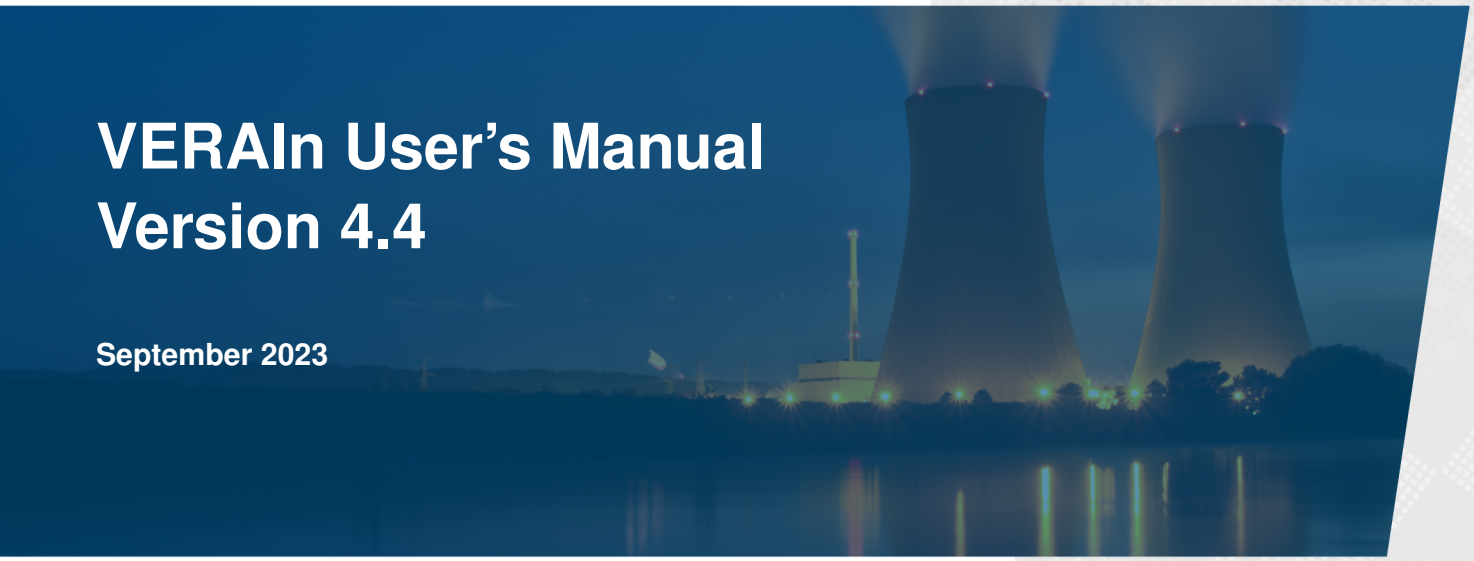
VERA Virtual Environment for Reactor Applications

ORNL/SPR-2023/3091



VERAIn User's Manual Version 4.4

September 2023

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OAK RIDGE National Laboratory

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VERAIn User's Manual Version 4.4

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VERAIn User's Manual Version 4.4

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Aaron Graham, VERAIO Product Software Manager	**Date**
Bob Salko, Independent Reviewer	**Date**

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LIST OF FIGURES

ABBREVIATIONS

AIC	silver-indium-cadmium
BWR	boiling water reactor
CASL	Consortium for Advanced Simulation of Light Water Reactors
CE	continuous energy
CHF	critical heat flux
CMFD	coarse-mesh finite difference
CRAM	Chebyshev Rational Approximation Method
CRUD	Chalk River unidentified deposit
DNB	departure from nucleate boiling
DNBR	departure from nucleate boiling ratio
EFPD	effective full power day
EOC	end of cycle
ESSM	embedded self-shielding method
GT	guide tube
GWd/MT	gigawatt-days per metric ton heavy metal
HDF5	hierarchical data format 5
HM	heavy metal
IT	instrument tube
LWR	light-water reactor
MOC	middle of cycle
ModSim	modeling and simulation
MOX	mixed oxide
PPB	parts per billion
PPM	parts per million (usually boron)
PWR	pressurized water reactor
RIA	reactivity insertion accident
STH	system thermal hydraulic
T/H	thermal hydraulic
VERA	Virtual Environment for Reactor Applications
VERAIn	VERA input processor
VERARun	VERA run script
XML	extensible markup language

1. INTRODUCTION

1.1 INTRODUCTION TO CASL

The Consortium for Advanced Simulation of Light Water Reactors (CASL), the first US Department of Energy (DOE) Energy Innovation Hub, was established in July 2010 to provide advanced modeling and simulation (ModSim) solutions for commercial nuclear reactors.

CASL's objective was to predict, with confidence, the performance of nuclear reactors through comprehensive, science-based modeling and simulation technology that would be deployed and applied broadly throughout the nuclear energy industry to enhance safety, reliability, and economics.

CASL's mission was to provide the coupled, high-fidelity, usable modeling and simulation capabilities needed to address light-water reactor (LWR) operational and safety performance-defining phenomena.

CASL's foundational technology products include CASL solutions and CASL ModSim Technologies. CASL's ModSim technology, the Virtual Environment for Reactor Applications (VERA), provides higher fidelity results than those offered by the current industry approach by incorporating coupled physics and science-based models, state-of-the-art numerical methods, modern computational science, integrated uncertainty quantification, and validation against data from operating pressurized water reactors (PWRs), single-effect experiments, and integral tests.

1.2 VERA

VERA is a specific collection of multiphysics computer codes used to model and simulate depletion of an LWR core over multiple cycles. Examples of the separate physics modeled in the core simulator include cross-section generation, neutron transport, isotopic depletion, thermal hydraulics, and fuel performance.

The purpose of the core simulator is to simulate depletion of the reactor core and provide data and boundary conditions to model CASL Challenge Problems such as crud-induced power shift (CIPS, also called axial offset anomaly), crud-induced localized corrosion (CILC), departure from nucleate boiling (DNB), pellet-cladding interaction (PCI), and reactivity insertion accident (RIA) analyses.

One important feature of the core simulator is that a single common input file is used to drive all of the different physics codes.[1] One benefit of using a single common input is that users only need to understand and be proficient with one input instead of having to understand multiple inputs for multiple physics codes. Another benefit of using a single common input is that all codes work from a single geometry description, and this reduces errors from inconsistent geometries in different codes.

The most up-to-date version of this document resides in the VERA Git repository file "VERAIO/verain/docs/verain_UM.pdf"; please refer to this location for the latest version of the input manual.

Additional information can be found on the VERA website: https://vera.ornl.gov/.

[1] The only exception to this is for computational fluid dynamics codes, which generally require a detailed CAD file to support mesh generation and perform meaningful analysis.

1.3 MANUAL ORGANIZATION

This manual is organized into three main parts.

The first part, which includes Chapters 2 through 6, is the "User's Manual," which describes how a user would set up typical input. This part of the manual gives the most common inputs a user would need and describes how to use them. It does not include a complete list of inputs or show every available option.

The second part of the manual, Chapter 7, is a "Reference Manual" and includes a complete list of every available input.

The third part of the manual, Chapter 8, gives several example input decks. Additional example input files can be found in the code installation directory.

In addition, a description of the VERARun script that is used to run VERA jobs is given in Chapter 9.

Note that the VERA input processor (VERAIn) is an open-source software project and can be found on the CASL Github website: github.com/casl/verain. The open-source input processor does not include any physics packages.

1.4 TRAINING REQUIREMENTS

No training is required to run VERA, but users should have a basic understanding of LWR technology. Users who perform any engineering or safety-related work with VERA should follow the procedures of their own organizations.

Optional user training is periodically available from the VERA Users Group. Please contact support (see Section 1.9, "Software Support") to inquire about training opportunities.

1.5 PURPOSE AND FUNCTIONAL REQUIREMENTS

The purpose and functional requirements of VERAIn are as follows:

1. Read an ASCII input provided by the user as described in this manual.
2. Perform basic error checking on the ASCII input. Additional error checking is performed by other VERA components.
3. Perform basic geometry processing such as expanding input maps from octant to full geometry where applicable.
4. Create an extensible markup language (XML) output file that can easily be read by other VERA components.

The purpose of the VERA run script (VERARun) is to provide a single interface to run the VERA codes, usually in parallel computing environments. The specific functional requirements for VERARun are as follows:

1. Run VERAIn to create an XML file that can be read by other VERA components.
2. Run any input preprocessors as necessary (such as XML2CTF or XML2Bison).
3. Submit jobs to a parallel computing cluster.

1.6 CODE CAPABILITIES AND LIMITATIONS

The current code capabilities of VERAIn and VERARun are specified by the functional requirements listed previously. Requirements not explicitly stated in this list are assumed to be limitations.

One general limitation in the input processor is that the input is limited to standard LWR designs. For example, the input processor does not support reactors with hexagonal or plate fuel or with coolant that is not water.

Other VERA components might have limitations; the user should refer to the documentation of the other VERA components for these limitations.

1.7 TESTING

Information regarding system testing can be found in the respective VERAIn and VERARun Software Requirements, Test Plan, and Test Reports. These documents contain summaries of all system testing and associated requirements. Any feature not covered in these reports is considered to be untested.

