. For IVTY = 7: NVTB1 > 0 corresponds to the number of safety relief valve banks. The user must input NVTB1 tuples of data in the VTB1 array (**Card Set 56**). NVTB1 <= 0 are not allowed since one or more tuples are required for proper operation of this valve type. For IVTY = -1 or 11: NVTB1 > 0 implies that the valve stem position is being adjusted directly and the flow area is interpolated based on a table lookup. This parameter defines the number of table pairs for the normalized stem position vs. normalized flow area fraction table required for array VTB1 (**Card Set 56**). NVTB1 <= 0 means that the valve flow area, rather than stem position, is
NVSV	The independent-variable ID number for the rate factor that is applied to the first (and second when defined) valve table independent variable. NVSV > 0 defines the ID number for a signal-variable parameter; NVSV < 0 defines the ID number for a control-block output parameter; NVSV = 0 (when NVRF ≠0) defines the difference between the trip signal and the setpoint value that turns the trip OFF when the valve table is trip controlled.

VALVE Component Data

Card Number 9. (Format 5I14) **IVTR, IVSV, NVTB1, NVSV, NVRF** (See note in **Card Number 8** above).

Variable	Description
NVRF	The number of rate-factor table data pairs (defined by the absolute value of NVRF). The rate factor is applied as a factor to the first (and second when defined) valve table independent variable when the rate factor is defined. No rate factor is defined when NVSV and NVRF are both zero. NVRF > 0 defines the rate-factor table independent variable to be the NVSV parameter; NVRF < 0 defines it to be the sum of the change in the NVSV parameter over each timestep times the trip set-status value ISET during that timestep (when the valve table is trip controlled); NVRF = 0 defines the rate factor to be the NVSV parameter.

Card Number 10. (Format 5I14) **IQP3TR, IQP3SV, NQP3TB, NQP3SV, NQP3RF**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 46**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Note:

Variable	Description
IQP3TR	Trip ID number that controls the evaluation of the power-to-the-wall table defined by **Card Set 59** (array QP3TB) [|IQP3TR| ≤ 9999]. [input IQP3TR = 0 when there is to be no trip control and the table is to be evaluated every timestep during the transient calculation].
IQP3SV	The independent-variable ID number for the power-to-the-wall table. IQP3SV > 0 defines the ID number for a signal-variable parameter; IQP3SV < 0 defines the ID number for a control-block output parameter.
NQP3TB	The number of power-to-the-wall table data pairs (defined by the absolute value of NQP3TB). NQP3TB > 0 defines the table independent-variable form to be the IQP3SV parameter; NQP3TB < 0 defines the table independent-variable form to be the sum of the change in the IQP3SV parameter over each timestep times the trip set-status value ISET during that timestep (when the power-to-the-wall table is trip controlled); NQP3TB = 0 defines the power to the wall to be the IQP3SV parameter.

Card Number 10. (Format 5I14) **IQP3TR, IQP3SV, NQP3TB, NQP3SV, NQP3RF (Continued)**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card. If NODES > 0 and QPPP (**Card Set 46**) > 0, this card is read. However, if QPPP = 0 this card is read but not used.

Note:

Variable	Description
NQP3SV	The independent-variable ID number for the rate factor that is applied to the power-to-the-wall table's independent variable. NQP3SV > 0 defines the ID number for a signal-variable parameter; NQP3SV < 0 defines the ID number for a control-block output parameter; NQP3SV = 0 (when NQP3RF ≠ 0) defines the independent variable to be the difference between the trip signal and the setpoint value that turns the trip OFF when the power-to-the-wall table is trip controlled.
NQP3RF	The number of rate-factor table data pairs (defined by the absolute value of NQP3RF). The rate factor is applied as a factor to the power-to-the-wall table's (QP3TB) independent variable when the rate factor is defined. No rate factor is defined when NQP3SV and NQP3RF are both zero. NQP3RF > 0 defines the rate-factor table's independent variable to be the NQP3SV parameter; NQP3RF < 0 defines it to be the change in the NQP3SV parameter over the last timestep times the trip set-status value ISET when the power-to-the-wall table is trip controlled; NQP3RF = 0 defines the rate factor to be the NQP3SV parameter.

Card Number 11. (Format 2I14) **IVTROV, IVTYOV**

Variable	Description
IVTROV	Trip ID number that overrides valve adjustments with or without trip ID number IVTR (Word 1 on **Card Number 9**) control and opens ($ON_{Forward}$) or closes ($ON_{Reverse}$) the valve at the constant rate RVOV (Word 2 on **Card Number 12**) when trip ID number IVTROV is ON [input IVTROV = 0 when IVTY = 5 or 6 (Word 3 on **Card Number 8**)] (|IVTROV| ≤ 9999).
IVTYOV	The type of flow-area adjustment by RVOV (Word 2 on **Card Number 12**) when the overriding trip ID number IVTROV is ON (not used when IVTY = 5 or 6). 0 = flow-area fraction per second; 1 = relative valve-stem position per second.
IVTRLO	Trip ID number that makes a multiple-bank SRV (i.e. IVTY=7) switch from an initial set of pressure setpoints to a set of lower pressure setpoints (i.e. the low/low SRV setpoints in a BWR)

Card Number 12. (Format 4E14.4) **RVMX, RVOV, FMINOV, FMAXOV**

Variable	Description
RVMX	Maximum rate of VALVE flow-area fraction or relative valve-stem position adjustment (1/s).
RVOV	Rate of VALVE flow-area adjustment (1/s) when the overriding trip ID number IVTROV (Word 1 on **Card Number 11**) is ON (not used when IVTY = 5 or 6).
FMINOV	The minimum flow-area fraction (IVTYOV = 0) or minimum relative valve-stem position (IVTYOV = 1) during valve adjustment by the overriding trip ID number IVTROV ($0.0 \le$ FMINOV < FMAXOV).
FMAXOV	The maximum flow-area fraction (IVTYOV = 0) or maximum relative valve-stem position (IVTYOV = 1) during valve adjustment by the overriding trip ID number IVTROV (FMINOV < FMAXOV ≤ 1.0).

Card Number 13. (Format 5E14.4) **RADIN, TH, HOUTL, HOUTV, TOUTL**

Note: The four parameters, HOUTL, HOUTV, TOUTL, and TOUTV, allow flexibility in calculating possible heat losses from the outside of the PIPE wall. Typically, such heat losses are not important for fast transients or large-break loss-of-coolant accidents (LOCAs), and HOUTL and HOUTV can be set equal to zero. When heat losses are significant, they often can be approximated by a constant HTC temperature for the liquid and gas fluid phases outside the pipe wall.

Variable	Description
RADIN	Inner radius (m, ft) of the VALVE wall.
TH	Wall thickness (m, ft) of the VALVE wall.
HOUTL	Heat-transfer coefficient (HTC) [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the VALVE wall and the liquid outside the VALVE wall.
HOUTV	HTC [W/(m^2 K), Btu/(ft^2 °F hr)] between the outer boundary of the VALVE wall and the gas outside the VALVE wall.
TOUTL	Liquid temperature (K, °F) outside the VALVE wall.

Card Number 14. (Format 5E14.4) **TOUTV, AVLVE, HVLVE, FAVLVE, XPOS**

Variable	Description
TOUTV	Gas temperature (K, °F) outside the VALVE wall.
AVLVE	VALVE adjustable-interface flow area (m^2, ft^2) when the VALVE adjustable-interface IVPS is at a flow-area fraction or relative valve-stem position of 1.0 corresponding to 100% open.
HVLVE	VALVE adjustable-interface hydraulic diameter (m, ft) when the VALVE adjustable-interface is 100% open.
FAVLVE	Initial flow-area fraction (ignoring leakage) at the VALVE adjustable-interface IVPS (Word 4 on **Card Number 8**) ($0.0 \leq$ FAVLVE ≤ 1.0). If FAVLVE < 0.0 or FAVLVE > 1.0 is input, a consistent value of FAVLVE is evaluated internally by TRACE based on the input value of XPOS.
XPOS	Initial relative valve-stem position (ignoring leakage) at the VALVE adjustable-interface IVPS (0.0 = no flow area, valve closed; 1.0 = AVLVE flow area, valve 100% opened). If $0.0 \leq$ FAVLVE ≤ 1.0 is input, a consistent value for XPOS is evaluated internally by TRACE based on the valve stem controlling a guillotine closure of a circular flow-area cross section. Otherwise, a consistent value of FAVLVE is evaluated internally by TRACE based on $0.0 \leq$ XPOS ≤ 1.0 that is input.

Card Number 15. (Format 4E14.4, I14) **QP3IN, QP3OFF, RQP3MX, QP3SCL, NHCOM**

Variable	Description
Note:	If NODES = 0 (Word 2 on **Card Number 3**), do not input this card.
QP3IN	Initial power (W, Btu/hr) deposited in (to) the wall and distributed according to the QPPP array. If QP3IN > 0.0, it is the total power to the entire wall. When QP3IN < 0.0, the initial power to the wall in each cell is |QP3IN|, and the negative sign indicates the power to the wall is to be a cell-dependent array of NCELLS (Word 1 on **Card Number 3**) powers. Each data pair of the power-to-the-wall table [for QP3IN < 0.0] has 1 + NCELLS values (an independent-variable value and NCELLS power values for cells 1 through NCELLS). When the power-to-the-wall table is not being evaluated, the same power value of |QP3IN| or QP3OFF [if QP3OFF $> -10^{19}$ W (-3.41×10^{19} Btu/hr)] is applied at each of the NCELLS cells.

Card Number 15. (Format 4E14.4, I14) **QP3IN, QP3OFF, RQP3MX, QP3SCL, NHCOM**

Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input this card.

Variable	Description
QP3OFF	Power (W, Btu/hr) to the wall when the controlling trip is OFF after being ON [not used if IQP3TR = 0 (Word 1 on **Card Number 10**); use the last table-evaluated power when the trip was ON if QP3OFF $\leq -10^{19}$ W (-3.41×10^{19} Btu/hr)].
RQP3MX	Maximum rate of change of the power to the wall [W/s, (Btu/hr)/s] [RQP3MX $\geq$ 0.0].
QP3SCL	Scale factor (–) for the power-to-the-wall table. The dependent variable in the table defined by **Card Set 59** (array QP3TB) is multiplied by QP3SCL to obtain the absolute power (W, Btu/hr) to the wall.
NHCOM	Component number receiving outside wall energy.

Note: Input **Card Number 16** to **Card Number 18** only if IVTY = 8 (Word 3 on **Card Number 8**)

Card Number 16. (Format 5E14.4) **ALEAKB, BOSP, EOSP, BCSP, ECSP**

Note: It is required that BCSP $\leq$ ECSP $\leq$ EOSP $\leq$ BOSP.

Variable	Description
ALEAKB	Minimum valve flow area for leakage (Motor valve only).(m^2, ft^2)
BOSP	Pressure above which valve begins to open. (Pa)
EOSP	Pressure below which valve stops opening. (Pa)
BCSP	Pressure below which valve begins to close. (Pa)
ECSP	Pressure above which valve stops closing. (Pa)

Card Number 17. (Format 2E14.4) **ROPEN, RCLOS**

Variable	Description
ROPEN	Rate at which valve opens (fraction of total valve stem travel per second). ROPEN $\geq$ 0.

Card Number 17. (Format 2E14.4) **ROPEN, RCLOS (Continued)**

Variable	Description
RCLOS	Rate at which valve closes (fraction of total valve stem travel per second). RCLOS ≥ 0.

Card Number 18. (Format 4I14) **MODEM, ISENS, NVTX, IVPG**

Variable	Description
MODEM	Defines attempted valve operation (0 = no movement, +1 = opening movement, -1 = closing movement).
ISENS	Number of cell for which pressure is checked against pressure set points defined by BOSP, EOSP, BCSP and ECSP.
NVTX	Number of VALVE table entry pairs used by VALVE type 8 (motor control valve). Only used when IVPG = 3.
IVPG	VALVE pressure gradient option. (See explanation of IVTY = 8)

Card Number 19. (Format I14,2F14) **HYSTER, ADDDP, LEAKARAT**

Note: Input only if IVTY = 9 (Word 3 on **Card Number 8**), Check Valve

Variable	Description
HYSTER	Check valve type. Enter +1 for a static pressure-controlled check valve (no hysteresis), 0 for a static pressure/flow-controlled check valve (has hysteresis effect), or -1 for a static/dynamic pressure-controlled check valve (has hysteresis effect). It is recommended that 0 be used for most calculations, as it is more stable (i.e., less noisy and less oscillations) than +1 or -1.
ADDDP	Additional delta pressure needed to open the valve (Pa, psia).
LEAKARAT	Ratio of the leak flow area divided by the open flow area.

Note: Input cards **Card Number 20** through **Card Number 22** only if IVTY = 10 (Word 3 on **Card Number 8**) Inertial Check Valve.

Card Number 20. (Format I14,4E14) **LATCHOPT, ADDDP, LEAKARAT, THETA, THETAMIN**

Variable	Description
LATCHOPT	Latch option. The valve can open and close repeatedly if the latch option is zero. When W1 = 1, the valve either opens or closes only once if the initial angle is between the maximum and minimum. If the flapper starts at either the maximum or minimum angle it will not move. When W1 = 2, the flapper will latch only at the maximum position. If it starts at the maximum, it will not move.
ADDDP	Additional pressure needed to open the valve (Pa, psia).
LEAKARAT	Ratio of the leak flow area divided by the open flow area.
THETA	Initial flapper angle (degrees). The flapper angle must be within the minimum and maximum angles specified in Words 2 and 3.
THETAMIN	Minimum flapper angle (degrees). This must be greater than or equal to zero.

Card Number 21. (Format 5E14) **THETAMAX, FLAPMOMI, OMEGA, FLAPLEN, FLAPRAD**

Variable	Description
THETAMAX	Maximum flapper angle (degrees).
FLAPMOMI	Moment of inertia of valve flapper (kg/m^2, lb/ft^2).
OMEGA	Initial angular velocity (rad/s).
FLAPLEN	Moment length of flapper (m, ft).
FLAPRAD	Radius of flapper (m, ft).

Card Number 22. (Format(E14) **FLAPMASS**

Variable	Description
FLAPMASS	Mass of flapper (kg, lb).

Card Number 23. (Format(E14) **LATCHOPT**

Note: Input this card if IVTY = 11, (Word 3 on **Card Number 8**)	
Variable	**Description**
LATCHOPT	Interpreted as the latch option for the open and closing trips for the RELAP5 type Motor Valve. 0 = No latched trips 1 = Only latch the open trip. 2 = Only latch the close trip. 3 = Both trips are latchable.

Card Number 24. (Format 2E14, I14) **NORMFAFACTOR, CSUBVFACTOR, NVTX**

Note: Input only if IVTY = -1 or 11 (Word 3 on **Card Number 8**), NVTB2 >0 and namelist variable NFRC1 = 2.	
Variable	**Description**
NORMFAFACTOR	Multiplier on the normalized area or stem positions in the C_v.tables.
CSUBVFACTOR	Multiplier on the C_v forward and reverse flow coefficients. One good use of this input parameter would be to convert K_v flow coefficients (definition based on SI units) to C_v flow coefficients (definition is based on imperial units).
NVTX	NVTX > 0 defines table input for valve C_v data for reverse flow. The table input is fractional area or stem position (if NVTB1 > 0) versus the C_v value. NFF (**Card Set 34**) can not be -1 or -100 for the valve face (IVPS, Word 4 of). Namelist variable NFRC1 must be set to 2. NVTX pairs of data must be input for valve table VLTB (**Card Set 54**)

VALVE Component Data

VALVE Array Cards

Input each of the following arrays using LOAD format.