1.8 COMPUTER SYSTEM VULNERABILITIES

Running VERAIn or VERARun on any machine is not known to expose the system to any security vulnerabilities at this time. VERAIn and VERARun should not be run with administrative-level access permissions.

1.9 SOFTWARE SUPPORT

For specific questions about the use of VERAIn or VERARun, the licensing of the code, or to report bugs, users should send an email to `vera-support@ornl.gov`.

Additional user information can be found on the VERA website: https://vera.ornl.gov/.

2. USER MANUAL

The VERA common input is an ASCII file and is designed to be modular. The input is divided into separate modules (or blocks) to describe the different geometric objects in the core and to define specific modeling options for each of the physics codes.

Geometric objects are defined as the physical "parts" of the reactor core and include fuel assemblies, control rod assemblies, removable burnable poison assemblies, and detectors. By defining each geometric object as a separate block, the objects can be described independently of each other, relying on very little global information. The independent descriptions make quality assurance easier and allow objects to be defined in one cycle and to be reused in subsequent cycles without concerns about input conflicts. Another advantage of the module approach is that it is easier to shuffle fuel assemblies and to insert and withdraw "inserts" such as control rods, detectors, and removable burnable poison assemblies into the fuel assemblies as the core configuration changes.

Additional modules/blocks are used to define modeling options and parameters for each of the physics codes. Separating the geometry description from the modeling options allows all of the physics codes to share the same geometry description and the same input to be used with multiple physics codes.

The VERA input blocks are as follows:

CASEID This block contains an input title input.

CORE This block describes the core layout, including the core map, assembly locations, control rod locations, and assembly insert locations. The CORE block contains data that does not change during a cycle depletion.

STATE These blocks describe reactor core operating parameters (state point values) at a particular point in time. Parameters include inlet temperature, pressure, power, control rod positions, and others. STATE values can, and usually do, change at each state point.

BRANCH These blocks describe branch calculations that can be done after each state point. They can be used to perturb a variety of operational parameters defined in the [STATE] block. They will typically be be used to generate nodal cross-section data with **MPACT**.

ASSEMBLY These blocks contain the geometry and physical description of the nuclear fuel assemblies. The assembly descriptions do not include control rods, detectors, or inserts.

INSERT These blocks contain the geometry and physical description of the assembly inserts. An *insert* is a generic term used to describe a removable burnable poison assembly or a thimble plug assembly.

CONTROL These blocks contain the geometry and physical description of a control rod assembly. A control rod assembly is similar to an assembly insert, except that it can move during operations.

DETECTOR This block contains the geometry and physical description of a detector string.

EDITS This block contains information about what edits the code should produce.

COUPLING This block contains parameters for coupling different physics codes together.

TRANSIENT This block contains parameters for transient calculations.

RUN This block contains run time parameters for the execution of VERA calculations.

In addition to the previously listed blocks, additional code-specific blocks contain options specific to each physics code: **COBRATF**, **MPACT**, **MAMBA**, **SHIFT**, **BISON**, and **FAST**. Additional code-specific input blocks can be added as new physics codes are added to the core simulator.

The rest of this chapter describes the most common concepts and features of each input block. This section does not provide a comprehensive list of each input or option on each input. Refer to Chapter 7 for a detailed list of all inputs and options.

2.1 INPUT SYNTAX

VERA input files are text files that contain standard printable ASCII characters. The data are organized in blocks with names and purposes, as described in the Introduction. The start of a block is denoted by the block name enclosed in square brackets (e.g., [STATE]). The file block structure is flat, so there is no hierarchy in the block segments. The start of a new block also implies the end of the previous block. There can be multiple instances of [ASSEMBLY], [INSERT], and [STATE] blocks. Other blocks, like [CORE] and the code-specific blocks, are unique, so a new block with the same name of an existing block will overwrite the existing block data. There is no required order of the blocks in the input file except for the [STATE] blocks, in which each state point must be entered in chronological order.

The blocks contain inputs that are generally organized as keyword-value pairs or keyword-tag-value triplets, where *tag* denotes the keyword name tag that can be referenced in the other related commands. Keywords should not have blank spaces since the spaces typically imply delimiters in the input data. A value can be a single entry or a list entry. Input value entries can contain different data types, depending on the input format. The data types are real numbers, integers, characters, and character strings. String entries that include spaces should be enclosed in single or double quotation marks.

The block, keyword, and tag names are case sensitive. Therefore, users should not depend on capitalization for differentiation among entries in the file.

In this manual, all input examples are shown in `typewriter font`. When inputs are used in the text (not in the examples), they are listed in *italic font*. All block names are enclosed in square brackets.

The exclamation mark, "!", is a special character used for adding comments in an input file; everything from an exclamation point to the end of the line is a comment and is ignored by the processor.

The semicolon, ";", is a record termination character that can be used to list several input options on a single line. Using the semicolon causes the processor to behave as if everything following the semicolon were placed on a new line. This is useful primarily for visual organization of the input file.

The keyword *include* can be used to insert the contents of another file into the input file.

Short commands are expected to complete within a single line. Longer commands, like input maps, can be split across multiple lines.

An example input fragment with blocks, comments, and inputs follows:

```
! comments start with an exclamation point

[STATE]            ! block names are enclosed in square brackets
  power   85.0     ! inputs with parameters(s)
  flow    80.0     ! inputs and parameters are separated by one or more spaces

  rodbank A 228    ! inputs can span more than one line
          B 228
```

```
          C 228
          D 228

[CORE]             ! start of second block
  title  "Title must be enclosed in quotes if spaces are used"
```

Lists of values can be generated by using the following bracket nomenclature:

$$< n..m \text{ x } i >$$

where n is the starting list number, m is the ending list number, x is a delimiter, and i is the step. If "x i" is ommitted, then the step size is one. Examples of generated lists include:

```
<0..5>          0, 1, 2, 3, 4, 5
<10..16x2>      10, 12, 14, 16
<0..4x0.5>      0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0
```

Additional list options can be found on the List::Maker web page.

2.2 CORE DESCRIPTION

The [CORE] block describes the nuclear reactor core configuration. This block describes the core layout, including the placement of nuclear fuel assemblies, control rods, detectors, inserts, and other core parameters that do not change during a cycle depletion.

The geometric objects inside the core are defined in separate input blocks; the [CORE] block simply describes how all of these objects are placed together.

2.2.1 Core Geometry

The reactor core geometry must be defined first. The overall *size* of the core is given by the number of assemblies across one major axis of the core. The assembly pitch (*apitch*) defines the width of each assembly, including the assembly gap. The distance from the top of the lower core plate to the bottom of the upper core plate is given by the parameter *height*. The assembly layout is given by the *core_shape* map. Note that the core shape map is the only "square" core map in the input, and it must be of *size* assemblies by *size*. Once the core shape is defined, subsequent core maps include entries only for actual fuel assembly locations.

```
size 15            ! number of assemblies across one axis
apitch 21.5        ! assembly pitch (cm)
height 406.337     ! distance from lower core plate to upper core plate (cm)

core_shape
  0 0 0 0 1 1 1 1 1 1 1 0 0 0 0
  0 0 1 1 1 1 1 1 1 1 1 1 1 0 0
  0 1 1 1 1 1 1 1 1 1 1 1 1 1 0
  0 1 1 1 1 1 1 1 1 1 1 1 1 1 0
  1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
  1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
  1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
  1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
  1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
  1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
```

```
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0 1 1 1 1 1 1 1 1 1 1 1 1 1 0
0 1 1 1 1 1 1 1 1 1 1 1 1 1 0
0 0 1 1 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0 1 1 1 1 1 1 1 0 0 0 0
```

The *core_shape* map is unique because it is square in shape and composed of the integers 1 and 0. The 1 represents a location with a fuel assembly, and a 0 is an unoccupied location. The purpose of this map is to define the shape for subsequent core maps.

Most physics codes support calculations run in either full-core, half-core, or quarter-core symmetry. If a calculation is run in half-core or quarter-core symmetry, the code must know whether the symmetry is mirror symmetric or rotationally symmetric. The type of symmetry is defined with the *bc_sym* input. The symmetry option is ignored if the calculation is run in full core.

```
bc_sym mir    ! define quarter-core symmetry as mirror
```

2.2.2 Core Maps

Core maps are used to define the location of geometry objects in the core. There are different core maps to define types and locations of assemblies, inserts, detectors, and control rods. The entries in the maps are composed of arbitrary-length character strings. Even though the character strings can be any size, it is recommended to use compact names so the maps remain legible.

All of the maps require one entry for each assembly location defined in the *core_shape* map. However, the input parser can be used to take advantage of core symmetry. If the core is symmetric, then the user only needs to input the maps in quarter or octant symmetry, and the input parser will automatically unfold the map to full symmetry using mirror symmetry, regardless of the value for *bc_sym*. The symmetry used in the core maps is independent of the symmetry used to run the actual calculations. For example, the user can enter all of the core maps in octant symmetry and still run the calculations in quarter or full symmetry. The quadrant and octant that the parser expects is shown in Figure 1.

If there is an empty location in the map (e.g., if there is no detector or no control rod in an assembly), then enter a dash (also known as a *hyphen*) "-" for that location. The dash is significant and signifies an empty location in the core map. (The dash indicates that something is missing, but it is still a valid assembly location. The "0" in the *core_shape* represents an invalid assembly location.)

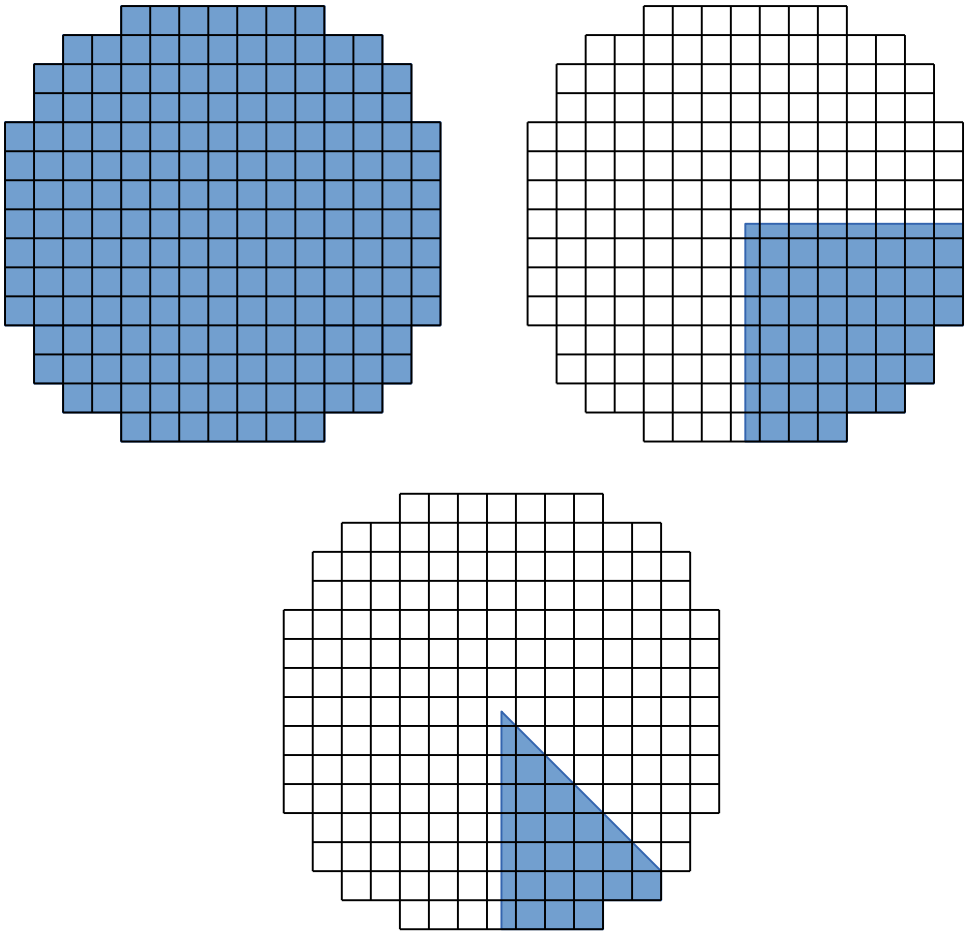

Figure 1. Full, quarter, and octant symmetry regions for a core map.

The *assm_map* shows where the assembly types are located within the core. In the following example, there are three assembly types that will be defined in [ASSEMBLY] block(s).

```
assm_map
                A3 A3 A3 A3 A3 A3 A3
            A3 A3 A3 A1 A3 A1 A3 A1 A3 A3 A3
         A3 A3 A2 A1 A2 A1 A2 A1 A2 A1 A2 A3 A3
         A3 A2 A2 A2 A1 A2 A1 A2 A1 A2 A2 A2 A3
      A3 A3 A1 A2 A1 A2 A1 A2 A1 A2 A1 A2 A1 A3 A3
      A3 A1 A2 A1 A2 A1 A2 A1 A2 A1 A2 A1 A2 A1 A3
      A3 A3 A1 A2 A1 A2 A1 A2 A1 A2 A1 A2 A1 A3 A3
      A3 A1 A2 A1 A2 A1 A2 A1 A2 A1 A2 A1 A2 A1 A3
      A3 A3 A1 A2 A1 A2 A1 A2 A1 A2 A1 A2 A1 A3 A3
      A3 A1 A2 A1 A2 A1 A2 A1 A2 A1 A2 A1 A2 A1 A3
      A3 A3 A1 A2 A1 A2 A1 A2 A1 A2 A1 A2 A1 A3 A3
         A3 A2 A2 A2 A1 A2 A1 A2 A1 A2 A2 A2 A3
         A3 A3 A2 A1 A2 A1 A2 A1 A2 A1 A2 A3 A3
            A3 A3 A3 A1 A3 A1 A3 A1 A3 A3 A3
                  A3 A3 A3 A3 A3 A3 A3
```

The following map is equivalent to the previous map but demonstrates the use of input with octant symmetry. Only values in the octant shown in Figure 1 are entered in the map, and the parser automatically unfolds the map to full symmetry.

```
assm_map
   A1
   A2 A1
   A1 A2 A1
   A2 A1 A2 A1
   A1 A2 A1 A2 A2
   A2 A1 A2 A1 A2 A3
   A1 A3 A1 A3 A3 A3
   A3 A3 A3 A3         ! assembly map with octant symmetry
```

The *insert_map* is used to show where assembly inserts are located within the core. In the following quarter-symmetry example, the inserts are burnable poison assemblies with different numbers of Pyrex rods. The *insert_map* can also be used to place geometry objects such as thimble plugs. The geometry description of the inserts will be given in the [INSERT] block.

```
insert_map
    -    BP20   -    BP20   -    BP20   -    BP12
   BP20   -    BP24   -    BP20   -    BP24   -
    -    BP24   -    BP20   -    BP16   -    BP8
   BP20   -    BP20   -    BP20   -    BP16   -
    -    BP20   -    BP20   -    BP24   -
   BP20   -    BP16   -    BP24  BP12   -
    -    BP24   -    BP16   -     -
   BP12   -    BP8    -
```

The *insert_map* is optional if no inserts are present in the core. A dash "-" is used to specify assembly locations without an insert.

The *det_map* is used to show where detectors are located in the core. The geometry description of the corresponding detector strings is given in the [DETECTOR] block. In this example, there is only one detector type, denoted with a "1." Since the "1" occurs in a core map, it is treated as a character string. This example uses a full-symmetry map.

```
det_map
                - - 1 - - 1 -
          1 - - 1 - 1 - - - - -
      - - - - - - 1 - 1 - 1 - 1
      1 1 - - - - 1 - - - - - -
  - - - - 1 - - - 1 - 1 - 1 - -
  1 - 1 - - 1 - 1 - - - - - 1 -
  - - - 1 - - 1 - - 1 - - 1 - -
  1 - 1 - 1 - 1 - - 1 - 1 1 1 -
  - 1 - - - - - - 1 - 1 - - - 1
  - - - - 1 - 1 - - - - 1 - - -
  1 - - - 1 - - 1 - - 1 - - - 1
    - - - - 1 - - 1 - - 1 - -
    - 1 - 1 - - 1 - - - - - 1
      1 - - - 1 - - 1 - 1 -
          1 - - 1 - - -
```

The *det_map* is optional if no detectors are present in the core. A dash "-" is used to specify assembly locations without a detector.

The control rod assemblies are described with two maps. The *crd_map* defines the control rod types and locations in the core. The *crd_bank* map assigns control rod locations to control rod banks. The control rod maps are optional if no control rods are present in the core. In the following example, there is only one control rod type, labeled "1."

```
crd_map
                - - - - - - -
          - 1 - 1 - 1 - 1 - 1 -
      - - - 1 - 1 - 1 - 1 - - -
      1 - 1 - - - 1 - - - 1 - 1
  - - 1 - 1 - - - - - 1 - 1 - -
  - 1 - - - 1 - 1 - 1 - - - 1 -
  - - 1 - - - - - - - - - 1 - -
  - 1 - 1 - 1 - 1 - 1 - 1 - 1 -
  - - 1 - - - - - - - - - 1 - -
  - 1 - - - 1 - 1 - 1 - - - 1 -
  - - 1 - 1 - - - - - 1 - 1 - -
    1 - 1 - - - 1 - - - 1 - 1
    - - - 1 - 1 - 1 - 1 - - -
      - 1 - 1 - 1 - 1 - 1 -
          - - - - - - -
```

```
crd_bank
                -  -  -  -  -  -  -
          - SA  -  B  -  C  -  B  - SA  -
       -  -  - SD  - SB  - SB  - SC  -  -  -
     SA  -  D  -  -  -  D  -  -  -  D  - SA
   -  - SC  -  A  -  -  -  -  -  A  - SD  -  -
   -  B  -  -  -  C  -  A  -  C  -  -  -  B  -
   -  - SB  -  -  -  -  -  -  -  -  - SB  -  -
   -  C  -  D  -  A  -  D  -  A  -  D  -  C  -
   -  - SB  -  -  -  -  -  -  -  -  - SB  -  -
   -  B  -  -  -  C  -  A  -  C  -  -  -  B  -
   -  - SD  -  A  -  -  -  -  -  A  - SC  -  -
     SA  -  D  -  -  -  D  -  -  -  D  - SA
      -  -  - SC  - SB  - SB  - SD  -  -  -
         - SA  -  B  -  C  -  B  - SA  -
                -  -  -  -  -  -  -
```

2.2.3 Core Baffle and Vessel

The *core baffle* or *shroud* is a steel reflector that closely surrounds the fuel assemblies in the core. The *barrel* is a round steel structure that surrounds the baffle, and the *vessel* is the round outer pressure vessel. These structures are shown in Figure 2.