Card Set Number	Variable	Dimension	Description
25	**DX**	NCELLS	Cell lengths (m, ft).
26	**VOL**	NCELLS	Cell volumes (m^3, ft^3).
27	**FA**	NCELLS+1	Cell-edge flow areas (m^2, ft^2).
Note: Setting FRIC > 10^{20} at a cell edge invokes the steam-separator model (only the gas phase is allowed to flow through the cell interface). Setting FRIC < -10^{20} invokes the liquid-separator model (only the liquid is allowed to flow through the cell interface). If the reverse additive loss-coefficient option (NFRC1 = 2 in the NAMELIST data) is chosen, steam-separator and liquid-separator models may be used separately in each forward and reverse direction.			
28	**FRIC**	NCELLS+1	Additive loss coefficients (–). See NAMELIST variable IKFAC for optional K factors input.
Note: Input array FRICR only if NFRC1 (NAMELIST variable) = 2.			
29	**FRICR**	NCELLS+1	Additive loss coefficients (–) in the reverse flow direction. See NAMELIST variable IKFAC for optional K factors input.
30	**GRAV or ELEV**	NCELLS+1 (NCELLS for ELEV)	Gravity or elevation terms (– or m, ft). GRAV is the ratio of the elevation difference to the DX flow length between the centers of cell i and cell i-1 for interface i. A positive GRAV value indicates increasing elevation with increasing cell number. See NAMELIST variable IELV for optional cell-centered elevation ELEV input.
31	**HD**	NCELLS+1	Hydraulic diameters (m, ft) (see NAMELIST variable NDIA1 for additional input of heat-transfer diameters).
Note: If NAMELIST variable NDIA1 ≠ 2 do not input array HD-HT.			
32	**HD-HT**	NCELLS+1	Heat transfer diameters (m, ft).
Note: If NAMELIST variable ICFLOW = 0 or 1 do not input array ICFLG. Setting ICFLG > 0 at adjacent cell-edges can lead to numerical difficulties. Use only where choked flow can be realistically expected to occur..			

Card Set Number	Variable	Dimension	Description
33	**ICFLG**	NCELLS+1	Cell-edge choked-flow model option. 0 = no choked-flow model calculation; 1 = choked-flow model calculation using default multipliers; 2 to 5 = choked-flow model calculation using NAMELIST variable defined multipliers.
34	**NFF**	NCELLS+1	Friction-factor correlation option. 0 = constant friction factor based on FRIC input; 1 = homogeneous-flow friction factor plus FRIC; –1 = homogeneous-flow friction factor plus FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE; –100 = FRIC plus an abrupt flow-area change form loss evaluated internally by TRACE.
Note: If NCCFL = 0 (Word 5 on **Main-Data Card 9**), do not input array LCCFL.			
35	**LCCFL**	NCELLS+1	Countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].
36	**ALP**	NCELLS	Initial gas volume fractions (–).
37	**VL**	NCELLS+1	Initial liquid velocities (m/s, ft/s).
38	**VV**	NCELLS+1	Initial gas velocities (m/s, ft/s).
39	**TL**	NCELLS	Initial liquid temperatures (K, °F).
40	**TV**	NCELLS	Initial gas temperatures (K, °F).
41	**P**	NCELLS	Initial pressures (Pa, psia).
42	**PA**	NCELLS	Initial noncondensable-gas partial pressure (Pa, psia).

Card Set Number	Variable	Dimension	Description
			Note: If NAMELIST variable NOLT1D = 0, input array ILEV. Otherwise, leave it out.
43	**ILEV**	NCELLS	Level tracking flags. ILEV = 1 indicates that the two-phase level exists in the current cell. ILEV = 0 indicates that the two-phase level does not exist in the current cell. If ILEV = -1, the level tracking calculation will be turned off for this cell.
			Note: If NAMELIST variable MWFL = 0, do not input array WFMFL.
44	**WFMFL**	NCELLS+1	Wall-friction multiplier factor for the liquid phase [$0.9 \leq$ WFMFL ≤ 1.1].
			Note: If NAMELIST variable MWFV = 0, do not input array WFMFV.
45	**WFMFV**	NCELLS+1	Wall-friction multiplier factor for the gas phase [$0.9 \leq$ WFMFV ≤ 1.1].
			Note: If NODES = 0 (Word 2 on **Card Number 3**), do not input arrays QPPP, MATID, TW, IDROD, and NHCEL.
46	**QPPP**	NODES × NCELLS	A relative power shape (–) in the VALVE wall. Input values for cell 1, node 1 through NODES; then cell 2, node 1 through NODES; etc. If the array is filled with the same nonzero constant, a uniform volumetric heat source in the wall results. TRACE internally normalizes the shape to have a volume-average value of unity {each QPPP(I) is normalized to have the value QPPP(I) × [Σ_K VOL(K)]/[Σ_K QPPP(K) × VOL(K)]}. Filling the array with zeros results in no power being deposited in the wall regardless of the values of QP3IN, QP3TB, etc.
47	**MATID**	NODES–1	Wall-material ID array, which specifies material ID between radial nodes. Dimension is 1 if NODES = 1. 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 12 = inconel, type 600.
48	**TW**	NODES × NCELLS	Initial wall temperatures (K, °F) in the VALVE that are input in the same order as QPPP.

Card Set Number	Variable	Dimension	Description
Note: If NHCOM = 0 (Word 5 on **Card Number 15**), do not input arrays IDROD and NHCEL.			
49	**IDROD**	1	Vessel radial-theta cell number or input 0 when NHCOM is a 1D component.
50	**NHCEL**	NCELLS	Connecting axial cell numbers in component NHCOM.
Note: If ICONC = 0 (Word 2 on **Card Number 8**), do not input array CONC.			
51	**CONC**	NCELLS	Initial solute mass to liquid-coolant mass ratios [kg(solute)/kg (liquid), lb_m(solute)/lb_m (liquid)]. Requires ISOLUT = 1 (Word 3 on**Main-Data Card 9**).
Note: If ICONC = 0 or 1, (Word 2 on **Card Number 8**), or the NAMELIST parameter USESJC > 0, do not input array S.			
52	**S**	NCELLS	Initial macroscopic densities of plated-out solute (kg/m^3, lb_m/ft^3). Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**)
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
53	**XGNB**	NCELLS	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).
Note: Input array XLNB only if NTRACEL > 0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
54	**XLNB**	NCELLS	Mass fraction for liquid trace species.

Valve Tables

Card Set Number	Variable	Dimension	Description
			Note: Input array VLTB if NVTX > 0 (Word 3 on **Card Number 18**), IVTY = 8 (Word 3 on **Card Number 8**) and IVPG = 3 (Word 4 on **Card Number 18**). Input array VLTB if IVTY = -1 or 11 (Word 3 on **Card Number 8**), NVTB2 > 0 (Word 5 on **Card Number 8**), and NVTX> 0 (Word 3 on **Card Number 24**).
55	**VLTB**	2*NVTX	If IVTY = 8, input fractional valve stem position, valve area fraction pairs If IVTY = -1 or 11 and NVTX > 0, then enter fractional valve area or fractional stem position vs. reverse flow C_v pairs where C_v has units of $\frac{m^3/s}{\sqrt{Pa}}$ for SI input and $\frac{(gal)/(min)}{\sqrt{(lb_f)/(in^2)}}$ for British input.
			Note: If NVTB1 = 0 (Word 3 on **Card Number 9**), do not input array VTB1. Table VTB1 is used when IVTY = -1, 1 to 4, 7 or 11.
56	**VTB1**	2*|NVTB1| for IVTY≠7, *M**|NVTB1| for IVTY=7, where *M*=5 for IVTRLO=0 and *M*=7 for IVTRLO ≠ 0	First valve-adjustment table (*,–). Interpretation of table entries depends on the value of IVTY. In all cases, |NVTB1| (Word 3 on **Card Number 9**) tuples are required. For IVTY≠7, the table is defined by pairs having the following form [independent-variable, dependent variable #1, dependent variable #2, ...]. The independent variable form is defined by one of three values, depending upon the specific valve type (IVTY) that is being defined: IVSV (Word 2 on **Card Number 9**), flow-area fraction, or relative valve-stem position. If IVTY = -1 or 11, input stem position vs. area fraction.

Card Set Number	Variable	Dimension	Description
			For IVTY=7, the table is defined by tuples having the following form [independent-variable, dependent variable #1, dependent variable #2, ...]. One tuple is provided for each discrete bank of relief valves. The independent variable is defined by the IVSV variable and corresponds to the pressure used to determine the opening and closing of the SRV bank. The dependent variables are defined as follows:
			6) Valve bank fraction area relative to AVLVE. 7) Valve bank initial opening pressure. 8) Valve bank initial closing pressure. 9) Valve bank form loss coefficient. 10) Valve bank fractional hyd diameter relative to HVLVE. 11) Valve bank low/low opening pressure. 12) Valve bank low/low closing pressure.and IVTRLO The number of dependent values depends upon the value of IVTRLO. For IVTRLO = 0, the first five words are required for each valve bank. For IVTY = 7 and IVTRLO ≠ 0 all seven words are required for each valve bank. The form loss coefficient (i.e. the fourth word of this card set) is used to compute an equivalent form loss for the open valve banks assuming that the banks open starting with the lowest numbered bank and close starting with the highest numbered bank. The sixth and seventh words become active only after the trip defined by IVTRLO is ON

Card Set Number	Variable	Dimension	Description
Note: If NVTB2 = 0 (Word 5 on **Card Number 6**), do not input array VTB2.			
57	**VTB2**	2×|NVTB2|	Second valve-adjustment table (*,–). If IVTY = 3 or 4 and NVTB2 ≠ 0, then input |NVTB2| (Word 5 on **Card Number 8**) table-defining data pairs having the following form [independent-variable form defined by IVSV (Word 2 on **Card Number 9**), flow-area fraction or relative valve-stem position]. Define the flow-area fraction or relative valve-stem position values in the second valve-adjustment table to vary in the same direction as they do in the first valve adjustment table VTB1; that is, if the flow-area fraction or relative valve-stem position increases in going from left to right in the first valve-adjustment table, define them in the second valve-adjustment table to increase in going from left to right as well. If IVTY = -1 or 11 and NVTB2 > 0, then enter fractional valve area or fractional stem position vs. forward flow C_v pairs where C_v has units of $\frac{m^3/s}{\sqrt{Pa}}$ for SI input and $\frac{(gal)/(min)}{\sqrt{(lb_f)/(in^2)}}$ for British input.
Note: If NVTB1 = 0 or NVRF = 0 (Words 3 and 5 on **Card Number 9**), do not input array VRF.			
58	**VRF**	2×|NVRF|	Rate-factor table (*,–) for the first (and second if NVTB2 ≠ 0) valve-adjustment table independent variable. Input |NVRF| (Word 5 on **Card Number 9**) table-defining data pairs having the following form [independent-variable form defined by NVSV (Word 4 on **Card Number 9**), rate factor to be applied to the valve-adjustment table independent variable].
Note: If NQP3TB = 0 (Word 3 on **Card Number 10**), do not input array QP3TB.			

Card Set Number	Variable	Dimension	Description
59	QP3TB	2×|NQP3TB| when QP3IN > 0.0; (1+NCELLS) ×|NQP3TB| when QP3IN < 0.0.	Power-to-the-wall independent-variable-form table [(*,W), (*,Btu/hr)]. Input |NQP3TB| (Word 3 on **Card Number 10**) table-defining data pairs having the following form [independent-variable form defined by IQP3SV (Word 2 on **Card Number 10**), power to the wall]. If QP3IN > 0.0, the dependent variable specifies the total power to the entire wall; if QP3IN < 0.0, the dependent variable is a power shape that specifies the power to the wall at each cell from cell 1 to cell NCELLS.

VESSEL Component Data

Note: BREAK and PLENUM components cannot be connected to VESSEL component source-connection junctions. The FILL component can connect to the VESSEL component using the FILL leak path junction.

Card Number 1. (Format A14,2I14,A30) **TYPE, NUM, ID, CTITLE**

Variable	Description
TYPE	Component type (VESSEL left justified).
NUM	Component ID number (must be unique for each component, 1 ≤ NUM ≤ 999).
ID	User ID number (arbitrary).
CTITLE	Hollerith component description.

Card Number 2. (Format 2A14) **EOS, PHASECHANGE**

Note: Only input this card when the number of inputs for FLUIDS (a NAMELIST variable) is more than one.

Variable	Description
EOS	EOS identifier for this component (i.e. “h2o” or “r5h2o”, etc.).
PHASECHANGE	Phase change flag. Input TRUE or true, if phase change is allowed for this component. Input FALSE or false, if phase change is not allowed for this component.

Card Number 3. (Format 5I14) **NASX, NRSX, NTSX, NCSR, IVSSBF**

Variable	Description
NASX	Number of axial (z-direction) cells (levels).
NRSX	Number of radial (r-direction) cells (rings) or x-direction cells. [IGEOM (Word 1 on **Card Number 6**) defines cylindrical or Cartesian geometry].
NTSX	Number of azimuthal (θ-direction) cells (sectors) or y-direction cells.

Card Number 3. (Format 5I14) **NASX, NRSX, NTSX, NCSR, IVSSBF** (Continued)

Variable	Description
NCSR	Number of 1D hydraulic-component (but not BREAK or PLENUM component) junction connections to VESSEL-component cell interfaces. Each of the six VESSEL-cell interfaces can have any number of 1D hydraulic-component junction connections.
IVSSBF	Axial boundary-condition option [IVSSBF > 0 requires additional input of level data for axial cells (levels) 0 and NASX + 1 to define their constant FILL or BREAK cell boundary condition]. The r- or x-directional and the θ- or y-directional boundaries below axial cell (level) 1 and above axial cell (level) NASX are no-flow walls. 0 = no-flow wall below axial cell (level), 1 and above axial cell (level) NASX (default); 2 = axial cell (level) 0 defines a FILL and axial cell (level) NASX + 1 defines a BREAK boundary condition; 20 = axial cell (level) 0 defines a BREAK boundary condition and axial cell (level) NASX + 1 defines a FILL boundary condition; 22 = both axial cells (levels) 0 and NASX+1 define a BREAK.

Card Number 4. (Format 5I14) **IDCU, IDCL, IDCR, ICRU, ICRL**

Variable	Description
IDCU	Axial cell (level) number at which its upper interface is the downcomer upper-boundary elevation. If no downcomer is present, input IDCU = 0 (this is the necessary and sufficient condition to indicate no downcomer is present in the VESSEL component as far as TRACE setting downcomer-interface flow areas to zero internally).
IDCL	Axial-cell (level) number at which its upper interface is the downcomer lower-boundary elevation. If IDCU = 0, input IDCL = 0.
IDCR	Radial-cell (ring) number at which its outer interface is the downcomer inner-radial boundary. If IDCU = 0, input IDCR = 0.
ICRU	Axial-cell (level) number at which its upper interface is the reactor-core region upper-boundary elevation. If no reactor-core region is present, input ICRU = 0.
ICRL	Axial-cell (level) number at which its upper interface is the reactor-core region lower-boundary elevation. If no reactor-core region is present, input ICRL = 0.

Card Number 5. (Format 5I14) **ICRR, ILCSP, IUCSP, IUHP, ICONC**

Variable	Description
ICRR	Radial-cell (ring) number at which its outer interface is the reactor-core outer-radial boundary. ICRR is used to define the reactor-core region with ICRU and ICRL as well as with ILCSP and IUCSP. If no reactor-core region is defined by both ICRU and ICRL as well as ILCSP and IUCSP, input ICRR = 0.
ILCSP	Axial-cell (level) number at which its upper interface is the core-region lower-boundary support-plate elevation to be used for evaluating graphics output. Defaults to the value of ICRL (Word 5 on **Card Number 4**) if ILCSP = 0 is input.
IUCSP	Axial-cell (level) number at which its upper interface is the core-region upper-boundary support-plate elevation to be used for evaluating graphics output. Defaults to the value of ICRU (Word 4 on **Card Number 4**) if IUCSP = 0 is input.
IUHP	Axial-cell (level) at which its upper interface is the upper-head support-plate elevation to be used for evaluating graphics output. Defaults to the value of IDCU (Word 1 on **Card Number 4**) if IUHP = 0 is input.
ICONC	Solute in the liquid coolant option. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**) when ICONC > 0. 0 = no; 1 = dissolved solute only; 2 = both dissolved and plated-out solute.

Card Number 6. (Format 4(I14)) **IGEOM, NVENT, NVVTB, NSGRID, VESSTYPE**

Variable	Description
IGEOM	VESSEL geometry option. 0 = cylindrical geometry; 1 = Cartesian geometry.
NVENT	Number of vent valves in the VESSEL. No vent valve or a maximum of one vent valve per radial interface between VESSEL cells is allowed; therefore, actual valves may have to be lumped together for each cell interface.
NVVTB	Number of vent-valve resistance table data pairs. If NVVTB = 0, the maximum and minimum vent-valve pressure drops and flow-loss resistances are input. If NVVTB > 0, the flow-loss resistance vs pressure drop table is input on **Card Set 17** (array VVTAB).
NSGRID	Number of spacer grids present in the core region. Input zero if no grid spacers are present or you don't intend to model their effect.

Card Number 6. (Format 4(I14)) **IGEOM, NVENT, NVVTB, NSGRID, VESSTYPE** (Continued)

Variable	Description
VESSTYPE	The type of modelling behavior employed by this VESSEL: 0 = model VESSEL as an RPV (the default) 1 = model VESSEL as a drywell. This option uses a special wall condensation model appropriate for drywells. Otherwise, it behaves the same as VESSTYPE = 0.

Card Number 7. (Format 2E14.4, 2I14) **SHELV, EPSW, NOLT, RFLDINPUT**

Variable	Description
SHELV	Elevation (m, ft) of the bottom interface of axial cell (level) 1 in the VESSEL (used only when NAMELIST variable IELV = 1 is input).
EPSW	Wall surface roughness (m, ft).
NOLT	Turns 3D level tracking on or off (used only when NAMELIST variable NOLT3D = 0) If NOLT is positive 3D level tracking is turned off in the VESSEL. If NOLT = 0; 3D level tracking is turned on in the VESSEL and is controlled by ILEV (see **Card Set 58**)
RFLDINPUT	Flag to indicate the existence of special optional input of importance to reflood calculations. If non-zero, then **Card Set 13** and **Card Set 14** (i.e. UNHEATFR and NHSCA) are input. If zero, then card array sets 13 & 14 are not input.

Card Number 8. (Format I14, E14.4) **MATHS, HSOUT**

Note: If NAMELIST variable USEROD ≠ 1, do not input this Card.

Variable	Description
MATHS	Material type for the lumped slab heat structure.
HSOUT	Flag for vessel heat structure edit in the output file. 0 = no, 1= yes.

Card Number 9. (Format I14,4(E14.4)) **NODESD, DHOUTL, DHOUTV, DTOUTL, DTOUTV**

Note: If NAMELIST variable USEROD ≠ 1, do not input this Card.	
Variable	**Description**
NODESD	Number of conduction heat transfer nodes in double slabs.
DHOUTL	Heat transfer coefficient to liquid on vessel outside surface [W/(m^2 K), Btu/(ft^2 ^oF hr)].
DHOUTV	Heat transfer coefficient to vapor on vessel outside surface [W/(m^2 K), Btu/(ft^2 ^oF hr)].
DTOUTL	Liquid temperature outside vessel (K, ^oF).
DTOUTV	Vapor temperature outside vessel (K, ^oF).

VESSEL Geometry Cards

Note: There are three Card Sets, one set for each of the following arrays. Use LOAD format. Each array has its element values defined by a Card Set of one or more cards.

Card Set Number	**Variable**	**Dimension**	**Description**
10	**Z**	NASX	Axial upper-interface locations (elevations) (m, ft) of the z-direction axial-cells (levels) [referenced to a 0.0 m (0.0 ft) (elevation) value at the bottom interface of the first axial-cell (level) in the VESSEL].
11	**R or X**	NRSX	Radii or x outer-interface locations (m, ft) of the r- or x-directional cells [referenced to a 0.0 m (0.0 ft) value at the inner interface of cell 1].

Card Set Number	Variable	Dimension	Description
12	**T or Y**	NTSX	Azimuthal angle θ or y outer-interface locations of the θ- or y-direction cells (referenced to a 0.0 rad or m (0.0 deg or ft) value at the inner interface of the first cell). For cylindrical geometry [IGEOM = 0 (Word 1 on **Card Number 6**)] and input data in SI units [NAMELIST variable IOINP = 0], the azimuthal angles θ can be input in either degree (0.0 deg < T ≤ 360.0 deg) or radian (0.0 rad < T ≤ 2 π = 6.2832 rad) units. For cylindrical geometry [IGEOM = 0 (Word 1 on **Card Number 6**)] and input data in English units [NAMELIST variable IOINP = 1], the azimuthal angles must be input in degree units. A full-geometry cylinder VESSEL model requires that the last azimuthal angle T(NTSX) = 360.0 deg or 6.2832 rad. Rotational symmetries of 30.0 deg (0.5236 rad), 45.0 deg (0.7854 rad), 60.0 deg (1.0472 rad), 90.0 deg (1.5708 rad), 120.0 deg (2.0944 rad), or 180.0 deg (3.1426 rad) can be defined by inputting T(NTSX) with one of these rotational-sector angles. A partial-geometry cylinder VESSEL model with any other last azimuthal angle less than 360.0 deg or 6.2832 rad can be defined but requires that array FRFAYT (**Card Set 41**) input data have 0.0 values for all the NTSX azimuthal interfaces of the NRSX radial cells [(NTSX)ht value for radial cell 1, (2*NTSX)th value for radial cell 2,..., (NRSX*NTSX)th value for radial cell NRSX].
Note: If RLFDINPUT = 0 (i.e. Word 4 on **Card Number 7**), do not input arrays UNHEATFR and NHSCA for the core-reflood model			
13	**UNHEATFR**	NTSX × NRSX	Fractions of the HTSTR component element surface in each of the NTSX x NRSX horizontal-plane mesh-cell columns, which are unheated.
14	**NHSCA**	NTSX × NRSX	The HTSTR component numbers that define the primary powered average (power) element in each of the NTSX × NRSX horizontal-plane mesh-cell columns.

VESSEL Vent Valve Data:

Note: If NVENT = 0 (Word 2 on **Card Number 6**), do not input **Card Number 15**, **Card Number 16**, and **Card Set 17**.

Card Number 15. Vent-Valve Location and Area Card: (Format 2I14,E14.4) **IZV, KV, AVENT**

Note: Input this Card for each NVENT (Word 2 on **Card Number 6**) vent valves.

Variable	Description
IZV	Axial-cell (level) number of the vent-valve interface location.
KV	Horizontal-plane relative-cell number [J + NTSX × (I–1) where I is the r- or x-direction cell number and J is the θ- or y-direction cell number] of the vent-valve interface location on the outer radial or x interface of the cell.
AVENT	Maximum flow area (m^2, ft^2) of the vent valve located on the outer radial or x interface of the cell.

Card Number 16. Vent-Valve Pressure-Drop and Friction-Loss Card: (Format 4E14.4) **DPCVN, DPOVN, FRCVN, FROVN**

Note: If NVVTB ≠ 0 (Word 3 on **Card Number 6**), do not input this card

Input this Card for each NVENT (Word 2 on **Card Number 6**) vent valves.

Variable	Description
DPCVN	Maximum pressure drop (Pa, psid) between the inner and outer radial or x-direction cells when the vent valve is closed.
DPOVN	Minimum pressure drop (Pa, psid) between the inner and outer radial or x-direction cells when the vent valve is opened.
FRCVN	Flow-loss resistance (–) of the vent valve in its closed position.
FROVN	Flow-loss resistance (–) of the vent valve in its open position.

VESSEL Vent-Valve Flow-Loss Resistance Table

Note: If NVVTB = 0 (Word 3 on **Card Number 6**), do not input this card set. Input a table of vent-valve flow-loss resistance vs pressure drop across the vent valve. Use LOAD format. Only one table is input for all vent valves.

Card Set Number	Variable	Dimension	Description
17	**VVTAB**	2 × |NVVTB|	Vent-valve FRIC flow-loss resistance table [(Pa,–), (psid, –)]. [input |NVVTB| (Word 3 on **Card Number 6**) table-defining data pairs having the following form (pressure drop across the vent valve, FRIC flow-loss resistance of the vent valve)].

The vent-valve FRIC flow-loss resistance input must be of the form $K_{i+1/2}\, D_{hi+1/2}/(\Delta r_i + \Delta r_{i+1})$ or $K_{i+1/2}\, D_{hi+1/2}/(\Delta x_i + \Delta x_{i+1})$, where $K_{i+1/2}$ is the K-factor form-loss coefficient, $D_{hi+1/2}$ is the i+1/2 interface hydraulic diameter, and Δr_i and Δr_{i+1} or Δx_i and Δx_{i+1} are the radial or x-direction lengths of the fluid cells on each side of the vent-valve interface. Note that the NAMELIST variable IKFAC, which determines how the additive-loss coefficient is defined for input, does not affect the vent-valve FRIC flow-loss resistance form.

The hydraulic diameter in the radial direction, HDXR (**Card Set 46**), must be the value corresponding to the vent valve for each cell connected to a vent valve.

VESSEL Spacer Grid Elevation Cards:

Note: If NSGRID = 0 (Word 4 on **Card Number 6**), do not input the Vessel Spacer-Grid Elevation Cards. Use LOAD format. The ZSGRID array elements are defined by a Card Set of one or more cards.

Card Set Number	Variable	Dimension	Description
18	**ZSGRID**	NSGRID	Axial z-direction location (elevation) (m, ft) of each spacer grid in the core region as measured from the VESSEL bottom [consistent with the Z array (**Card Set 10**)].

VESSEL Gravity Card:

Card Number 19. (Format 4E14.4) **GC, GYTC, GXRC, GZ**

Note:	If NAMELIST variable NVGRAV = 0, do not input this card. The values of GYTC, GXRC, and GZC range between –1.0 and 1.0 and must satisfy the requirement that: **GYTC*GYTC + GXRC*GXRC + GZC*GZC = 1.0** (all three input values are normalized with the same factor to satisfy this requirement). For gravity acceleration in the downward axial direction: **GYTC** = 0.0, **GXRC** = 0.0, and **GZC** = -1.0

Variable	Description
GC	Gravitational-acceleration constant [when GC ≤ 0.0 is input, GC is defined internally by TRACE with the value 9.80665 m/s^2 (32.17405 ft/s^2)]. The GC value from the last VESSEL component input also is used for the one-dimensional components.
GYTC	The θ- or y-direction component (–) of the gravity unit vector located at the center of mesh cell (1,1,1).
GXRC	The r- or x-direction component (–) of the gravity unit vector located at the center of mesh cell (1,1,1).
GZC	The z-direction component (–) of the gravity unit vector located at the center of mesh cell (1,1,1).

VESSEL Source-Connection Cards:

Note: If NCSR = 0 (Word 4 on **Card Number 3**), do not input the Vessel Source-Connection Cards defined by this card set. Input one card for each of the NCSR source connections of a one-dimensional component to a VESSEL cell interface. See VESSEL description in **Volume 2**.

Card Set Number	Variable	Description
20	**LISRL**	Axial-cell (level) number of the source connection.
	LISRC	Horizontal-plane relative-cell number associated with the source connection [cell numbering in a VESSEL level counts through the NTSX (Word 3 on **Card Number 3**) θ- or y-direction cells while considering each of the r- or x-direction cells from 1 to NRSX (Word 2 on **Card Number 3**)].
	LISRF	Face number associated with the source connection. A positive number indicates a connection to the upper or outer face of the cell; a negative number indicates a connection to the lower or inner face of the cell. 1 = θ or y direction; 2 = axial z direction; 3 = r or x direction.
	LJUNS	Junction number associated with the source connection of a VESSEL cell interface to a 1D component.

VESSEL Level Cards:

Input **Card Set 21** through **Card Set 68** using LOAD format. These Card Sets are input as a group for each axial cell (level) number in increasing numerical order from 1 to NASX (Word 1 on **Card Number 3**) if IVSSBF = 0 (Word 5 on **Card Number 3**) or from 0 to NASX+1 if IVSSBF > 0. If desired, the data from a level already input can be repeated by a single REPEAT LEVEL card for another level (see description after the level data description.)

Note: The following parameters [dimensioned NTSX x NRSX (Words 3 and 2 on **Card Number 3**)] are input for each (r, θ) or (x, y) mesh cell in each axial level; that is, these cells extend over the entire VESSEL plane perpendicular to the axial direction for each axial cell (level). Because a separate group of 39 Card Sets is input for each axial cell (level), these parameters are specified for all mesh cells in the VESSEL. If IVSSBF > 0 (Word 5 on **Card Number 3**), input data also must be defined for the 0 and NASX+1 levels to provide boundary-condition information.

Card Set Number	Variable	Dimension	Description
			Note: If NAMELIST variable USEROD = 1, lumped parameter and double-sided heat structure data are input (**Card Set 21** thorough **Card Set 26**).
21	**HSA**	NTSX × NRSX	Lumped parameter heat slab area (m^2, ft^2).
22	**HSM**	NTSX × NRSX	Mass of lumped parameter heat slab (kg, lb_m). Must be input but not used for cells in which HSA=0.
			Note: If NODESD = 0 (Word 1 on **Card Number 9**) do not input **Card Set 23** thorough **Card Set 26**.
23	**DSA**	NTSX × NRSX	Double slab inside surface area (One slab per vessel cell is allowed) [m^2, ft^2].
24	**DSTH**	NTSX × NRSX	Double slab thickness (m, ft). Must be input but not used for cells in which DSA=0.
25	**MATDS**	NTSX × NRSX	Double slab material type. Must be input but not used for cells in which DSA=0.
26	**DST**	NODESD × NTSX × NRSX	Double slab nodal temperature (K, °F).
			Note: The forward-flow direction flow-resistance parameters are defined by arrays CFZLYT, CFZLZ, CFZLXR, CFZVYT, CFZVZ and CFZVXR. These arrays must always be supplied. If NAMELIST variable IKFAC = 1, K-factors rather than FRIC additive-friction-loss coefficients should be input. **Note:** **Abrupt Expansion/Contraction Form Loss**. Providing a negative value for CFZLYT, CFZLZ, or CFZLXR results in TRACE internally evaluating an abrupt expansion/contraction form loss (for when the mesh-cell flow area changes between mesh cells adjacent to each other), which then is added to the absolute value of the input values of CFZLYT, CFZLZ, and CFZLXR and to the positive value of the input values of CFZVYT, CFRLYT, CFRVYT, CFZVZ, CFRLZ, CFRVZ, CFZVXR, CFRLXR, and CFRVXR.
27	**CFZLYT**	NTSX × NRSX	Liquid additive-friction-loss coefficients (–) in the θ or y direction.
28	**CFZLZ**	NTSX × NRSX	Liquid additive-friction-loss coefficients (–) in the z direction.

Card Set Number	Variable	Dimension	Description
29	**CFZLXR**	NTSX × NRSX	Liquid additive-friction-loss coefficients (–) in the r or x direction.
30	**CFZVYT**	NTSX × NRSX	Gas additive-friction-loss coefficients (–) in the θ or y direction.
31	**CFZVZ**	NTSX × NRSX	Gas additive-friction-loss coefficients (–) in the z direction.
32	**CFZVXR**	NTSX × NRSX	Gas additive friction-loss coefficients (–) in the r or x direction.
Note: Input these arrays only if NAMELIST variable NFRC3 = 2. Reverse-flow direction flow-resistance parameters are defined by arrays CFRLYT, CFRLZ, CFRLXR, CFRVYT, CFRVZ and CFRVXR. If NAMELIST variable IKFAC = 1, K-factors rather than FRIC additive-friction-loss coefficients are input.			
33	**CFRLYT**	NTSX × NRSX	Liquid reverse-flow direction additive-friction-loss coefficients (–) in the θ or y direction.
34	**CFRLZ**	NTSX × NRSX	Liquid reverse-flow direction additive-friction-loss coefficients (–) in the z direction.
35	**CFRLXR**	NTSX × NRSX	Liquid reverse-flow direction additive-friction-loss coefficients (–) in the r or x direction.
36	**CFRVYT**	NTSX × NRSX	Gas reverse-flow direction additive-friction-loss coefficients (–) in the θ or y direction.
37	**CFRVZ**	NTSX × NRSX	Gas reverse-flow direction additive-friction-loss coefficients (–) in the z direction.
38	**CFRVXR**	NTSX × NRSX	Gas reverse-flow direction additive-friction-loss coefficients (–) in the r or x direction.
Note: If NCCFL = 0, (Word 5 **Main-Data Card 9**), do not input array LCCFL.			
39	**LCCFL**	NTSX × NRSX	Countercurrent flow limitation option. 0 = no countercurrent flow limitation calculation at the cell interface; N = the countercurrent flow limitation parameter set number used to evaluate countercurrent flow limitation at the cell interface [1 ≤ N ≤ NCCFL (Word 5 on **Main-Data Card 9**)].