The *baffle* is defined with a single material, the size of the gap between the outer assembly and baffle, and the baffle thickness.

```
baffle   SS304 0.19 1.26   ! material, gap (cm), and thickness (cm)
```

The barrel and vessel are defined with a *vessel* input. This input allows the user to enter any arbitrary number of rings surrounding a core by specifying the ring radii and the materials between the rings.

```
vessel   mod 166.7 SS304 169.2 mod 175.0 SS304 176.0   ! materials and radii (cm)
```

Currently, there is no input defined to specify the neutron pad.

2.2.4 Core Plates

The core plates are large steel plates at the top and bottom of the core that have various flow holes passing through them. All of the axial core heights are defined relative to the top of the bottom core plate, and the total core *height* is defined as the distance between the top of the bottom core plate and the bottom of the top core plate.

The core plates are modeled in the neutronics codes as smeared materials. The upper and lower core plates are defined with a material composition, a thickness, and a volume fraction of the structural material. The remainder of the volume fraction is filled with coolant.

```
lower_plate SS304  5.0  0.5   ! material, thickness (cm), volume fraction
upper_plate SS304  7.6  0.5   ! material, thickness (cm), volume fraction
```

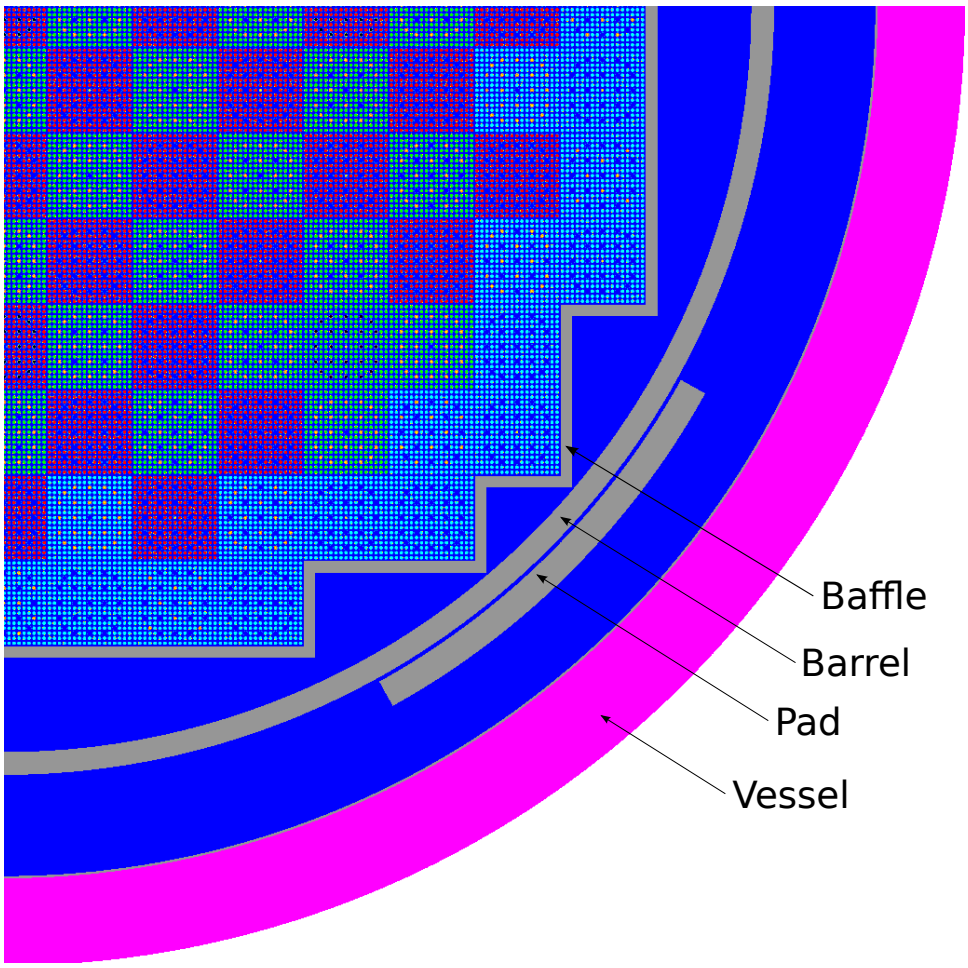

Figure 2. Core baffle and vessel (image courtesy of Andrew Godfrey).

2.2.5 Small Core Geometries

Even though the VERA input is designed for "real" core geometries, it can accommodate smaller problems as well. For example, to run a single-assembly calculation, the user would define the core size as one assembly by one assembly, and all of the core maps would contain a single assembly.

```
size 1                ! core composed of a single-assembly
core_shape
   1
```

To model a single fuel rod, the user would define a core with one assembly and an assembly with one rod in it.

2.3 ASSEMBLY DESCRIPTION

The [ASSEMBLY] block contains the geometric description of a unique fuel assembly design (type). Multiple [ASSEMBLY] blocks are permitted to describe different assembly designs in the core.

If there are multiple assembly designs that are geometrically identical (i.e., everything is the same except the enrichments), then they can all be defined in a single [ASSEMBLY] block. Each assembly type will have a unique *axial* input with possibly unique axial levels and lattice types. Assemblies within a single reload typically have a design similar enough that they can share a single [ASSEMBLY] block.

If assembly designs are not geometrically identical (e.g., if they are from different vendors or different generations), then they need to be defined in separate [ASSEMBLY] blocks. One advantage to having separate blocks for each assembly design is that each design can be modeled (and archived) independently without the need to rely on global definitions.

A typical PWR assembly is shown in Figure 3. Refer to this figure in the following discussions.

A complete list of all the inputs in the [ASSEMBLY] block is located in Chapter 7.

2.3.1 Initial Data

Each assembly block must contain a geometry description with the number of pins across the assembly and the pin pitch. An assembly block can also include an optional title input.

```
title "Westinghouse 17x17"      ! assembly title
npin 17                         ! number of pins across one side
ppitch 1.260                    ! pin pitch (cm)
```

The number of pins *npin* must be the same for every assembly in a core.

The inter-assembly gap on each side of the assembly is calculated as $[apitch - npin * ppitch]/2$.

For a boiling water reactor (BWR), a channel box may be specified with the following inputs. See Section 2.7 for a complete description of the channel box inputs.

```
channel_box zirc 0.254 0.10         ! mat, corner thickness (cm), corner radius (cm)
channel_box_segments 0.18 2.5 0.2   ! segment thickness (cm), segment length (cm),
                                    ! segment ramp (cm)
```

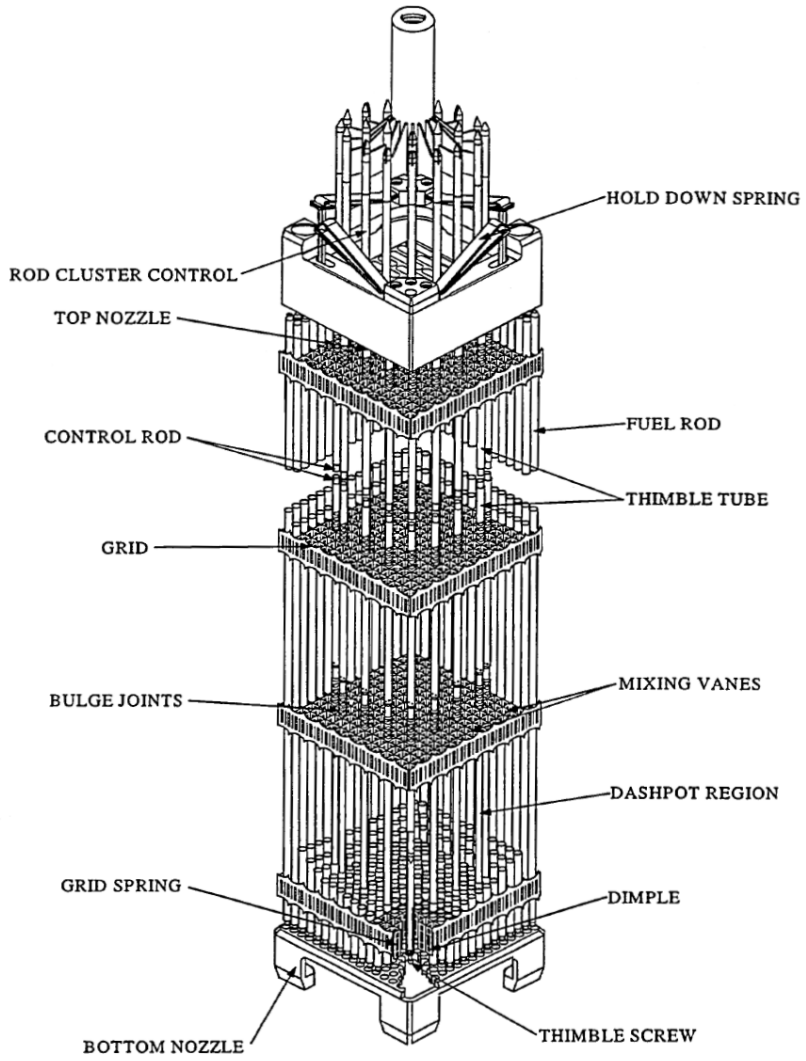

Figure 3. PWR fuel assembly (Image courtesy of the US Nuclear Regulatory Commission).