Card Set Number	Variable	Dimension	Description
40	FRVOL	NTSX × NRSX	Cell fluid-volume fractions (–) (0.0 ≤ VOL ≤ 1.0).
41	FRFAYT	NTSX × NRSX	Cell-edge flow-area fractions (–) in the θ or y direction (0.0 ≤ FRFAYT ≤ 1.0).
42	FRFAZ	NTSX × NRSX	Cell-edge flow-area fractions (–) in the z direction (0.0 ≤ FRFAZ ≤ 1.0).
43	FRFAXR	NTSX × NRSX	Cell-edge flow-area fractions (–) in the r or x direction (0.0 ≤ FRFAXR ≤ 1.0).
44	HDYT	NTSX × NRSX	Hydraulic diameters (m, ft) in the θ or y direction.
45	HDZ	NTSX × NRSX	Hydraulic diameters (m, ft) in the z direction [for heat-transfer purposes, do not input the axial-direction hydraulic diameter with a value of 0.0].
46	HDXR	NTSX × NRSX	Hydraulic diameters (m, ft) in the r or x direction.
47	ALPN	NTSX × NRSX	Initial gas volume fractions (–).
48	VVNYT	NTSX × NRSX	Initial gas velocities (m/s, ft/s) in the θ or y direction.
49	VVNZ	NTSX × NRSX	Initial gas velocities (m/s, ft/s) in the z direction.
50	VVNXR	NTSX × NRSX	Initial gas velocities (m/s, ft/s) in the r or x direction.
51	VLNYT	NTSX × NRSX	Initial liquid velocities (m/s, ft/s) in the θ or y direction.
52	VLNZ	NTSX × NRSX	Initial liquid velocities (m/s, ft/s) in the z direction.
53	VLNXR	NTSX × NRSX	Initial liquid velocities (m/s, ft/s) in the r or x-direction.
54	TVN	NTSX × NRSX	Initial gas temperatures (K, °F).
55	TLN	NTSX × NRSX	Initial liquid temperatures (K, °F).

Card Set Number	Variable	Dimension	Description
56	**PN**	NTSX × NRSX	Initial pressures (Pa, psia).
57	**PAN**	NTSX × NRSX	Initial noncondensable-gas partial pressure (Pa, psia).
Note: If NAMELIST parameter NOLT3D = 0 and NOLT = 0 (Word 3 on **Card Number 7**), input array ILEV.			
58	**ILEV**	NTSX × NRSX	ILEV = 1 indicates that the two-phase level exists in the current cell. ILEV = 0 indicates that the two-phase level does not exist in the current cell. If ILEV = -1, the level tracking calculation will be turned off for this cell.
Note: If NAMELIST variable MWFL = 0, do not input arrays VWFMLY, VWFMLZ, and VWFMLX.			
59	**VWFMLY**	NTSX × NRSX	Wall-friction multiplier factor for the liquid phase in the θ or y direction (–) (0.9 ≤ VWFMLY ≤ 1.1).
60	**VWFMLZ**	NTSX × NRSX	Wall-friction multiplier factor for the liquid phase in the z direction (–) (0.9 ≤ VWFMLZ ≤ 1.1).
61	**VWFMLX**	NTSX × NRSX	Wall-friction multiplier factor for the liquid phase in the r or x direction (–) (0.9 ≤ VWFMLX ≤ 1.1).
Note: If NAMELIST variable MWFV = 0, do not input arrays VWFMVY, VWFMVZ, and VWFMVX.			
62	**VWFMVY**	NTSX × NRSX	Wall-friction multiplier factor for the gas phase in the θ or y direction (–) [0.9 ≤ VWFMVY ≤ 1.1].
63	**VWFMVZ**	NTSX × NRSX	Wall-friction multiplier factor for the gas phase in the z direction (–) [0.9 ≤ VWFMVZ ≤ 1.1].
64	**VWFMVX**	NTSX × NRSX	Wall-friction multiplier factor for the gas phase in the r or x direction (–) [0.9 ≤ VWFMVX ≤ 1.1].
Note: If ICONC = 0 (Word 5 on **Card Number 5**), do not input array CONC.			
65	**CONC**	NTSX × NRSX	Initial solute mass to liquid-coolant mass ratios [kg(solute)/kg(liquid), lb_m(solute)/lb_m(liquid)]. Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).

Card Set Number	Variable	Dimension	Description
Note: If ICONC = 0 or 1 (Word 5 on **Card Number 5**), do not input array S.			
66	**S**	NTSX × NRSX	Initial macroscopic densities of plated-out solute (kg/m^3, lb$_m$/ft^3). Requires ISOLUT = 1 (Word 3 on **Main-Data Card 9**).
Note: Input array XGNB only if NTRACEG>0 (Word 1 on **Main-Data Card 11**) or IGAS>11 (a Namelist input). Repeat this card set NTRACEG times or repeat IGAS-10 times if IGAS > 11. If IGAS>11, then NTRACEG cannot be greater than zero and the sum of XGNB for each cell must be 1.0.			
67	**XGNB**	NTSX × NRSX	Mass fraction for gas trace species or if IGAS>11, then mass fraction for each non-condensable gas species. Non-condensable gas species index is defined by the order in which gas species are input in the NCGasSpecies array (a Namelist input).
Note: Input array XLNB only if NTRACEL>0 (Word 2 on **Main-Data Card 11**). Repeat this card set NTRACEL times.			
68	**XLNB**	NTSX × NRSX	Mass fraction for liquid trace species.

VESSEL Level Repeat Card.

Card Number 69. REPEAT LEVEL Card. (Format A12,2X,I4)

Variable	Description
Note: This card can be used to repeat the data from a level already input or repeated to define the data for the next level. Each `REPEAT LEVEL` card can repeat only the data from a level with a lesser level number that was input before it (level numbers are specified sequentially). These cards may be used consecutively.	
AREP	The character string: "`REPEAT LEVEL`" (where ^ indicates a blank space).
NLEV	Input the number of the level whose data is to be repeated.

End-of-Component Input Card

After all the component data input is read, a single card containing the characters "**end**" in columns 1 to 3 must be input for both initial and restart calculations. An "**end**" card is only needed when the input data is in the FREE format (see **Main-Data Card 1**) for an initial calculation (which is pretty much true for all input decks).

Timestep Data

The last data block of input information is the timestep data cards for controlling the calculation and output edits. The problem time span to be evaluated is separated into time domains. Each domain (specified by two cards) may have different minimum and maximum timestep sizes and output-edit time intervals. Any number of time domains may be input. **TEND** from the previous time domain is the ending time of the calculation when **DTMIN** < 0.0. The format of each set of two timestep cards follows.

Card Number 1. (Format 5E14.4) **DTMIN, DTMAX, TEND, RTWFP, POWERC**

Variable	Description
DTMIN	Minimum timestep size (s) for this time domain.
DTMAX	Maximum timestep size (s) for this time domain.
TEND	End time (s) for this time domain.
RTWFP	Ratio between heat-transfer and fluid-dynamics timestep sizes (a positive value is used during steady-state calculations; a negative value results in |RTWFP| being used during transient as well as steady-state calculations; suggested value = 10.0).
POWERC	Maximum convection-power difference (W, Btu h^{-1}) between what goes into the fluid and what comes from the wall in the convection heat-transfer calculation. Define POWERC > 0.0 W or Btu h^{-1}. If its value is ≤ 0.0 or not input (the field is left blank), its value is set to 1.0×10^{20} W or Btu h^{-1}, which effectively sets no control over the convection-power difference. This convection-energy-error controller reduces the timestep size until the convection-power difference for all **HTSTR**-component surface nodes is less than **POWERC**. Specifying too small a value for **POWERC** may result in a significant increase in the calculative effort.

Card Number 2. (Format 4E14.4) **EDINT, GFINT, DMPINT, SEDINT**

Variable	Description
EDINT	Long-printout-edit time interval (s) for this time domain.
GFINT	Graphics-edit time interval (s) for this time domain.
DMPINT	Dump/restart-edit time interval (s) for this time domain.

Card Number 2. (Format 4E14.4) **EDINT, GFINT, DMPINT, SEDINT**

Variable	Description
SEDINT	Short-printout-edit time interval (s) for this time domain.

End-of-Input End Flag Card

The TRACE input is terminated by an endflag card that has the value of -1.0.

A

Deprecated Functionality

ROD or SLAB Components

(no longer applicable as of V3.690)

These sections (and included card specifications) represent deprecated functionality with respect to the current specification for TRACE input decks. They are included here to assist the user in being able to understand old legacy TRAC-P/TRACE decks.

Note: The input data for HTSTR components with ROD or SLAB elements *must* follow the input data of *all* hydraulic components in the TRACIN input-data file**.**

Card Number 1. (Format A14,2I14,A30) TYPE, NUM, ID, CTITLE

Columns	Variable	Description
1–4	TYPE	Component type (ROD or SLAB).
15–28	NUM	Component ID number (must be unique for each component, 1 ≤ NUM ≤ 999 and greater than the ID numbers of all hydraulic components).
29–42	ID	User ID number (arbitrary).
43–72	CTITLE	Hollerith component description.

Card Number 2. (Format 5I14) NCRX, NCRZ, ITTC, IEXT, M1D

Columns	Variable	Description
1-14	NCRX	Number of different average (power) ROD or SLAB elements (they may be coupled to NCRX different hydraulic cells in the level of a VESSEL component or coupled to NCRX different 1D hydraulic components).

Columns	Variable	Description
15–28	NCRZ	Number of axial intervals between node rows in the ROD or SLAB element.*
29–42	ITTC	Specification of an external thermocouple (T/C) on the ROD- or SLAB-element surface. 0 = no; 1 = yes.
43-56	IEXT	Specifies if this component input was generated by the postprocessor EXTRACT 0 = no (default); 1 = yes.
57-70	M1D	Option for multiple 1D hydraulic-component coupling to this HTSTR component by inputting M1D > 0. First input M1D = 0 for all HTSTRs that do not have multiple 1D hydraulic-component coupling. Then input M1D = 1 for the first, M1D = 2 for the second, M1D = 3 for the third, etc. HTSTRs that have multiple 1D hydraulic-component coupling and input these HTSTRs in that order.

Card Number 3. (Format 5I14) NOPOWR, NRIDR, MODEZ, LIQLEV, IAXCND

Columns	Variable	Description
1–14	NOPOWR	Power-source presence option. 0 = yes; 1 = no.
15–28	NRIDR	Specification of the hydraulic-cell location that is coupled to the inner and/or outer surfaces of the ROD or SLAB element. 0 = define the IDROD array (Card Set 44) for the supplemental ROD or SLAB elements [last NRODS–NCRX ROD or SLAB elements where NRODS (Word 1 on Card Number 12) is the total number of different ROD or SLAB elements evaluated], the average (power) rods are automatically distributed among the NCRX coolant paths.; 1 = define the IDROD array (Card Set 44) for all NRODS ROD or SLAB elements; or

*Currently, NCRZ + 1 must be ≤ 250; see variable NZMAX (Word 4 on Card Number 12) for a discussion on this limit.

Columns	Variable	Description

Columns	Variable	Description
		2 = define the IDROD array for all NRODS ROD or SLAB elements for both surfaces of the HTSTR component. Card Set 44 (array IDROD) defines the hydraulic-cell coupling to the inner surface and Card Set 45 (array IDRODO) defines the hydraulic-cell coupling to the outer surface.
29–42	MODEZ	Specification of the axial cell-edge locations of the node rows or the axial cell lengths between node rows. 0 = input NCRZ + 1 axial cell-edge locations; 1 = input NCRZ axial cell lengths.
43–56	LIQLEV	Specification of liquid-level tracking. 0 = no liquid level calculated on ROD- or SLAB-element surface; 1 = liquid level tracked on ROD- or SLAB-element surface (this produces a more accurate axial heat-transfer solution).
57–70	IAXCND	Specification of axial conduction. 0 = no axial heat-transfer conduction calculated; 1 = axial heat-transfer conduction calculated in the ROD or SLAB element (explicit numerics when NAMELIST variable NRSLV = 0; implicit numerics when NRSLV = 1).

Card Number 4. (Format 2I14,2E14.4) IDBCI, IDBCO, HDRI, HDRO

Note: If ITTC = 1 (Word 3 on Card Number 2), input IDBCI = 2 (to define the outer clad-surface hydraulic-cell coupling) and IDBCO = 2 (to define the thermocouple-surface hydraulic-cell coupling).Variables HDRI and HDRD are only used if NAMELIST variable ITHD = 1, when the user wishes to specify an appropriate heated perimeter for heat transfer coefficient calculation.

Columns	Variable	Description
1–14	IDBCI	Boundary-condition option for the inner surface of the ROD or SLAB element. 0 = adiabatic boundary condition; 1 = constant HTCs and external temperatures; 2 = coupled to specified cells in one or more hydraulic components.

Columns	Variable	Description
15–28	IDBCO	Boundary-condition option for the outer surface of the HTSTR ROD or SLAB element. 0 = adiabatic boundary condition; 1 = constant HTCs and external temperatures; 2 = coupled to specified cells in one or more hydraulic components.
29–42	HDRI	Heat-transfer diameter (m, ft) used to evaluate the heat-transfer coefficient (HTC) for the inside surface of the ROD or SLAB element. HDRI is used when NAMELIST variable ITHD = 1 and the hydraulic diameter HD is used when ITHD = 0.
43–56	HDRO	Heat-transfer diameter (m, ft) used to evaluate the heat-transfer coefficient (HTC) for the outside surface of the ROD or SLAB element. HDRO is used when NAMELIST variable ITHD = 1 and the hydraulic diameter HD is used when ITHD = 0.

Note: **Thermal Radiation Heat Transfer Model (Card Numbers 5 through 7)**. Currently, the thermal radiation heat transfer model is only available in TRACE/F77. For TRACE/F90, Cards 5 to 7 must be omitted.

Card Number 5. (Format 2I14) IFRADI, IFRADO

Note: If NAMELIST variable NENCL = 0, do not input Card Number 5

Columns.	Variable.	Description.
1–14	IFRADI	Inner surface is part of a radiation enclosure option. 0 = no; 1 = yes.
15–28	IFRADO	Outer surface is part of a radiation enclosure option. 0 = no; 1 = yes.

Card Number 6.(Format 3E14.4) EMCIF1, EMCIF2, EMCIF3. Note: Note

If NAMELIST variable NENCL = 0, do not input Card Number 6.

Note: Note

Note: Input Card Number 6 if IFRADI = 1 (Word 1 on Card Number 5). The following quadratic-polynomial coefficients define the inner-surface emissivity as a function of the inner-surface temperature.

Columns	Variable	Description
1–14	EMCIF1	Zero-order term in the quadratic fit of inner-surface emissivity as a function of the inner-surface temperature (–).
15–28	EMCIF2	First-order term in the quadratic fit of inner-surface emissivity as a function of the inner-surface temperature (K^{-1}, $°F^{-1}$).
29–42	EMCIF3	Second-order term in the quadratic fit of inner-surface emissivity as a function of the inner-surface temperature (K^{-2}, $°F^{-2}$).

Card Number 7. (Format 3E14.4) EMCOF1, EMCOF2, EMCOF3

Note: Note

If NAMELIST variable NENCL = 0, do not input Card Number 7.

Note: Note

Note: Input Card Number 7 if IFRADO = 1 (Word 2 on Card Number 5). The following quadratic-polynomial coefficients define the outer-surface emissivity as a function of the outer-surface temperature.

Columns	Variable	Description
1–14	EMCOF1	Zero-order term in the quadratic fit of outer-surface emissivity as a function of the outer-surface temperature (–).
15–28	EMCOF2	First-order term in the quadratic fit of outer-surface emissivity as a function of the outer-surface temperature (K^{-1}, $°F^{-1}$).
29–42	EMCOF3	Second-order term in the quadratic fit of outer-surface emissivity as a function of the outer-surface temperature (K^{-2}, $°F^{-2}$).

Card Number 8. (Format E14.4,I14) WIDTH, lPATCH

Note: Note

Input Card Number 8 for a SLAB (Word 1 on Card Number 1).

Columns	Variable	Description
1–14	WIDTH	Width (m, ft) of SLAB-element surface (used to compute surface area).

Columns	Variable	Description
15–28	IPATCH	Hot-patch modeling. Used only if NAMELIST variable NEWRFD = 1. 0 = no; 1 = yes.

Card Number 9. (Format 4E14.4) ZUPTOP, ZUPBOT, ZLPTOP, ZLPBOT

Note: Note

If IPATCH = 0 (Word 2 on Card Number 8), do not input Card Number 9.

Note: Note

These axial locations are defined to be consistent with Card Set 35 (array Z) or SHELV (Word 5 on Card Number 13) and Card Set 36 (array DZ).

Columns	Variable	Description
1–14	ZUPTOP	Axial location (m, ft) of the top of the upper hot patch.
15–28	ZUPBOT	Axial location (m, ft) of the bottom of the upper hot patch.
29–42	ZLPTOP	Axial location (m, ft) of the top of the lower hot patch.
43–70	ZLPBOT	Axial location (m, ft) of the bottom of the lower hot patch.

Card Number 10. (Format 4E14.4) TLI, TVI, HLI, HVI

Note: Note

Input Card Number 10 if IDBCI = 1 (Word 1 on Card Number 4).

Columns	Variable	Description
1–14	TLI	Constant liquid temperature (K, °F) at the inner surface of the ROD or SLAB element.
15–28	TVI	Constant vapor temperature (K, °F) at the inner surface of the ROD or SLAB element.
29–42	HLI	Constant liquid heat-transfer coefficient (HTC) (W m^{-2} K^{-1} Btu ft^{-2} $°F^{-1}$ h^{-1}) at the inner surface of the ROD or SLAB element.
43–56	HVI	Constant vapor HTC (W m^{-2} K^{-1} Btu ft^{-2} $°F^{-1}$ h^{-1}) at the inner surface of the ROD or SLAB element.

Card Number 11. (Format 4E14.4) TLO, TVO, HLO, HVO

Note: Note

Input Card Number 11 if IDBCO = 1 (Word 2 on Card Number 4).

Columns	Variable	Description
1–14	TLO	Constant liquid temperature (K, °F) at the outer surface of the ROD or SLAB element.
15–28	TVO	Constant vapor temperature (K, °F) at the outer surface of the ROD or SLAB element.
29–42	HLO	Constant liquid HTC (W m^{-2} K^{-1} Btu ft^{-2} $°F^{-1}$ h^{-1}) at the outer surface of the ROD or SLAB element.
43–70	HVO	Constant vapor HTC (W m^{-2} K^{-1} Btu ft^{-2} $°F^{-1}$ h^{-1}) at the outer surface of the ROD or SLAB element.

Card Number 12. (Format 5I14) NRODS, NODES, IRFTR, NZMAX, IRFTR2

Columns	Variable	Description
1–14	NRODS	Total number of calculational ROD or SLAB elements defined by this HTSTR component (NRODS ≥ NCRX). If NRODS > NCRX (Word 1 on Card Number 2), the last NRODS-NCRX supplemental ROD or SLAB elements do not affect the fluid-dynamic solution through heat-transfer coupling.
15–28	NODES	Number of ROD-radial or SLAB-thickness heat-transfer nodes in the ROD or SLAB elements. A value of 1 invokes the lumped-parameter solution (see TRACE/F90 Theory Manual). Its value should include the thermocouple if ITTC = 1 (Word 3 on Card Number 2).NODES must be ≤ NRFMX, where NRFMX is a parameter constant set in module VessCon (header file PARSET1 for TRACE/F77), currently to 20.
29–42	IRFTR	Trip ID number for implementing the axial fine-mesh calculation (no axial fine-mesh calculation is performed if IRFTR = 0 or if trip IRFTR is not set ON).

Columns	Variable	Description
43–56	NZMAX	Maximum number of rows of nodes in the axial direction $(NCRZ+1) + \sum_{I} NFAX(I) \le$ NZMAX ≤ NZFMX, where array NFAX is input on HTSTR Card Set 50, and NZFMX ia a parameter constant set in TRACE/F90 module VessCon (header file PARSET1 for TRACE/F77). If NZMAX is greater than NZFMX, the code internally sets NZMAX = NZFMX. Currently, NZFMX = 250. If NZMAX is less than NCRZ + 1, the code internally sets NZMAX = NCRZ + 1. Users should use small values of NZMAX if possible and especially if axial-conduction heat transfer will not be calculated. Large values of NZMAX lead to very large graphics files and a large HTSTR computer-memory requirement.
57–70	IRFTR2	Trip ID number for evaluating the core reflood model when the trip set status is ON and NEWRFD = 1 [the reflood model is not evaluated when IRFTR2 = 0 or when the IRFTR2 ¦ 0 trip set status is OFF].

Card Number 13. (Format 5E14.4) DTXHT(1), DTXHT(2), DZNHT, HGAPO, SHELV

Columns	Variable	Description
1–14	DTXHT(1)	Maximum ΔT (K, °F) surface-temperature change between node rows above which a row of nodes is inserted in the axial fine-mesh heat-transfer calculation for the nucleate and transition boiling regimes [suggested value: DTXHT(1) = 3.0 K (5.4°F)].
15–28	DTXHT(2)	Maximum ΔT (K, °F) surface-temperature change between node rows above which a row of nodes is inserted in the axial fine-mesh heat-transfer calculation for all heat-transfer regimes except the nucleate and transition-boiling regimes [suggested value: DTXHT(2) = 10.0 K (18.0°F)].
29–42	DZNHT	Minimum ýZ (m, ft) axial interval between node rows below which no additional row of nodes is inserted in the axial fine-mesh heat-transfer calculation (this value should be based on the diffusion number when explicit axial heat-conduction numerics is being evaluated).

43–56	HGAPO	ROD or SLAB element gas-gap HTC (W m^{-2} K^{-1}, Btu ft^{-2} °F^{-1} h^{-1}). HGAPO must be set to a non-zero value. HGAPO is used as the gap conductance when NFCI = 0 (Word 2 on Card 19); it is used as an initial guess for the gap conductance when NFCI = 1.
57–70	SHELV	Axial location (m,ft) of the first (bottom) node row [use to define Z(1) when MODEZ =1 (Word 3 on Card Number 3) and DZ axial cell-interval lengths are input with Card Set 36].

Note: Note

Note: If NOPOWR = 1 (Word 1 on Card Number 3) for an unpowered HTSTR component, go to the array-data beginning with Card Set 27 (NHCOMI, etc.). If NOPOWR = 0, input the following scalar parameters that need to be defined for powered HTSTR component ROD or SLAB elements.

Card Number 14. (Format 5I14) IRPWTY, NDGX, NDHX, NRTS, NHIST

Columns	Variable	Description

1–14	IRPWTY	Neutronic point-reactor kinetics or reactor-core power option for defining programmed reactivity (–) or reactor-core power (W, Btu h^{-1}). Input parameters required for each option value are shown in parentheses. Add 10 to the value of IRPWTY if reactivity feedback is to be evaluated. For IRPWTY = 15, 16, or 17, reactivity feedback is evaluated and output but not used because the reactor-core power is being defined directly. 1 = point-reactor kinetics with constant REACT programmed reactivity (requires RPOWRI and REACT); 2 = point-reactor kinetics with table lookup of programmed reactivity (requires RPOWRI, IRPWSV, NRPWTB, and RPWTB); 3 = point-reactor kinetics with an initial zero programmed reactivity and trip-initiated constant REACT programmed reactivity (requires RPOWRI, IRPWTR, and REACT); 4 = point-reactor kinetics with an initial constant REACT programmed reactivity and trip-initiated table lookup of programmed reactivity (requires RPOWRI, REACT, IRPWTR, IRPWSV, NRPWTB, and RPWTB); 5 = constant reactor-core power (requires RPOWRI); 6 = table lookup of reactor-core power (requires IRPWSV, NRPWTB, and RPWTB); 7 = initial constant reactor-core power with trip-initiated table lookup of reactor-core power (requires RPOWRI, IRPWTR, IRPWSV, NRPWTB, and RPWTB).
15–28	NDGX	The number of delayed-neutron groups (if NDGX ≤ 0 is input when IRPWTY = 1, 2, 3, 4, 11, 12, 13, or 14, TRAC-P defaults to 6 delayed-neutron groups with the delayed-neutron constants defined internally; input NDGX = 0 when IRPWTY = 5, 6, 7, 15, 16, or 17).

Columns **Variable** **Description**

29–42	NDHX	The number of decay-heat groups [For IRPWTY = 1, 2, 3, 4, 11, 12, 13, or 14: input NDHX = 69 to define the ANS-79 decay-heat standard, input NDHX = 71 to define the ANS-79 decay-heat standard plus the heavy-element decay for ^{239}U and ^{239}Np, input any other positive value for NDHX when the TRACE user wishes to input-specify their own decay-heat parameters, or input NDHX ≠ 0 to have TRACE internally default to the ANS-79 decay-heat standard of NDHX = 69 (an exception to this default occurs when inputting NDHX = –11 to have TRACE internally define the 11 decay-heat group that was the default in the MOD1 and earlier versions of TRAC). For IRPWTY = 5, 6, 7, 15, 16, or 17: input NDHX = 0].
43–56	NRTS	The number of timesteps between file output edits of the reactor-core power and reactivity-feedback changes to the TRCOUT file (NRTS = 10, default).
57–70	NHIST	The number of value pairs in the power-history table. NHIST = 0 when IRPWTY = 5, 6, 7, 15, 16, or 17. 0 = the user will input the delayed-neutron precursor concentrations (CDGN) and the decay-heat precursor concentrations (CDHN); 1 = CDGN and CDHN will be calculated assuming an infinite history of operation at the user input power level of RPOWRI; ≥2 = a power history table will be input and used to calculate initial values for CDGN and CDHN.

Card Number 15. (Format 5E14.4) Q235, Q239, Q238, QAVG, R239PF

Note: Note

Note: If IRPWTY = 1, 2, 3, 4, 11, 12, 13, or 14 (Word 1 on Card Number 14) and NDHX = 69 or 71 or <0 (but not –11) (Word 3 on Card Number 14), input Card Number 15; otherwise, skip this card.

Column	Variable	Description
1–14	Q235	Energy per fission from ^{235}U (Mev per fission).
15–28	Q239	Energy per fission from ^{239}Pu (Mev per fission).
29–42	Q238	Energy per fission from ^{238}U (Mev per fission).
43–56	QAVG	Average energy per fission (Mev per fission).
57–70	R239PF	Atoms of ^{239}U produced per fission.

Card Number 16. (Format 4E14.4) FISPHI, RANS, FP235, FP238

Note: Note

If IRPWTY = 1, 2, 3, 4, 11, 12, 13, or 14 (Word 1 on Card Number 14) and NDHX = 69 or 71 or <0 (but not –11) (Word 3 on Card Number 14), input Card Number 16; otherwise, skip this card.

Note: Note

Note: It is assumed that FP235 + FP238 + FP239 = 1.0, where FP239 is the corresponding ^{239}Pu fraction. FP235 and FP238 are used only if NHIST < 2 (Word 5 on Card Number 14).

Columns	Variable	Description
1–14	FISPHI	Fissions per initial fissile atom.
15–28	RANS	Multiplier (–) applied to the ANS 79 decay heat (RANS = 1.0, default).
29-42	FP235	Fraction of fission power (–) associated with ^{235}U fissions at time zero.
43-56	FP238	Fraction of fission power (–) associated with ^{238}U fissions at time zero.

Card Number 17. (Format 5I14) IRPWTR, IRPWSV, NRPWTB, NRPWSV, NRPWRF

Note: If IRPWTY = 1, 5, 11, or 15 (Word 1 on Card Number 11), do not input Card Number 17.

Columns	Variable	Description
1–14	IRPWTR	The trip ID number which controls initiation of the reactivity-power table (0 < |IRPWTR| ≤ 9999 when IRPWTY = 3, 4, 7, 13, 14, or 17; IRPWTR = 0 otherwise).
15–28	IRPWSV	The reactivity-power table's abscissa-coordinate independent variable ID number. IRPWSV defines the independent-variable parameter for the reactivity-power table. IRPWSV > 0 defines the ID number for a signal-variable parameter; IRPWSV < 0 defines the ID number for a control-block output parameter (0 < |IRPWSV| ≤ 9999 when IRPWTY = 2, 4, 6, 7, 12, 14, 16, or 17; IRPWSV = 0 otherwise).
29–42	NRPWTB	The number of reactivity-power table value pairs (defined by the absolute value of NRPWTB). NRPWTB > 0 defines the table's independent-variable form to be the IRPWSV parameter; NRPWTB < 0 defines the reactivity-power table independent-variable form to be the sum of the change in the IRPWSV parameter over each timestep times the trip set-status value ISET during that timestep (when the reactivity-power table is trip controlled); NRPWTB = 0 defines the reactivity-power table's reactivity or power to be the IRPWSV parameter.

Columns	Variable	Description
43–56	NRPWSV	The rate-factor table's abscissa-coordinate variable ID number. NRPWSV defines the independent-variable parameter to determine the rate factor that is applied to the reactivity-power table's independent variable. NRPWSV > 0 defines the ID number for a signal-variable parameter; NRPWSV < 0 defines the ID number for a control-block output parameter; NRPWSV = 0 (when NRPWRF ≠ 0) defines the difference between the trip signal and the setpoint value that turns the trip OFF when the reactivity-power table is trip controlled.
57–70	NRPWRF	The number of rate-factor table value pairs (defined by the absolute value of NRPWRF). The rate factor is applied to the reactivity-power table's independent variable when the rate factor is defined. No rate factor is defined when NRPWSV and NRPWRF (Words 4 and 5 on Card Number 14) are both zero. NRPWRF > 0 defines the rate-factor table's abscissa coordinate to be the NRPWSV parameter; NRPWRF < 0 defines it to be the sum of the change in the NRPWSV parameter over each timestep times the trip set-status value ISET during that timestep (when the reactivity-power table is trip controlled); NRPWRF = 0 defines the rate factor to be the NRPWSV parameter.

Card Number 18. (Format 5I14) IZPWTR, IZPWSV, NZPWTB, NZPWSV, NZPWRF

Columns	Variable	Description
1–14	IZPWTR	The trip ID number that controls the evaluation of the axial-power-shape table (0 < |IZPWTR| ≤ 9999) (input IZPWTR = 0 when the evaluation of the axial power-shape table is not trip controlled).
15–28	IZPWSV	The axial-power-shape table's abscissa-coordinate variable ID number. IZPWSV defines the independent variable-parameter for the axial-power-shape table. IZPWSV > 0 defines the ID number for a signal-variable parameter; IZPWSV < 0 defines the ID number for a control-block output parameter.

Columns	Variable	Description
29–42	NZPWTB	The number of axial-power-shape table [x, f(z) shape] value pairs (defined by the absolute value of NZPWTB). Each pair consists of an abscissa-coordinate value x and NZPWZ (Word 1 on Card Number 17) ordinate-coordinate values of f(z) defining the axial-power shape. NZPWTB > 0 defines the table's independent-variable form to be the IZPWSV parameter; NZPWPB < 0 defines the axial-power-shape table independent-variable form to be the sum of the change in the IZPWSV parameter over each timestep times the trip set-status value ISET during that timestep (when the axial-power-shape table is trip controlled).
43–56	NZPWSV	The rate-factor table's abscissa-coordinate variable ID number. NZPWSV defines the independent-variable parameter to determine the rate factor that is applied to the axial-power-shape table's independent variable. NZPWSV > 0 defines the ID number for a signal-variable parameter; NZPWSV < 0 defines the ID number for a control-block output parameter; NZPWSV = 0 (when NZPWRF ≠ 0) defines the difference between the trip signal and the setpoint value that turns the trip OFF when the axial-power-shape table is trip controlled.
57–70	NZPWRF	The number of rate-factor table value pairs (defined by the absolute value of NZPWRF). The rate factor is applied to the axial-power-shape table's independent variable when the rate factor is defined. No rate factor is defined when NZPWSV and NZPWRF (Words 4 and 5 on Card Number 15) are both zero. NZPWRF > 0 defines the rate-factor table's abscissa coordinate to be the NZPWSV parameter; NZPWRF < 0 defines it to be the sum of the change in the NZPWSV parameter over each timestep times the trip set-status value ISET during that timestep (when the axial-power-shape table is trip controlled); NZPWRF = 0 defines the rate factor to be the NZPWSV parameter.