The fuel and structural materials are defined with the following inputs. See Chapter 4 for a complete description of the material inputs.

```
fuel U31 10.257 95.0 / 3.1   ! mat, density (g/cc), Theoretical density (%)
                             !    / U-235 enrichment (%)
mat inc   8.19               ! mat, density (g/cc)
mat ss    8.0
mat zirc4 6.56
```

2.3.2 Cell Descriptions

Cell inputs are used to describe "pincells." A pincell is defined as a configuration of concentric cylinders (or rings) centered in a square region of coolant. Cell configurations can be used to model fuel rods or guide tubes (GTs), as shown in Figure 4.

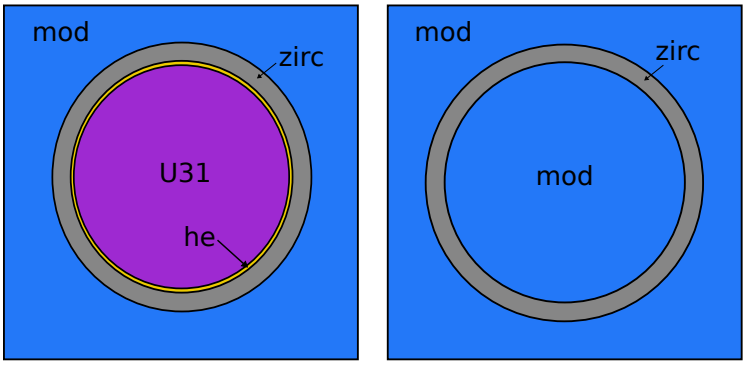

Figure 4. Pincell diagrams of a fuel rod and a guide tube.

The first parameter on the *cell* input is the cell ID. This is followed by a list of radii for each ring in the cell, followed by a slash. After the slash is a list of materials that comprise each ring. The cell IDs are used in the rod maps described in the next section.

```
cell 1     0.4096 0.418 0.475 / U31 he zirc4
cell GT           0.561 0.602 / mod    zirc4      ! guide tube
cell IT           0.561 0.602 / mod    zirc4      ! instrument tube
cell 7            0.418 0.475 / mod    mod        ! empty location
cell 8            0.418 0.475 /     he zirc4      ! plenum
cell 9                  0.475 /        zirc4      ! pincap
```

In this example, in cell "1," the material "U31" extends from radius 0 to 0.4096. The material "he" extends from a radius 0.4096 to 0.418. The materials "U31" and "he" are defined on *fuel* and *mat* inputs, respectively. (Refer to Chapter 4 for a complete description of material definitions.)

The outside of each cell is automatically filled with the special material "mod," which refers to the moderator (or coolant). The composition of "mod" is calculated by the codes using the local thermal hydraulic (T/H) conditions and the soluble boron concentration and cannot be specified by a user on a *mat* input.

In the preceding example, the GT and instrument tube (IT) descriptions use the special moderator material "mod" to define the moderator material on both the inside and outside of the tubes.

Large water rods that span more than one lattice cell can be specified by adding an optional keyword "large4" to the end of the *cell* input.

```
! large CE 16x16 water rod
  ppitch  1.28524
  cell WR 1.26 1.28 / mod zirc4 / large4
```

2.3.3 Lattice Descriptions

Once the cells are defined, they are placed into 2D "lattices," shown subsequently. Like the core maps, lattice maps can be entered with either full-symmetry, quarter-symmetry, or octant-symmetry. The following maps are octant-symmetric maps for 17 × 17 assembly designs.

```
rodmap FUEL1
    IT
     1 1
     1 1 1
    GT 1 1 GT
     1 1 1  1 1
     1 1 1  1 1 GT
    GT 1 1 GT 1  1 1
     1 1 1  1 1  1 1 1
     1 1 1  1 1  1 1 1 1

rodmap LGAP1
    IT
     7 7
     7 7 7
    GT 7 7 GT
     7 7 7  7 7
     7 7 7  7 7 GT
    GT 7 7 GT 7  7 7
     7 7 7  7 7  7 7 7
     7 7 7  7 7  7 7 7 7

rodmap PLEN1
    IT
     8 8
     8 8 8
    GT 8 8 GT
     8 8 8  8 8
     8 8 8  8 8 GT
    GT 8 8 GT 8  8 8
     8 8 8  8 8  8 8 8
     8 8 8  8 8  8 8 8 8

rodmap PCAP1
    IT
     9 9
     9 9 9
    GT 9 9 GT
     9 9 9  9 9
     9 9 9  9 9 GT
    GT 9 9 GT 9  9 9
     9 9 9  9 9  9 9 9
     9 9 9  9 9  9 9 9 9
```

Rod maps define each unique axial level in the assembly. The first parameter is the lattice name (e.g., FUEL1 and PCAP1), followed by a map of the *cell* IDs.

Each entry in a rod map must be a valid cell ID.

2.3.4 Axial Descriptions

After rod maps are defined for each axial level, the lattices are "stacked" into an assembly using an *axial* input as shown in the following.

```
axial A1    6.050
    LGAP1  10.281
    PCAP1  11.951
    FUEL1 377.711
    PLEN1 393.711
    PCAP1 395.381
    LGAP1 397.501
```

The *axial* input tells the code how to place the lattices axially. The first parameter is the name of the assembly (A1), followed by a list of elevations and lattice types. For example, lattice "FUEL1" extends from 11.951 to 377.711 cm axially.

Multiple assembly types can be defined in a single [ASSEMBLY] block by using multiple *axial* inputs, each with a unique assembly ID.

All axial elevations are defined relative to the top of the lower core plate.

2.3.5 Grid Spacer Descriptions

Grid inputs are used to define unique grid spacer types. The following example defines two grid types, "END" and "MID."

```
grid END inc    3.866 1017 / loss=0.9070  ! material, height(cm), mass (g), loss coef
grid MID zirc4  3.810 875 / loss=0.9065
```

The grid types are placed axially with the *grid_axial* input:

```
grid_axial
    END  13.884
    MID  75.2
    MID 127.4
    MID 179.6
    MID 231.8
    MID 284.0
    MID 336.2
    END 388.2
```

The elevations are the midpoints of the spacer grid and are relative to the top of the lower core plate.

2.3.6 Nozzle Descriptions

The assembly nozzles are modeled in the neutronics codes as smeared materials. This approximation is very good since the nozzles are not in the active fuel region and are mostly composed of water, steel, and zirconium. The user only specifies a nozzle mass and a nozzle height. The total volume of the nozzle region is calculated from the assembly pitch and nozzle height. The volume of the nozzle is calculated from the nozzle mass and density. The volume of the coolant is then calculated as the total volume minus the volume of the nozzle. The coolant density is updated with the local T/H conditions.

```
lower_nozzle  ss 6.05  6250.0  ! mat, height (cm), mass (g)
upper_nozzle  ss 8.827 6250.0  ! mat, height (cm), mass (g)
```

Only a single material can be specified on a nozzle input. To use more than one material to define a nozzle, the user can define a custom material that is a mixture of the materials and then use the custom material in the nozzle input.

Note that the *lower_nozzle* height should match the bottom elevation on the *axial* input. The *upper_nozzle* height + the top elevation on the *axial* input must match the core *height* in the [CORE] block. The input parser does not currently perform a check to make sure the elevations are consistent. Therefore, this check should be performed in each of the individual physics codes.

2.4 CONTROL ROD ASSEMBLY DESCRIPTION

The [CONTROL] block contains the geometric description of a control assembly.

A control rod assembly is defined in a manner similar to that used to define a fuel assembly. The user specifies cells, lattices, and axial descriptions of the control rod assembly. The main difference between the control rod assembly and the fuel assembly is that the control rod assembly describes what is inside the GTs, whereas the fuel assembly defines the GTs themselves.

Control rod positions change during operation, so the geometric description of a control rod should always be for a rod in the **fully inserted** position. In the following example, the bottom of the control rod in the fully inserted position is at an axial location of 15.46 cm.

```
title "B4C control rods with AIC tips"
npin 17

cell 1  0.382 0.386 0.484 / aic he ss      ! AIC cell
cell 2  0.373 0.386 0.484 / b4c he ss      ! B4C cell

rodmap  AIC
   -
   - -
   - - -
   1 - - 1
   - - - - -
   - - - - - 1
   1 - - 1 - - -
   - - - - - - - -
   - - - - - - - - -

rodmap  B4C
   -
   - -
   - - -
   2 - - 2
   - - - - -
   - - - - - 2
   2 - - 2 - - -
   - - - - - - - -
   - - - - - - - - -

axial CR1 15.46 AIC  376.44 B4C  394.3
```

The name of the control rod "CR1" refers to the control rod type in the *crd_map* in the [CORE] block.