Card Number 19. (Format 5I14) NMWRX, NFCI, NFCIL, IPWRAD, IPWDEP

Columns	Variable	Description
1–14	NMWRX	Metal-water reaction option. 0 = off; 1 = on.

15–28	NFCI	Fuel-cladding gap conductance calculation option. NFCI = 1 performs the dynamic gas-gap conductance calculation. When NFCI = 0, HGAPO (Word 4 on Card Number 13) is used as the gap conductance. 0 = off; 1 = on.
29–42	NFCIL	Maximum number of fuel-cladding gas-gap conductance calculations per timestep. Input NFCIL = 1 when NFCI = 1.
43–56	IPWRAD	Spatial power-shape option. 0 = 1D axial power-shape table (default); 1 = 2D axial-r or axial-x power-shape table.
57–70	IPWDEP	Power-shape table-dependence option. –1 = the power-shape table dependence is defined for each node by a signal-variable or control-block ID number that defines the node power density, and the resulting power shape is not normalized by TRAC-P to a spatially averaged value of unity; 0 = the power-shape table dependence is defined by signal-variable or control-block ID number IZPWSV (Word 2 on Card Number 18) (default); 1 = the power-shape table dependence is defined for each node by a signal-variable or control-block ID number that defines the node power density, and the resulting power shape is normalized by

Card Number 20. (Format 5I14) NZPWZ, NZPWI, NFBPWT, NRPWR, NRPWI

Columns	Variable	Description
1–14	NZPWZ	Number of axial locations defining the axial-power shape; if NZPWZ < 2 is input, NZPWZ is redefined to be NCRZ+1 (NCRZ is Word 2 on Card Number 2) and Card Set 57 (array ZPWZT) is not input.

Columns	Variable	Description
15–28	NZPWI	Axial-power shape integration option for the heat-transfer calculation. –1 = histogram with step changes at the axial locations defined by Card Set 57 (array ZPWZT); 0 = histogram with step changes midway between the axial locations defined by ZPWZT; 1 = trapezoidal integration [with linear variation between the axial-power shape densities defined by Card Set 59 (array ZPWTB) at the axial locations defined by ZPWZT].
29–42	NFBPWT	Option for replacing the radial, axial, and/or horizontal-plane power shapes with another user-defined shape for volume averaging the reactivity-feedback parameters over the core region. (Add 1 for defining ROD-radial or SLAB-thickness shape, 2 for defining an axial shape, and 4 for defining a (r,θ) or (x,y) plane shape).
43–56	NRPWR	Number of ROD-radial or SLAB-thickness locations defining the 2D axial-r or axial-x power shape if IPWRAD = 1 (Word 4 on Card Number 19) and NRPWR ≥ 2; if IPWRAD = 1 and NRPWR < 2, the same definition applies and NRPWR is redefined to be NODES (Word 2 on Card Number 12), array RPWRT (Card Set 58) is not input, and array RADRD (Card Set 47) defines array RPWRT. If IPWRAD = 0, a 1D axial power shape and a 1D radial or Cartesian power shape are input, NRPWR is redefined by TRACE to be 1, and array RPWRT is not input.
57–70	NRPWI	ROD-radial or SLAB-thickness power-shape integration option for the heat-transfer calculation when IPWRAD = 1 (Word 4 on Card Number 19). –1 = histogram with step changes at the radial or thickness locations defined by array RPWRT (Card Set 58); 0 = histogram with step changes midway between the radial or thickness locations defined by array RPWRT; 1 = trapezoidal integration with linear variation between the radial or Cartesian geometry power-shape densities defined by array ZPWTB (Card Set 59) at the radial or thickness locations defined by array RPWRT.

Card Number 21. (Format 5E14.4) REACT, TNEUT, RPWOFF, RRPWMX, RPWSCL

Columns	Variable	Description
1–14	REACT	Initial programmed reactivity (–) (IRPWTY = 1, 2, 4, 11, 12, 14) or trip-initiated programmed reactivity (–) (IRPWTY = 3 or 13) [REACT = ρ_{PROG} = (K_{eff} – 1) K_{eff}^{-1}, where K_{eff} is the reactor-multiplication constant; both and K_{eff} have no units].
15–28	TNEUT	The prompt-neutron lifetime (s) (TNEUT 0.0 s defaults internally to TNEUT = 1.625×10^{-5} s).
29–42	RPWOFF	Programmed reactivity (–) (IRPWTY = 3, 4, 13, 14) or reactor-core power (W, Btu h^{-1}) (IRPWTY = 7 or 17) when the reactivity/power controlling trip is OFF after being ON; the last value when the trip was ON is held constant when RPWOFF $\leq -1.0 \times 10^{19}$ W(-3.4121×10^{19} Btu h^{-1}).
43–56	RRPWMX	The maximum rate of change of programmed reactivity (s-1) or reactor power (W s^{-1}, Btu h^{-1} s^{-1}) [RRPWMX $\geq$ 0.0 s^{-1} or 0.0 W s^{-1} (0.0 s^{-1} or 0.0 Btu h^{-1} s^{-1})].
57–70	RPWSCL	Reactivity-power table's scale factor for programmed reactivity (–) or reactor-core power (–). The dependent variable in the table Card Set 62 (array RPWTBR or RPWTBP) is multiplied by RPWSCL to obtain its absolute value of programmed reactivity (–) or reactor-core power (W, Btu h^{-1}).

Card Number 22. (Format 4E14.4) RPOWRI, ZPWIN, ZPWOFF, RZPWMX

Columns	Variable	Description
1–14	RPOWRI	Initial total reactor-core power (W, Btu h^{-1}) of all the average (power) ROD or SLAB elements of this HTSTR component.
15–28	ZPWIN	The axial-power-shape table's abscissa-coordinate variable value (*) corresponding to the initial axial-power shape.
29–42	ZPWOFF	The axial-power-shape table's abscissa-coordinate variable value (*) corresponding to the axial-power shape to be used when the axial-power-shape table's controlling trip is OFF after being ON; use the last evaluated axial-power shape when the trip was ON when ZPWOFF $\leq -1.0 \times 101^{9}$ (*).
43–56	RZPWMX	The maximum rate of change of any z-location value in the axial-power shape (s^{-1}) (RZPWMX $\geq$ 0.0 s^{-1}).

Card Number 23. (Format 4E14.4) EXTSOU, PLDR, PDRAT, FUCRAC

Columns	Variable	Description
1–14	EXTSOU	The fission power (W, Btu h^{-1}) produced by external source neutrons in the reactor core (used only when the point-reactor kinetics equations are evaluated: IRPWTY = 1, 2, 3, 4, 11, 12, 13, or 14).
15–28	PLDR	Pellet-dish radius (m, ft) [no calculation of pellet dishing is performed if PLDR = 0.0 m (0.0 ft)] (currently not used in subroutine FROD).
29–42	PDRAT	ROD element pitch-to-diameter or SLAB element pitch-to-thickness ratio (–) (currently not used in subroutines CHEN and CHF).
43–56	FUCRAC	Fraction of the fue pellet radius l (–) which is not cracked [used only when NFCI = 1 (Word 2 on Card Number 19)].

Card Number 24. (Format 5I14) IRCJTB(I,J), I = (1, 4), IBU(J) where J = (1, 4)

Note: Note

If reactivity feedback is not evaluated when IRPWTY < 11 (Word 1 on Card Number 14), do not input Card Number 24.

Card Number 24 has a total of four cards that are input:

- the J = 1 card defines the fuel-temperature reactivity-coefficient table,
- the J = 2 card defines the coolant-temperature reactivity-coefficient table,
- the J = 3 card defines the gas volume-fraction reactivity-coefficient table, and
- the J = 4 card defines the solute-mass concentration reactivity-coefficient table.

Columns	Variable	Description
1–14	IRCJTB(1,J)	The number of fuel-temperature T_f-dependent entries in the Jth reactivity-coefficient table [1 ≤ IRCJTB(1,J)].
15–28	IRCJTB(2,J)	The number coolant-temperature T_c-dependent entries in the Jth reactivity-coefficient table [1 ≤ IRCJTB(2,J)].
29–42	IRCJTB(3,J)	The number of gas volume-fraction -dependent entries in the Jth reactivity-coefficient table [1 ≤ IRCJTB(3,J)].
43–56	IRCJTB(4,J)	The number of solute-mass B_r or B_m-dependent entries in the Jth reactivity-coefficient table [1 ≤ IRCJTB(4,J)].

Columns	Variable	Description
57–70	IBU(J)	The solute-units definition index for the Jth reactivity coefficient: IBU(J) = –2 if $x = B_r$ and $B = B_r$, IBU(J) = –1 if $x = B_r$ and $B = B_m$, IBU(J) = 0 if $x = B_m$ and $B = B_r$, IBU(J) = 1 if $x = B_m$ and $B = B_m$, where $\partial K_{eff}/\partial x = fcn(T_f, T_c, \alpha, B)$. The two solute-mass concentrations are: B_m density, which is the mass of solute in the coolant-channel volume (kg m^{-3}, lb_m ft^{-3}) and B_r ratio which is the parts solute mass per million parts liquid-coolant mass (ppm).

Card Number 25. (Format 5I14) IRCJFM(J), J = (1, 4), ISNOTB

Note: If reactivity feedback is not evaluated when IRPWTY < 11 (Word 1 on Card Number 14), do not input Card Number 25.

The reactivity-coefficient type form numbers are defined as follows:

IRCJFM(J) = 0 for $\partial K_{eff}/\partial x$,
IRCJFM(J) = 1 for $(1/K_{eff}) \neq \partial K_{eff}/\partial x$,
IRCJFM(J) = 2 for $x\ \partial K_{eff}/\partial x$, and
IRCJFM(J) = 3 for $(x/K_{eff}) \neq \partial K_{eff}/\partial x$,

where $x = T_f$ for J = 1, $x = T_c$ for J = 2, $x = \alpha$ for J = 3, and $x = B_m$ [when IBU(4) = (0, 1)] or $x = B_r$ [when IBU(4) = (–2, –1)] for J = 4.

Columns	Variable	Description
1–14	IRCJFM(1)	Form number for the fuel-temperature reactivity-coefficient type.
15–28	IRCJFM(2)	Form number for the coolant-temperature reactivity-coefficient type.

Columns	Variable	Description
29–42	IRCJFM(3)	Form number for the gas volume-fraction reactivity-coefficient type.
43–56	IRCJFM(4)	Form number for the solute-mass concentration reactivity-coefficient type.

57–70	ISNOTB	Option to exclude burnable-poison pin and control-rod boron from the solute reactivity-feedback calculation. 0 = no (the solute is assumed to be orthoboric acid); 1 = yes.

Card Number 26. (Format 5E14.4) POWEXP, BPP0, BPP1, BCR0, BCR1

Note: Note

If reactivity feedback is not evaluated when IRPWTY < 11 (Word 1 on Card Number 14), do not input Card Number 26.

Columns	Variable	Description
1–14	POWEXP	Exponent value (–) to which the cell values of the power distribution are raised in defining the weighting factor for volume averaging the reactivity-feedback parameters over the powered reactor-core region (suggested value: 2.0).
15–28	BPP0	Zero-order coefficient (kg m^{-3}, lb$_m$ ft^{-3}) of the first-order polynomial $\rho_{m_{BPP}} = BPP0 + BPP1 \times T$ that defines the effective (smeared and shielded) core-averaged concentration of burnable-poison pin boron in the coolant-channel volume.
29–42	BPP1	First-order coefficient (kg m^{-3} K^{-1}, lb$_m$ ft^{-3} °F^{-1}) of the first-order polynomial $\rho_{m_{BPP}} = BPP0 + BPP1 \times T$ that defines the effective (smeared and shielded) core-averaged concentration of burnable-poison pin boron in the coolant-channel volume. Tc is the core-averaged coolant temperature (K, °F).
43–56	BCR0	Zero-order coefficient (kg m^{-3}, lb$_m$ ft^{-3}) of the first-order polynomial $\rho_{m_{BCR}} = BCR0 + BCR1 \times \rho_{PRO(}$ that defines the effective (smeared and shielded) core-averaged concentration of control-rod pin boron in the coolant-channel volume.

Columns	Variable	Description

57–70	BCR1	First-order coefficient (kg m^{-3}, lb$_m$ ft^{-3}) of the first-order polynomial $\beta_{m_{BCR}} = BCR0 + BCR1 \times \rho_{PROG}$ that defines the effective (smeared and shielded) core-averaged concentration of control-rod pin boron in the coolant-channel volume. ρ_{PROG} is programmed reactivity and has no units.

HTSTR Array Cards. (Use LOAD format. Each array has its element values defined by a Card Set of one or more cards.)

Note: Note

Card Sets 27 to 30. When M1D ≠ 0 (Word 5 on Card Number 2), input NCRX (Word 1 on Card Number 2) groups of Card Sets 27 to 30. The required order when NCRX > 1 for multiple 1D hydraulic component coupling is Card Sets 27 to 30 for the first average (power) ROD or SLAB element, Card Sets 27 to 30 for the second average (power) ROD or SLAB element, etc.

Note: Note

Card Sets 27 to 30. If ITTC = 1 (Word 3 on Card Number 2), then IDBCI = 2 and IDBCO = 2 (Words 1 and 2 on Card Number 4) and NHCOMI and NHCELI refer to the ROD or SLAB element outer-surface hydraulic coupling and NHCOMO and NHCELO refer to the thermocouple-surface hydraulic coupling.

Card Sets 27 & 28. If IDBCI ≠ 2 (Word 1 on Card Number 4), do not input Card Sets 27 and 28 (arrays NHCOMI and NHCELI).

Variable	Dimension	Description
NHCOMI	NCRZ+2	Component numbers of the hydraulic cells to which the HTSTR ROD- or SLAB-element inner surface is coupled starting with the cell below the first node row and going to the cell above the last node row. NHCOMI(J) defines the component number of the hydraulic cell between node rows J–1 and J. The input values for NHCOMI(1) and NHCOMI(NCRZ+2) are redefined internally.

Variable	Dimension	Description
NHCELI	NCRZ+2	Cell numbers of the hydraulic cells to which the heat-structure ROD- or SLAB-element inner surface is coupled starting with the cell below the first node row and going to the cell above the last node row. NHCELI(J) defines the cell number of the hydraulic cell between node rows J–1 and J. The input values for NHCELI(1) and NHCELI(NCRZ+2) are redefined internally. Define NHCELI(J) > 0 when the cell's higher-numbered interface is aligned with node row J; define NHCELI(J) < 0 when the cell's lower-numbered interface is aligned with node row J.

Card Sets 29 & 30. If IDBCO ≠ 2 (Word 2 on Card Number 4), do not input Card Sets 29 and 30 (arrays NHCOMO and NHCELO)

Variable	Dimension	Description
NHCOMO	NCRZ+2	Component numbers of the hydraulic cells to which the HTSTR ROD- or SLAB-element outer surface is coupled starting with the cell below the first node row and going to the cell above the last node row. NHCOMO(J) defines the component number of the hydraulic cell between node rows J–1 and J. The input values for NHCOMO(1) and NHCOMO(NCRZ+2) are redefined internally.
NHCELO	NCRZ+2	Cell numbers of the hydraulic cells to which the heat-structure ROD- or SLAB-element outer surface is coupled starting with the cell below the first node row and going to the cell above the last node row. NHCELO(J) defines the cell number of the hydraulic cell between node rows J–1 and J. The input values for NHCELO(1) and NHCELO(NCRZ+2) are redefined internally. Define NHCELO(J) > 0 when the cell's higher-numbered interface is aligned with node row J; define NHCELO(J) < 0 when the cell's lower-numbered interface is aligned with node row J.

Card Set 31. If NAMELIST variable MHTLI = 0 or IRFTR ≠ 0, do not input Card Set 31 (array HTMLI).

Variable	Dimension	Description
HTMLI	NCRZ	Liquid-phase wall heat-transfer multiplier factor for the inner surface (–) [0.9 ≤ HTMLI ≤ 1.1].

Card Set 32. If NAMELIST variable MHTLO = 0 or IRFTR ≠ 0, do not input Card Set 32 (array HTMLO).

Variable	Dimension	Description
HTMLO	NCRZ	Liquid-phase wall heat-transfer multiplier factor for the outer surface (–) [0.9 ≤ HTMLO ≤ 1.1].

Card Set 33. If NAMELIST variable MHTVI = 0 or IRFTR ≠ 0, do not input this card.

Variable	Dimension	Description
HTMVI	NCRZ	Gas-phase wall heat-transfer multiplier factor for the inner surface (–) [0.9 ≤ HTMVI ≤ 1.1].

Card Set 34. If NAMELIST variable MHTVO = 0 or IRFTR ≠ 0, do not input Card Set 34 (array HTMVO).

Variable	Dimension	Description
HTMVO	NCRZ	Gas-phase wall heat-transfer multiplier factor for the outer surface (–) [0.9 ≤ HTMVO ≤ 1.1].

Deprecated Functionality

Card Set 35. If MODEZ = 0 (Word 3 on Card Number 3), input Card Set 35 (array Z).

Variable	Dimension	Description
Z	NCRZ+1	Axial location (m, ft) of the hydraulic-cell edges where node rows are located in the ROD or SLAB element.

Card Set 36. If MODEZ = 1 (Word 3 on Card Number 3), input Card Set 36 (array DZ).

Variable	Dimension	Description
DZ	NCRZ	Axial cell lengths (m, ft) of the hydraulic-cells. TRACE internally defines Z(1) = SHELV and Z(k+1) = SHELV + DZ(1) + DZ(2) + DZ(k) for k=(1,NCRZ), where SHELV is Word 5 on Card Number 13.

Note: Note:

Thermal Radiation Heat Transfer Model (Card 37, Card Sets 38 and 39, Card 40, Card Sets 41 and 42). Currently, the thermal radiation heat transfer model is only available in TRACE/F77. For TRACE/F90, Cards 37 to 42 must be omitted.

Card Number 37. (Format 3I14) IENCLU, IFACEI, IZSI

Note: Note

Card 37, Card Sets 38 and 39. If IFRADI = 1 (Word 1 on Card Number 5), input NCRZ (Word 2 on Card Number 2) groups of Card Number 37 and Card Sets 38 and 39. This group of cards is repeated on a hydraulic-cell basis to supply radiation parameters for the inner surface. The total number of ITFACI faces is defined by the Radiation-Enclosure Data Cards that were input after the Control-Parameter Data section

Columns	Variable	Description
1–14	IENCLU	Radiation-enclosure number to which this node-row interval belongs. If the value is 0, the node-row interval does not belong to any radiation enclosure, IFACEI and IZSI are not used, and Card Sets 38 and 39 are not read.
15–28	IFACEI	Radiation face number that this node-row interval represents.
29–42	IZSI	Hydraulic-cell level that this node-row interval represents.

Card Sets 38 & 39.

Note: Note

Card 37, Card Sets 38 and 39. If IFRADI = 1 (Word 1 on Card Number 5), input NCRZ (Word 2 on Card Number 2) groups of Card Number 37 and Card Sets 38 and 39. This group of cards is repeated on a hydraulic-cell basis to supply radiation parameters for the inner surface. The total number of ITFACI faces is defined by the Radiation-Enclosure Data Cards that were input after the Control-Parameter Data section

Variable	Dimension	Description
GVF	ITFACI	Geometric view factor (–) from the IFACEI face to each of the ITFACI faces of the radiation enclosure.
PLEN	ITFACI	Radiation path length (m, ft) from the IFACEI face to each of the ITFACI faces of the radiation enclosure.

Card Number 40. (Format 3I14) IENCLU, IFACEO, IZSO

Note: Note

Card 40, Card Sets 41 and 42. If IFRADO = 1 (Word 2 on Card Number 5), input NCRZ (Word 2 on Card Number 2) groups of Card Number 40 and Card Sets 41 and 42. This group of cards is repeated on a hydraulic-cell basis to supply radiation parameters for the outer surface. The total number of ITFACI faces is defined by the Radiation-Enclosure Data Cards that were input at the end of the Control-Parameter Data section.

Columns	Variable	Description
1–14	IENCLU	Radiation-enclosure number to which this node-row interval belongs. If the value is 0, the node-row interval does not belong to any radiation enclosure, IFACEO and IZSO are not used, and Card Sets 41 and 42 are not read.
15–28	IFACEO	Radiation face number that this node-row interval represents.
29–42	IZSO	Hydraulic-cell level that this node-row interval represents.

Card Sets 41 & 42.

Variable	Dimension	Description
GVF	ITFACI	Geometric view factor (–) from the IFACEO face to each of the ITFACI faces of the radiation enclosure.
PLEN	ITFACI	Radiation path length (m, ft) from the IFACEO face to each of the ITFACI faces of the radiation enclosure.

Card Set 43.

Variable	Dimension	Description
GRAV or ELEV	NCRZ	Gravity-defining array (– or m, ft). If NAMELIST variable IELV = 0, each ROD- or SLAB-element axial cell is oriented to vertical by this GRAV array definition (similar to GRAV in the hydrodynamic components). GRAV is the cosine of the angle between a vector pointing upward and a vector from the low-numbered to the high-numbered axial cells. If NAMELIST variable IELV = 1, the elevation (m, ft) of each axial-cell center location defines GRAV internally in TRACE.

Card Set 44. If NRIDR = 0 (Word 2 on Card Number 3) and NRODS–NCRX = 0 (Word 1 on Card Number 12 and Word 1 on Card Number 2), do not input Card Set 44 (array IDROD).

Variable	Dimension	Description

Deprecated Functionality

IDROD	NRODS–NCRX when NRIDR = 0; NRODS when NRIDR = 1 or 2.	When coupled to a VESSEL component, IDROD defines the (r, θ)- or (x,y)-plane cell numbers of a VESSEL-component level where the supplemental (if NRIDR = 0) or all (if NRIDR = 1 or 2) ROD or SLAB elements are located. When coupled to 1D hydraulic components, IDROD defines the single average (power) and zero or more supplemental ROD- or SLAB-element numbers that couple to the same 1D hydraulic component. For 1D, this defines where the supplemental (if NRIDR = 0) or average + supplemental (if NRIDR = 1 or 2) ROD or SLAB elements are located. NRIDR is Word 2 on Card Number 3. For coupling to a VESSEL component, this array is used to define coupling to a specific hydraulic cell within a VESSEL-component level. In a VESSEL level, cell numbers first vary by θ or y and then by r or x. For 1D, numbers 1 through NCRX are first specified for the average rods, then appropriate numbers between 1 and NCRX for the supplemental rods. This definition is for the inner or outer surface of the ROD or SLAB element when NRIDR = 0 or 1 and is specifically for the inner surface of the ROD or SLAB element when NRIDR = 2.

Card Set 45. If NRIDR ≠ 2 (Word 2 on Card Number 3), do not input Card Set 45 (array IDRODO).

Variable	Dimension	Description
IDRODO	NRODS	IDRODO has the same definition as IDROD (Card Set 31) but is for the outer surface of the ROD or SLAB element when NRIDR = 2.

Card Sets 46 & 47.

Variable	Dimension	Description
RDX	NCRX	Number of actual physical fuel rod elements in each of the NCRX (r,θ) or (x,y) mesh-cell locations of a VESSEL component or in each of the NCRX 1D hydraulic components. This is a real-valued number, not an integer. A value with a fractional part models with the fractional part a ROD or SLAB element that is partly within the mesh cell.

RADRD	NODES	Distances to the heat conduction noes. ROD radii or SLAB thickness (m, ft) from the inside surface at no power cold conditions. **Note:** If ITTC = 1 (Word 3 on Card Number 2), then RADRD(NODES) corresponds to the external thermocouple.

Card Set 48. If ITTC=0 (Word 3 on Card Number 2), do not input the Card Set 48 (array TC).

Variable	Dimension	Description
TC	6	The following six thermocouple parameters are input as array elements. ANTC = Number of thermocouples per ROD or SLAB element; DIA = Diameter of the thermocouple (m, ft); AW = Perimeter of the ROD- or SLAB-element surface to thermocouple weld (m, ft); ATW = Thickness of the ROD or SLAB element at thermocouple weld (m, ft); CKW = The ROD or SLAB element to thermocouple effective thermal conductivity (W m^{-1} K^{-1}, Btu ft^{-1} °F^{-1} $h^{-1)}$; RADT = Distance from the ROD- or SLAB-element center to the center of the thermocouple (m, ft).

Card Set 49. Adjacent MATRD elements cannot both have the value 3 and MATRD(1) and MATRD(NODES – 1) cannot be 3. Additional material properties can be input. Choose material properties for regions bounded by array RADRD (Card Set 47). .

Variable	Dimension	Description
MATRD	NODES –1	ROD- or SLAB-element material ID numbers [dimension is 1 if NODES = 1 (Word 2 on Card Number 12)]. **ID Material Type** 1 = mixed oxide; 2 = zircaloy; 3 = fuel-clad gap gases; 4 = boron-nitride insulation; 5 = constantan/Nichrome heater wire; 6 = stainless steel, type 304; 7 = stainless steel, type 316; 8 = stainless steel, type 347; 9 = carbon steel, type A508; 10 = inconel, type 718; 11 = zircaloy dioxide; 12 = inconel, type 600.

Card Set 50.

Variable	Dimension	Description
NFAX	NCRZ	Number of permanent axial fine-mesh node rows added per axial hydraulic-cell interval at the start of the fine-mesh calculation when trip IRFTR (Word 3 on Card Number 12) is set ON. These permanent (and all temporary rezoning) axial fine-mesh node rows are removed when trip IRFTR is set OFF. [The total number of heat-transfer node rows per ROD or SLAB element: $NCRZ + 1 + \sum_{I} NFAX(I)$, must not be greater than NZMAX (Word 4 on Card Number 12)].

Card Set 51.

Note: **Temperature Array**. Input an RFTN Card Set for each of the NRODS (Word 1 on Card Number 12) ROD or SLAB elements. This includes each average and supplemental ROD or SLAB element.

Variable	Dimension	Description
RFTN	NODES × (NCRZ+1)	ROD (radial by axial) or SLAB (thickness by axial) element temperatures (K, °F).

Note: Note

Unpowered HTSTR. If NOPOWR = 1 (Word 1 on Card Number 3) for an unpowered HTSTR component, do not input the remaining arrays, which are defined for powered HTSTR-component ROD or SLAB elements.

Card Set 52. IF IPWRAD = 1 (Word 4 on Card Number 19), do not input Card Set 52 (array RDPWR).

Variable	Dimension	Description
RDPWR	NODES	Relative ROD-radial or SLAB-thickness power-density distribution (–) at the node locations defined by Card Set 47 (array RADRD).

Card Set 53. If NFBPWT (Word 3 on Card Number 20) is 0 or even valued, do not input Card Set 53 (array RS)

Variable	Dimension	Description
RS	NODES	Relative ROD-radial or SLAB-thickness power-density distribution (–) at the node locations defined by Card Set 47 (array RADRD) that will be used to volume average the reactivity-feedback parameters over the powered-core region. If IPWRAD = 1 (Word 4 on Card Number 19) and array RS is input, array ZS (Card Set 61) must be input as well.

Card Set 54.

Variable	Dimension	Description
CPOWR	NCRX	Relative power-density distribution (–) in the average (power) ROD or SLAB elements heat-transfer coupled to the (r,) or (x,y) mesh cells of a VESSEL-component level or to one or more 1D hydraulic components.

Card Set 55. If NFBPWT (Word 3 on Card Number 20) is less than 4, do not input Card Set 55 (array HS)

Variable	Dimension	Description
HS	NCRX	Relative power-density distribution (–) in the average (power) ROD or SLAB elements heat-transfer coupled to the (r,) or (x,y) mesh cell of a VESSEL-component level or to one or more 1D hydraulic components that will be used to volume average the reactivity-feedback parameters over the powered-core region.

Card Set 56.

Variable	Dimension	Description

RPKF	NRODS–NCRX	Supplemental ROD or SLAB element power-peaking factors [relative to the average (power) ROD or SLAB elements. which together are coupled to the (r,θ) or (x,y) mesh cells of a VESSEL-component level or to one or more 1D hydraulic components].

Card Set 57. If NZPWZ < 2 (Word 1 on Card Number 20) from input or NZPWTB = 0 (Word 3 on Card Number 18), do not input Card Set 57 (array ZPWZT)

Variable	Dimension	Description
ZPWZT	NZPWZ	The axial locations (m, ft) where the axial-power shape's relative power densities are defined [define ZPWZT(1) = Z(1) and ZPWZT(NZPWZ) = Z(NCRZ+1) to have the power distribution span the axial range over which the ROD- or SLAB-element node rows are defined (Card Set 35 defines array Z)].

Card Set 58. If IPWRAD = 0 (Word 4 on Card Number 19) or NRPWR < 2 (Word 4 on Card Number 20) or NZPWTB = 0 (Word 3 on Card Number 18), do not input Card Set 58 (array RPWRT).

Variable	Dimension	Description
RPWRT	NRPWR	The ROD-radial or SLAB-thickness locations (m, ft) where the power shape's relative power densities are defined [define RPWRT(1) = RADRD(1) and RPWRT(NRPWR) = RADRD(NODES) to have the power distribution span the radial or Cartesian range over which the ROD- or SLAB-element node rows are define (Card Set 47 defines array RADRD)].

Card Set 59. If NZPWTB = 0 (Word 3 on Card Number 18), do not input Card Set 59 (array ZPWTB).

Variable	Dimension	Description
ZPWTB	(1+NZPWZ × NRPWR) × |NZPWTB| where NZPWZ is NCRZ+1 if NZPWZ < 2 is input.	1D axial (if IPWRAD = 0, Word 4 on Card Number 19) or 2D axial-r or axial-x (if IPWRAD = 1) power-shape vs independent-variable form table (*, –). Input |NZPWTB| table-defining data pairs having the following form [independent-variable form defined by IZPWSV (Word 2 on Card Number 18), NZPWZ × NRPWR (Words 1 and 4 on Card Number 20) power-density values). NRPWR = 1 when IPWRAD = 0. NZPWTB = 1 and the power-density values are real values of the signal-variable or control-block ID numbers that TRAC-P uses to define the actual power-density values when IPWDEP = ±1 (Word 5 on Card Number 19). The relative power densities defining the power shape are specified at the NZPWZ axial locations of the ZPWZT array defined by Card Set 57 and at the NRPWR ROD-radial or SLAB-thickness locations of the RPWRT array defined by Card Set 58. There are |NZPWTB| power shapes being input with an independent-variable value and NZPWZ x NRPWR power-density values for each shape.

Card Set 60. If NZPWTB = 0 (Word 3 on Card Number 18) or NZPWRF = 0 (Word 5 on Card Number 18), do not input Card Set 60 (array ZPWRF).

Variable	Dimension	Description
ZPWRF	2 × |NZPWRF|	Rate-factor table (*,-) for the axial-power-shape table's independent variable. Input |NZPWRF| (Word 5 on Card Number 18) table-defining data pairs having the following form [independent-variable form defined by NZPWSV (Word 4 on Card Number 15), rate factor].

Card Set 61. If IRPWTY = 1, 5, 11, or 15 (Word 1 on Card Number 14) or NFBPWT = 0, 1, 4, or 5 (Word 3 on Card Number 20), do not input Card Set 61 (array ZS).

Variable	Dimension	Description
ZS	NZPWZ where NZPWZ is NCRZ+1 if NZPWZ < 2 is input	Relative axial-power-shape density (–) used to volume average the reactivity-feedback parameters over the powered-core region. If IPWRAD = 1 (Word 4 on Card Number 19) and array ZS is input, array RS (Card Set 53) must be input as well.

Deprecated Functionality

Card Set 62.If IRPWTY = 1, 5, 11, or 15 (Word 1 on Card Number 14) or NRPWTB = 0 (Word 3 on Card Number 17), do not input Card Set 62 (array RPWTBR or RPWTBP).