Control rod positions are assigned to a control rod bank with the *crd_bank* map in the [CORE] block, and then the banks are positioned with the *rodbank* input in the [STATE] block.

Note that the locations of the control rod fingers must match the GT locations in the corresponding [ASSEMBLY] block descriptions. Furthermore, the outer radii of the control rod fingers must be smaller than the inner radii of the GTs. The input parser does not currently perform a check to make sure the control rod finger descriptions are consistent with the GT descriptions. This check should be performed in each of the individual physics codes.

The user can define materials in the [CONTROL] block. These materials only have scope in this block and are not accessible by other blocks. See Chapter 4 for details.

A complete list of all the inputs in the [CONTROL] block is provided in Chapter 7.

2.4.1 Control Rod Stroke

The difference between control rod descriptions and assembly descriptions is that the control rods move during operation. This movement is defined with a *stroke* input.

The first value on the *stroke* input is the total length of the control rod travel (stroke) from fully inserted to fully withdrawn.

The second value on the *stroke* input is the number of steps in the fully withdrawn position. Step 0 is the fully inserted position. The number of steps in the fully withdrawn position is specified by the user, but 228 steps is often the number used for typical Westinghouse PWRs.

```
stroke  360.0 228      ! stroke (cm), number of steps fully withdrawn
```

To position the control rods in percent withdrawn (%), the number of steps should be set to 100, and each step will signify 1% withdrawn.

The geometry description in the input is for a control rod in the fully inserted position (step 0).

2.4.2 Control Rod Position Example

From the *axial* input shown previously, the bottom of the silver-indium-cadmium (AIC) at the fully inserted position is 15.46 cm. From the *stroke* input, the total stroke is 360.0 cm, and the number of steps in the fully withdrawn position is 228 steps. Therefore, the bottom elevation of the AIC lattice at step N will be

$$E(N) = 15.46 + \frac{360.0 \cdot N}{228} \quad . \tag{1}$$

Using this formula, the bottom elevation of the AIC lattice at the following step positions is as follows:

- Step 228 (fully withdrawn) = 15.46 + 360.0 * 228 / 228 = 375.46 cm
- Step 100 = 15.46 + 360.0 * 100 / 228 = 173.35 cm
- Step 0 (fully inserted) = 15.46 + 360.0 * 0 / 228 = 15.46 cm

The steps withdrawn can be specified as real numbers and fractions of a step.

2.5 INSERT DESCRIPTION

An assembly insert is defined in the same way as a fuel assembly or control rod assembly. The user defines the insert using cells, lattices, and axial descriptions.

The fuel assembly description should contain the GT descriptions, and the insert description defines what is inserted into the GTs. Assembly inserts can be inserted and withdrawn during a core shuffle (by specifying an *insert_map* input in the [CORE] block), but they cannot be moved during a cycle depletion.

The insert and control rod descriptions are very similar, with the only difference being that the insert cannot change position axially during a cycle depletion, and a control rod moves axially during operations.

The following example shows a definition of a Pyrex insert.

```
[INSERT]
    title "Pyrex"
    npin 17
    mat pyrx1 2.25 pyrex-vera
    cell 1  0.214 0.231 0.241 0.427 0.437 0.484 / he ss he pyrx1 he ss
    rodmap  PY24
       -
       - -
       - - -
       1 - - 1
       - - - - -
       - - - - - 1
       1 - - 1 - - -
       - - - - - - - -
       - - - - - - - - -

    axial INS24  15.76 PY24 376.441
```

The name of the insert "INS24" refers to an insert type defined in the *insert_map* in the [CORE] block.

The locations of the insert fingers must match the GT locations in the corresponding [ASSEMBLY] block descriptions. In addition, the outer radii of the insert fingers must be smaller than the inner radii of the GTs. The input parser does not currently perform a check to make sure the insert finger descriptions are consistent with the GT descriptions. This check should be performed in each physics code.

As with [ASSEMBLY] blocks, multiple insert types can be defined in a single [INSERT] block by using multiple *axial* inputs, each with a unique insert ID.

A complete list of all the inputs in the [INSERT] block is provided in Chapter 7.

2.6 DETECTOR DESCRIPTION

A detector string is defined in the same way that a fuel assembly or insert assembly is defined. The user defines cells, lattices, and axial descriptions for the detector string.

The insert and detector descriptions are very similar, with the difference being that detectors have special properties used to calculate instrumentation signals.

```
[DETECTOR]
  title "Incore instrument thimble"
  npin 17

  mat he 0.0001786
  mat ss 8.0

  cell 1  0.258 0.382 / he ss

  rodmap  LAT
     1
     - -
     - - -
     - - - -
     - - - - -
     - - - - - -
     - - - - - - -
     - - - - - - - -
     - - - - - - - - -

  axial D1  0.0 LAT 406.337
```

The name of the detector "D1" refers to a detector type defined in the *det_map* in the [CORE] block.

A complete list of all the inputs in the [DETECTOR] block is located in Chapter 7.

2.7 CHANNEL BOX

The *channel_box* and *channel_box_segments* inputs can be used to model the channel box that surrounds a BWR assembly. The *channel_box* input allows the representation of a normal box with a nominal thickness and rounded corners. When paired with the *channel_box_segments* input, a general explicit geometry of thick-thin designs can be modeled.

The inputs are shown in Figure 5.

```
channel_box  <material>  <corner_thickness>  <corner_radius>
channel_box_segments  <thickness_i>  <length_i>  <ramp_length_i>
```

Figure 5. Description of the channel box inputs.

All of the dimensional quantities are in units of centimeters. The segment length and segment ramp are deltas in length. The segment ramp should be entered as the horizontal distance and not the slope. The definitions of the inputs are illustrated in Figure 6.

The first channel box segment is entered at the halfspan of the box. Each additional segment is entered in the direction of the corner. It is assumed that the channels are symmetric about the corner and that all corners are alike. The thick corner length is internally calculated from the given channel segments.

For both the normal and thick-thin channel box designs, the wide and narrow gaps should be entered relative to the corner thickness. For the normal box, this is equivalent to the nominal channel thickness.

Sample inputs are provided in Figure 7.

A complete list of the channel box inputs is located in Chapter 7.

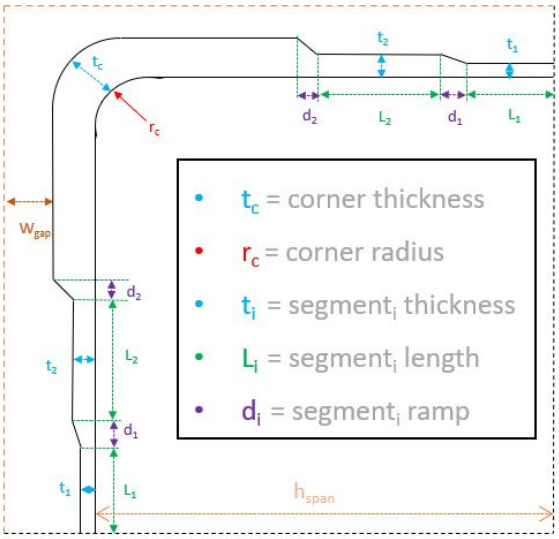

Figure 6. Demonstration of the channel box inputs.

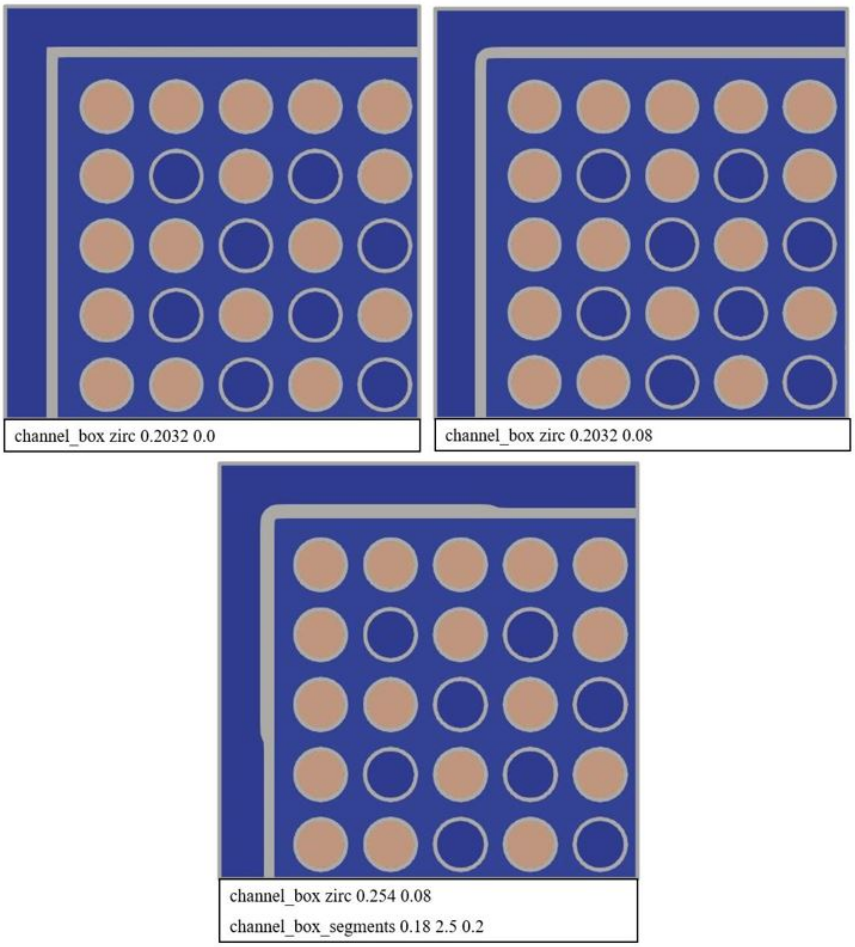

Figure 7. Sample inputs for the channel box inputs.

2.8 STATE DESCRIPTION

The [STATE] block defines the state of the core (power, flow, pressure, inlet temperature, rod positions, boron concentration, etc.) at a particular point in time. These values will typically change during a cycle depletion.

The following example shows the most common inputs in the [STATE] block. A complete listing of all the inputs in the [STATE] block is located in Chapter 7.

```
[STATE]
  power   98.0       ! % of rated power - rated values defined in [CORE] block
  flow   100.0       ! % of rated flow
  pressure 2250.0    ! psia
  tinlet 557.33 F    !
  feedback on        ! turn on \ac{th} feedback

  boron   1285       ! initial boron ppmB
  search  boron      ! turn on boron search

  sym qtr            ! run problem in qtr-symmetry

  rodbank SA 228
          SB 228
          SC 228
          SD 228
           A 228
           B 228
           C 228
           D 167
```

The *sym* input tells the code to run the calculation in full-core or quarter-core symmetry. If the calculation is run in quarter-core symmetry, then the symmetry is either set to quarter-core rotational or quarter-core mirror by the *bc_sym* input in the [CORE] block.

The *rodbank* input is used to position the control rods. The *rodbank* input includes pairs of bank names and bank positions. The bank names correspond to the *crd_map* in the [CORE] block. The positions indicate the position of the control rod bank in steps. Step 0 is fully inserted. The number of steps for a rod to be completely withdrawn is set by the *stroke* input in the [CONTROL] block (see Section 2.4.1). For Westinghouse PWRs, a typical value of fully withdrawn is 228 steps.

2.8.1 State Variable Persistence

Some inputs in the `[STATE]` block apply only to the state where the input is named, while some others will persist to the following states. Table 1 provides a list of all the state inputs and whether or not they persist. The persistence described in these tables also applies to reading from a restart file as well; the persistent state variables will be updated based on the values in the restart file, then overwritten by any values present in the input.

Table 1. List of state variables and their persistence between states

Variable	Persists?	Other Notes	Variable	Persists?	Other Notes
apitch_tec	No	First State Only	pout_dist	Yes	
axial_tec	No	First State Only	power	Yes	
axial_void	Yes		ppitch_tec	No	First State Only
b10	Yes		pred_order	No	
blade_pos	Yes		pressure	Yes	
boron	Yes		reset_sol	No	
branch	No		restart_isotope_set	No	
bypass	Yes		restart_jumpin	No	
cleanup_flow	Yes		restart_read	No	
cool_chem	Yes		restart_shuffle	No	
corr_order	No		restart_shuffle_error_checking	No	
crud	Yes		restart_write	No	
crud_cleaning	No	First State Only	rlx_xesm	Yes	
crud_removal	No		rodbank	Yes	
crud_replenish_b10	No		samar	Yes	
decay_heat	Yes		search	Yes	
deplete	No		search_bank	Yes	
edit	Yes		shuffle_homog	No	
excore_transport	Yes		shuffle_label	No	
expand3D	No	First State Only	subcool	Yes	
feedback	Yes		sym	No	First State Only
flow	Yes		temp_pert	Yes	
flow_dist	Yes		tfuel	Yes	
insert_shuffle_label	No		thexp	No	First State Only
jump_in_file	No	First State Only	thexp_info	No	First State Only
kcrit	Yes		thexp_outfile	No	First State Only
kmul_beta	Yes		thexp_tclad	No	First State Only
kmul_crw	Yes		thexp_tfuel	No	First State Only
kmul_doppler	Yes		thexp_tmod	No	First State Only
kmul_modtemp	Yes		tinlet	Yes	
modden	Yes		tinlet_dist	Yes	
natcirc	Yes		title	No	
neutron_transport	No		transient	No	First State Only
ni_p	Yes		vh2	Yes	
ni_s	Yes		void	Yes	
op_date	No		xenon	Yes	

2.9 EDITS DESCRIPTION

The [EDITS] block is used to control the output edits.

One of the edits produced by the core simulator is the rod power. The user has the ability to specify the axial levels that the power is averaged over with the *axial_edit_bounds* input. The user can choose to average power over uniform axial intervals (like most nodal codes) or to specify the edit intervals manually.

(Note: the edit options are under development, and more options will be added in the future.)

A complete listing of all the inputs in the [EDITS] block is located in Chapter 7.

2.9.1 CTF Nodalization

The *axial_edit_bounds* input is also used to set the axial nodalization when coupling the neutronics physics code to the CTF subchannel code.

When running CTF, the grid boundaries must be explicitly included in the *axial_edit_bounds*. This process can get a little complicated for the user. In the VERA input, spacer grids are defined in the [ASSEMBLY] block by specifying the grid heights on the *grid* input and the elevations of the grid midpoints on the *grid_axial* input. From the grid heights and midpoints, the elevations at the top and bottom of the spacer grid can be calculated, and then the top and bottom elevations must be included in the *axial_edit_bounds*.

For example, if a grid is defined with a centerline at 75.0 and a height of 2.5, then the *axial_edit_bounds* must include the points 75.0 ± 1.25 = 73.75 and 76.25.

```
[ASSEMBLY]
 grid GRID1 inc 1000 2.5    ! grid name, material, mass (g), and height (cm)
 grid_axial                 ! locations of grid midpoints (cm)
     GRID1 75.0

[EDITS]
 axial_edit_bounds
    ...
    73.75           ! this array must include top and bottom grid boundaries
    76.25
    ...
```

The reason for this restriction is that the power is calculated on the *axial_edit_bounds*, so it is natural to use the same power distribution to couple to the CTF model as well. The grids must be explicitly included in the CTF boundaries so that the loss coefficients are calculated correctly.

In the future, this restriction might be lifted and an additional edit bounds array might be added explicitly for CTF calculations.

2.10 COUPLING DESCRIPTION

The [COUPLING] block defines the relaxation parameters and convergence criteria to be used when coupling different physics codes. These values are used to determine convergence *between* physics codes. Convergence criteria *within* a physics code is controlled by the code-specific block.

Refer to Chapter 7 for a complete listing of all the inputs in the [COUPLING] block.

No code-specific information is included in the [COUPLING] block; all code-specific information is contained in the code-specific blocks. The [COUPLING] block is used only to define generic coupling parameters.

As an example, consider the following multiphysics code coupling:

1. Run T/H calculation
2. Run neutronics calculation
3. Check eigenvalue convergence
4. Check power convergence
5. Relax/dampen the power shape
6. If not converged, go to step 1.

The eigenvalue convergence in step 3 uses the input *epsk* to check the change in eigenvalue between coupled iterations. There are additional eigenvalue convergence criteria *within* the neutronics code, but the internal parameters are specified in the individual code blocks.

The power convergence in step 4 uses the input *epsp* to check the change in power between coupled iterations.

Additional convergence checks are made on the peak fuel temperature, maximum change in density, and change in boron concentration (if applicable).

The previous example uses a Piinput iteration to converge. Piinput iterations usually need to apply a relaxation factor (also called a damping factor or under-relaxation factor) to one or more of the calculated quantities to converge. The relaxation factors are applied in the following manner:

$$x = \omega\, x^{\text{new}} + (1 - \omega) x^{\text{old}} \quad , \tag{2}$$

where x is the calculated parameter and ω is the relaxation factor. A relaxation factor of 1.0 signifies that no relaxation is performed. A relaxation factor < 1.0 signifies under-relaxation.

Relaxation factors can be specified for the point-wise power, point-wise temperature, and/or point-wise density. The relaxation is applied to the transferred quantities sent between physics codes. The state variables within each physics code are not changed.

The following example shows a [COUPLING] input block.

```
[COUPLING]
  epsk        5.0  ! eigenvalue convergence (pcm)
  eps_temp    1.0  ! temperature convergence (deg C)
  eps_boron   0.1  ! boron convergence (ppm)
  rlx_power   0.5  ! power relaxation factor
  rlx_tfuel   1.0  ! fuel temperature relaxation factor
  rlx_den     1.0  ! density relaxation factor
  maxiter     20   ! maximum number of coupled iterations
```

A complete listing of all the inputs in the [COUPLING] block is located in Chapter 7.

3. BRANCH CASES

The [BRANCH] block can be used to define a set of branch calculations to be performed after a particular time step. Multiple [BRANCH] blocks can be used in a single input file. The blocks are called out by name in the [STATE] block, allowing each [STATE] block to have a unique set of branch calculations, if desired. The [STATE] block input *branch* <*name_1*> .. <*name_n*> will execute the [BRANCH] block inputs in the order listed. The names listed in the *branch* input are specified in the *title* input of each [BRANCH] block.