Variable	Dimension	Description
RPWTBR or RPWTBP	2×|NRPWTB|	Programmed-reactivity (–) or reactor-core power (W or Btu h^{-1}) vs independent-variable form (*) table [(*,– or W), (*,– or Btu h^{-1})]. Input |NRPWTB| (Word 3 on Card Number 17) table-defining data pairs having the following form [independent-variable form defined by IRPWSV (Word 2 on Card Number 17), programmed reactivity or reactor power as defined by IRPWTY].

Card Set 63. If NRPWTB = 0 (Word 3 on Card Number 17) or NRPWRF = 0 (Word 5 on Card Number 17), do not input Card Set 63 (array RPWRF).

Variable	Dimension	Description
RPWRF	2×|NRPWRF|	Rate-factor table (*,–) for the programmed-reactivity or reactor-power table's independent variable. Input |NRPWRF| (Word 5 on Card Number 17) table-defining data pairs having the following form [independent-variable form defined by NRPWSV (Words 4 on Card Number 17), rate factor to be applied to the programmed-reactivity or reactor-power table's independent variable].

Card Sets 64 to 67. If IRPWTY < 11 (Word 1 on Card Number 14), do not input Card Sets 64 to 67 (array RCTF, RCTC, RCAL, and RCBM, respectively).

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Variable	Dimension	Description
RCTF	IRCJTB(1,1) + IRCJTB(2,1) + IRCJTB(3,1) + IRCJTB(4,1) + (IRCJTB(1,1) x IRCJTB(2,1) x IRCJTB(3,1) x IRCJTB(4,1))	The fuel-temperature reactivity-coefficient table. Input IRCJTB(1,1) T_f values, IRCJTB(2,1) T_c values, IRCJTB(3,1) values, IRCJTB(4,1) B_r or B_m values, and IRCJTB(1,1) × IRCJTB(2,1) × IRCJTB(3,1) × IRCJTB(4,1) fuel-temperature reactivity-coefficient values that define the four dimensionally dependent table. (**Note:** This table and the following three tables are **not** entered with two-value pairs as is done for the one dimensionally dependent tables.)

Variable	Dimension	Description
RCTC	IRCJTB(1,2) + IRCJTB(2,2) + IRCJTB(3,2) + IRCJTB(4,2) + (IRCJTB(1,2) x IRCJTB(2,2) x IRCJTB(3,2) x IRCJTB(4,2))	The coolant-temperature reactivity-coefficient table.
RCAL	IRCJTB(1,3) + IRCJTB(2,3) + IRCJTB(3,3) + IRCJTB(4,3) + (IRCJTB(1,3) x IRCJTB(2,3) x IRCJTB(3,3) x IRCJTB(4,3))	The gas volume-fraction reactivity-coefficient table.
RCBM	IRCJTB(1,4) + IRCJTB(2,4) + IRCJTB(3,4) + IRCJTB(4,4) + (IRCJTB(1,4) x IRCJTB(2,4) x IRCJTB(3,4) x IRCJTB(4,4))	The solute-mass concentration reactivity-coefficient table.

Note: Note

Direct Definition of Reactor-Core Power. If IRPWTY = 5, 6, 7, 15, 16, or 17 (Word 1 on Card Number 14), do not input Card Sets 68 to 74 (arrays BETA, LAMDA, CDGN, LAMDH, EDH, CDHN, and PHIST).

Card Sets 68 & 69. If NDGX $\leq$ 0 (Word 2 on Card Number 14), do not input Card Sets 68 and 69 (arrays BETA and LAMDA). The default 6-group delayed-neutron constants will be defined internally by TRACE.

Variable	Dimension	Description
BETA	NDGX	The effective delayed-neutron neutron fraction (–).
LAMDA	NDGX	The delayed-neutron decay constant (s^{-1}).

Card Set 70. If NDGX > 0 and NHIST = 0 (Words 2 and 5 on Card Number 14) input Card Set 70 (array CDGN).

Variable	Dimension	Description
CDGN	NDGX	The delayed-neutron precursor power (W, Btu h^{-1}).

Note:

Card Sets 71 & 72. If NDHX ≤ 0 or NDHX = 69 or 71 (Word 3 on Card Number 14), do not input Card Sets 71 and 72 (arrays LAMDH and EDH). The default 69-group decay-heat constants will be defined internally by TRACE if NDHX ≤ 0 or the ANS 79 decay-heat constants will be defined internally by TRACE if NDHX = 69 or 71.

Variable	Dimension	Description
LAMDH	NDHX	The decay-heat decay constant (s^{-1}).
EDH	NDHX	The effective decay-heat energy fraction (–).

Card Set 73. If NDHX > 0 and NHIST = 0 (Words 3 and 5 on Card Number 14), input Card Set 73 (array CDHN).

Variable	Dimension	Description
CDHN	NDHX	The decay-heat precursor power (W, Btu h^{-1}).

Card Set 74. If NHIST = 0 or 1 (Word 5 on Card Number 14), do not input Card Set 74 (array PHIST).

Variable	Dimension	Description
PHIST	2 × NHIST	Power-history table [(s, W), (s, Btu h^{-1})]. Input NHIST (Word 5 on Card Number 14) table-defining data pairs having the following form [time at the start of the transient minus the past time, reactor-core prompt-fission power at that past time]. The first data pair should be for the power level at the start of the transient; that is, the time at the start of the transient minus the past time, which in this case is 0.0 s, with the time difference for subsequent data pairs being positive valued and increasing monotonically for each data pair.

Card Sets 75 & 76. If NDHX ≠ 69 and NDHX ≠ 71 or NHIST = 0 (Words 3 and 5 on Card Number 14), do not input Card Sets 75 and 76 (arrays FP235 and FP239).

Note: It is assumed that FP235 + FP239 + FP238 = 1.0.

Variable	Dimension	Description
FP235	max(1,NHIST-1)	Fraction (–) of fission power associated with ^{235}U fission during the power-history table interval from i to i+1.
FP239	max(1,NHIST-1)	Fraction (–) of fission power associated with ^{239}Pu fission during the power-history table interval from i to i+1.

Card Sets 77 to 84.

Variable	Dimension	Description
FPUO2	NCRX	Fraction (–) of plutonium dioxide (PuO_2) in mixed-oxide fuel.
FTD	NCRX	Fraction (–) of theoretical fuel density.
GMIX	NCRX*7	Mole fraction (–) of gap-gas constituents. GMIX is not used if NFCI = 0 (Word 2 on Card Number 19) but must be input. Enter data for NCRX (Word 1 on Card Number 2) cells for each gas in the order indicated. Index Gas 1 = helium; 2 = argon; 3 = xenon; 4 = krypton; 5 = hydrogen; 6 = air/nitrogen; 7 = water vapor.
GMLES	NCRX	Gram moles of gap gas (g-moles) per ROD or SLAB element. XGMILES is not used, but must be input.
PGAPT	NCRX	Average gap-gas pressure (Pa, psia). PGAPT is not used if NFCI = 0 (Word 2 on Card Number 16), but must be input.
PLVOL	NCRX	Plenum volume (m^3, ft^3) in each ROD or SLAB element above the pellet stack. PLVOL is not used, but must be input.
PSLEN	NCRX	Pellet-stack length (m, ft). PSLEN is not used, but must be input.
CLENN	NCRX	Clad total length (m, ft). CLENN is not used, but must be input.

Deprecated Functionality

Card Set 85.

Note: Burnup Arrays. Input a BURN Card Set for each of the NRODS (Word 1 on Card Number 12) ROD or SLAB elements. This includes each average and supplemental ROD or SLAB element of the HTSTR component**.**

Variable	Dimension	Description
BURN	NCRZ+1	ROD or SLAB element axial-location fuel burnup (MWD/ MTU).

Multipass Control Parameter Evaluation

(not applicable to version 3.860 or later)

Control parameters are evaluated in the following order: signal variables, control blocks, and trips. If a signal variable is to be evaluated after a control block or a trip or a control block is to be evaluated after a trip, two or more evaluation passes through the three control-parameter types are needed. For **NTCP** ≥ 2 evaluation passes (Word 5 on Main-Data Card 10), the following Control-Parameter List Cards are input to define the subrange of parameters to be evaluated for each control-parameter type during each evaluation pass.

Card Number 1.

Variable	Description
ISV1(1)	The smallest signal-variable ID number evaluated during the first control-parameter evaluation pass [1 ≤ ISV1(1)].
ISV2(1)	The largest signal-variable ID number evaluated during the first control-parameter evaluation pass [ISV1(1) ≤ ISV2(1); input ISV2(1) = 0 if no signal variables are to be evaluated during the i = 1 first pass].
ICB1(1)	The smallest (in absolute value) control-block ID number evaluated during the first control-parameter evaluation pass [ICB1(1) ≤ –1].

Card Number 1.

Variable	Description
ICB2(1)	The largest (in absolute value) control-block ID number evaluated during the first control-parameter evaluation pass [ICB2(1) ICB1(1); input ICB2(1) = 0 if no control blocks are to be evaluated during the i = 1 first pass].
ITP1(1)	The smallest (in absolute value) trip ID number evaluated during the first control-parameter evaluation pass [1 ≤ |ITP1(1)|].
ITP2(1)	The largest (in absolute value) trip ID number evaluated during the first control-parameter evaluation pass [|ITP1(1)| ≤ |ITP2(1)|; input ITP2(1) = 0 if no trips are to be evaluated during the i = 1 first pass].
ISV1(2)	The smallest signal-variable ID number evaluated during the second control-parameter evaluation pass [1 ≤ ISV1(2)].
ISV2(2)	Etc.

Namelist Options

Some NAMELIST options are no longer used by the code, or their meaning has changed with respect to older versions of the code.

Table A-1.

Variable	Value Range	Description	Default Value
NAXN	0.0 To 1.0	Number of axial levels in the channel core	0
USEROD	0 or 1	0 = implies do not read VESSEL wall lumped or double-sided slab input. 1 = implies read VESSEL wall lumped or double-sided slab input.	0

Table A-1.

Variable	Value Range	Description	Default Value
NEWRFD	0 or 1	This option when turned on will activate the reflood model for HTSTR and CHAN components coupled to VESSEL components when internal tests are satisfied. 0 = on 1 = off Note: NEWRFD must not be changed when performing a restart calculation	0
NHTSTR	≥ 0	Number of HTSTR components input (must be defined when NHTSTR > 0) after the hydraulic-component data.	0
NPOWER	≥ 0	Number of power components used to power CHAN or HTSTR components	0

Main Card Variables

Some variables on the main cards are no longer used by the code, or their meaning has changed with respect to older versions of the code.

Table A-2.

Variable	Description
NTCF	Total number of table entries for the tabular control blocks from input and the restart file (NTCF ≥ 0) (used to dimension variable storage).
NTCP	Number of passes made each timestep through the control-parameter evaluation of signal variables, control blocks, and trips (NTCP ≥ 0) (two or more passes may be needed when the signal or set status of a trip is a signal-variable or control-block input parameter or when a control procedure contains an implicit control-block evaluation loop).

B

Error Messages

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MESSAGE	EXPLANATION
	INPUT PROCESSING MESSAGES
ARRAY FILLED BUT OPERATION END NOT FOUND	Most components (BREAK, FILL, and PLENUM are exceptions) require "array data" to specify cell lengths, volumes, areas, etc. An "**e**" to denote the end of the array data was not found where expected by TRACE.
DUPLICATE COMP NUMBERS IN IORDER	Two components with the same number were found in the **tracin** file IORDER array.
FATAL INPUT ERROR(S)	TRACE will attempt to read the entire input-data file even if fatal errors are encountered. This message occurs after input-data processing is complete and indicates that you will need to correct all fatal errors encountered while TRACE was reading the input data (all of which have been flagged by warning messages).
ILLEGAL MATERIAL ID NUMBER	The material ID number is not a valid number between 1 and 12 for internal TRACE materials or >50 for user-defined materials.
INOPTS NAMELIST DATA NOT FOUND	The NAMELIST-data input option INOPT = 1 (Word 3 on **Main-Data Card 2**) was specified but no NAMELIST data were defined on the **tracin** file.

MESSAGE	EXPLANATION
INPUT ERROR DETECTED IN TRACIN. CARD NUMBER XXXX	The free-format input-option preprocessor sub-routine PREINP found an input-data error. Possible causes include an invalid character (for example, the = character in 1.0000E=07), the omission of **Main-Data Card 1**, or a simple typographical error. An immediate fatal error occurs if **Main-Data Card 1** is incorrect. In all other cases, a flag is set that stops execution after the entire input-data **tracin** file has been processed. **Note:** The card number is the last number on each card in the trcinp output file.
INPUT ERROR ENCOUNTERED ON CARD NO. XXXX, - REST OF COMPONENT SKIPPED	Array-reading subroutine LOAD found an error on a free-format defined card set. The rest of the component data are skipped. Execution of TRACE stops after the entire input-data **tracin** file is processed. **Note:** The card number is the last number on each card in the trcinp output file.
INPUT ERROR — NEW COMPONENT WAS ENCOUNTERED UNEXPECTEDLY ON CARD NO. XXXX	Data for a new component were found before reading the data for the current component was finished. For example, you may have omitted a data card expected by TRACE. The card might be required by an INOPTS option or a component feature; due to a simple oversight this was not provided. **Note:** The card number is the last number on each card in the trcinp output file.
INPUT ERROR ON CARD NO. XXXX – ENCOUNTERED UNEXPECTED LOAD DATA	TRACE encountered array data but was expecting non-array data. You have either too many or too few input-data cards because the card read is out of sequence. **Note:** The card number is the last number on each card in the trcinp output file.
INPUT ERROR ON CARD NO. XXXX - REAL DATA ENCOUNTERED IN INTEGER ARRAY	Real array data were found where integer array data were expected. You have either too many or too few input-data cards because the card read is out of sequence. **Note:** The card number is the last number on each card in the trcinp output file.

MESSAGE	EXPLANATION
NOT ENOUGH DATA TO FILL ARRAY	Insufficient data were input to define an array. Remember that one more value is required for cell-edge parameters such as flow area, hydraulic diameter, and the gravity parameter than for cell-centered parameters such as cell length and volume.

INITIALIZATION MESSAGES

JUNCTION BOUNDARY ERROR DETECTED	Adjacent components have mismatched geometry and hydraulic input-data at their junction interface. TRACE identifies the component, the mismatched parameter (area, hydraulic diameter, gravity parameter, etc.), and the unequal values.
CNTL. BLOCK NOT FOUND	A control-block output signal's ID number was specified to define the independent variable for a component-action table in component data, but the ID number could not be found in the list of defined control blocks.
SIGNAL VAR. NOT FOUND	A signal variable's ID number was specified to define the independent variable for a component-action table in component data, but the ID number could not be found in the list of defined signal variables.
SIG. VARIABLES EXCEED DIMENSION	The number of signal variables defined by the **tracin** file and **trcrst** file exceeds its NTSV storage-allocation number (Word 1 on **Main-Data Card 10**).

STEADY-STATE OR TRANSIENT MESSAGES

CANNOT REDUCE TIME STEP FURTHER	The timestep was reduced to the DTMIN minimum specified by the user, and the solution (outer iteration) failed to converge. This is one of the more difficult messages to handle because when it occurs at the start of a calculation, there probably is a difficulty with the input-data model.
STEADY-STATE SOLUTION NOT CONVERGED	The steady-state calculation did not reach a converged steady-state solution within the user-specified problem time for the calculation.

RESTART MESSAGES

MESSAGE	EXPLANATION
DUMP NOT FOUND ON RESTART FILE	On **Main-Data Card 6**, the DSTEP timestep number of the data dump to be used for restart was specified. The restart file (**trcrst**, which is **trcdmp** from the previous calculation) was searched and this timestep number (an integer) could not be found. Refer to the **trcout** or **trcmsg** file from the calculation that generated the **trcdmp** file (renamed **trcrst** for the current restart calculation), and check the timestep number for the data dump that is desired. Searching the **trcmsg** or **trcout** files for the word “restart” with a text editor will reveal the timestep numbers of all data dumps generated.
NUMBER TRIPS EXCEED DIMENSION	The number of trips defined by the **tracin** file and **trcrst** file exceeds its NTRP storage-allocation number on **Main-Data Card 10**.