When branch calculations are enabled in a [STATE] block, the following calculation sequence occurs:

1. nominal condition/depletion time step,
2. all branch cases, and
3. return to nominal condition to obtain the solution required for the depletion.

If multiple depletion time steps are specified in a [STATE] block that also has branch calculations enabled, the branch calculations and extra nominal condition calculation are conducted for every depletion time step. If the *branch* variable is set in one [STATE] block but not the next [STATE] block, no branch calculations are performed in the second [STATE] block calculations. The user must explicitly enable the branch calculations in every [STATE] block for which they desire branch calculations.

3.1 INPUT SYNTAX

3.1.1 Title

The first input, *title*, has already been discussed. It assigns a unique name to the [BRANCH] block so it can be referenced later in the [STATE] block.

3.1.2 Branch_set

The second input is the *branch_set* input. This input takes a list of state variable names, modes, and values and uses them to generate a set of branch calculations. The following variables are allowed:

- power
- pressure
- tfuel
- flow
- modden
- rodbank
- tinlet
- bypass
- boron
- b10
- subcool
- coolden

Each variable can have any number of values listed. Every permutation of values will be used to generate a new branch calculation. The syntax is defined as follows:

```
branch_set name_1 variable_1 [special_1] mode_1 <values_1(:)>
                  variable_2 [special_2] mode_2 <values_2(:)>
                  ...
```

```
                    variable_n [special_n] mode_n <values_n(:)>
branch_set name_2 variable_1 [special_1] mode_1 <values_1(:)>
                    variable_2 [special_2] mode_2 <values_2(:)>
                    ...
                    variable_n [special_n] mode_n <values_n(:)>
```

Every permutation of the values in *name_1* will be used to create a new state point; the same will be done with every permutation of values in *name_2*. Permutations of a value in *name_1* with a value in *name_2* are not considered. This allows the user a high degree of control over how variable values are combined. Examples are shown in Section 3.3 to illustrate these permutations and special values more clearly.

The *special* inputs are additional values that are required for certain values of *variable*. These are discussed in Section 3.2.

The *mode* inputs are required and can have the value of either *abs* or *rel*. If *abs*, then the *values* inputs are treated as the actual value of *variable*; if *rel*, the *values* inputs are treated as an additive perturbation to the nominal case. This is demonstrated more thoroughly in Section 3.3.

3.1.3 State_control

The final input is the *state_control* input, which is used to modify certain state variables. An example of this would be depleting with feedback on, but disabling feedback during the branch calculations to isolate the effects of modifying other variables. The following state variables can be modified with the *state_control* input:

- xenon
- samar
- search
- reset_sol
- feedback
- crud

For all variables, the acceptable values are the same as when they appear in the [STATE] block. The state variables will be modified only for any branch calculations defined in the same [BRANCH] block as the *state_control* variable. If multiple [BRANCH] names are specified in a single [STATE] block, the *state_control* input from each block will be applied only to the permutations from that block.

3.2 SPECIAL VALUES

There are two state variables that require use of the *special* input. For both of these variables, *special* input is required, but *special* input must not be used for any other variables. The first of these is the *tinlet* input, which requires that the temperature unit be placed in the *special* location. Inputs of *branch_set name boron abs 0 100 2000* and *branch_set name tinlet K abs 500 550 600* are valid, but an input of *branch_set name tinlet abs 500 550 600* is not.

The second variable that requires use of the *special* input is *rodbank*. In this case, the *special* input must contain the name of the bank label to be moved. The input *branch_set name rodbank abs 0 230* is invalid because the code has not been told which bank to move, but the input *branch_set name rodbank A abs 0 230* is valid because the code knows to move bank *A*.

3.3 EXAMPLES

3.3.1 One Branch Block

```
[STATE]
  search boron
  tinlet 500 K
  power 100
  xenon equil
  deplete GWDMT <0..5x1.0>
  branch 1
[BRANCH]
  title 1
  branch_set 1a boron rel 200 -200
  branch_set 1b tinlet K rel 50 -50
  branch_set 1c power abs 0 118
  state_control feedback off search keff
```

Table 2 shows the sequence of state calculations that will occur at each depletion time step D for $D \in [0, 1, 2, 3, 4, 5]$. For the final depletion step, the last nominal calculation will be skipped since there is no need to prepare for an additional depletion step. This leads to a total of 59 state points for this example.

Table 2. Resulting states for simple branch block example; *D* denotes depletion time step index

State Index	Boron	Tinlet	Power	Feedback	Search	Xenon
1+D*10	critical	500 K	100	on	boron	equil
2+D*10	critical + 200	550 K	0	off	keff	equil
3+D*10	critical - 200	550 K	0	off	keff	equil
4+D*10	critical + 200	450 K	0	off	keff	equil
5+D*10	critical - 200	450 K	0	off	keff	equil
6+D*10	critical + 200	550 K	118	off	keff	equil
7+D*10	critical - 200	550 K	118	off	keff	equil
8+D*10	critical + 200	450 K	118	off	keff	equil
9+D*10	critical - 200	450 K	118	off	keff	equil
10+D*10	critical	500 K	100	on	boron	equil

3.3.2 Rod Positions

```
[STATE]
  feedback on
  search boron
  xenon equil
  rodbank A  226
          B  226
          C  226
          D  226
          SA 226
          SB 226
          SC 226
          SC 226
```

```
  deplete GWDMT <0..5x1.0>
  branch 2
[BRANCH]
  title 2
  branch_set 2a rodbank  A abs 0 230
  branch_set 2b rodbank  D abs 0 230
  branch_set 2c rodbank  A abs 230
                rodbank  B abs 230
                rodbank  C abs 230
                rodbank  D abs 230
                rodbank SA abs 230
                rodbank SB abs 230
                rodbank SC abs 230
                rodbank SD abs 230
  branch_set 2d rodbank  A abs   0
                rodbank  B abs   0
                rodbank  C abs   0
                rodbank  D abs   0
                rodbank SA abs 230
                rodbank SB abs 230
                rodbank SC abs 230
                rodbank SD abs 230
  branch_set 2e rodbank  A abs 230
                rodbank  B abs 230
                rodbank  C abs 230
                rodbank  D abs 230
                rodbank SA abs   0
                rodbank SB abs   0
                rodbank SC abs   0
                rodbank SD abs   0
  branch_set 2f rodbank  A abs   0
                rodbank  B abs   0
                rodbank  C abs   0
                rodbank  D abs   0
                rodbank SA abs   0
                rodbank SB abs   0
                rodbank SC abs   0
                rodbank SD abs   0
  state_control feedback off search off xenon dep
```

Table 3 shows the sequence of state calculations that will occur at each depletion time step D for $D \in [0, 1, 2, 3, 4, 5]$. For the final depletion step, the last nominal calculation will be skipped since there is no need to prepare for an additional depletion step. This leads to a total of 59 state points for this example.

Table 3. Resulting states for control rod branch block example; *D* denotes depletion time step index

State Index	Rodbank, Alphabetically	Feedback	Search	Xenon
1+D*10	226, 226, 226, 226, 226, 226, 226, 226	on	boron	equil
2+D*10	0, 226, 226, 226, 226, 226, 226, 226	off	keff	dep
3+D*10	230, 226, 226, 226, 226, 226, 226, 226	off	keff	dep
4+D*10	226, 226, 226, 0, 226, 226, 226, 226	off	keff	dep
5+D*10	226, 226, 226, 230, 226, 226, 226, 226	off	keff	dep
6+D*10	230, 230, 230, 230, 230, 230, 230, 230	off	keff	dep
7+D*10	0, 0, 0, 0, 230, 230, 230, 230	off	keff	dep
8+D*10	230, 230, 230, 230, 0, 0, 0, 0	off	keff	dep
9+D*10	0, 0, 0, 0, 0, 0, 0, 0	off	keff	dep
10+D*10	226, 226, 226, 226, 226, 226, 226, 226	on	boron	equil

3.3.3 Complicated

This example combines the previous two to show the interactions between two [BRANCH] blocks.

```
[STATE]
  search boron
  tinlet 500 K
  power 100
  deplete GWDMT <0..5x1.0>
  branch TH
  branch rods
[BRANCH]
  title TH
  branch_set 1a boron rel 200 -200
  branch_set 1b tinlet K rel 50 -50
  branch_set 1c power abs 0 118
  state_control feedback off search keff
[BRANCH]
  title rods
  branch_set 2a rodbank  A abs 0 230
  branch_set 2b rodbank  D abs 0 230
  branch_set 2c rodbank  A abs 230
                rodbank  B abs 230
                rodbank  C abs 230
                rodbank  D abs 230
                rodbank SA abs 230
                rodbank SB abs 230
                rodbank SC abs 230
                rodbank SD abs 230
  branch_set 2d rodbank  A abs   0
                rodbank  B abs   0
                rodbank  C abs   0
                rodbank  D abs   0
```

```
                rodbank SA abs 230
                rodbank SB abs 230
                rodbank SC abs 230
                rodbank SD abs 230
branch_set 2e   rodbank  A abs 230
                rodbank  B abs 230
                rodbank  C abs 230
                rodbank  D abs 230
                rodbank SA abs   0
                rodbank SB abs   0
                rodbank SC abs   0
                rodbank SD abs   0
branch_set 2f   rodbank  A abs   0
                rodbank  B abs   0
                rodbank  C abs   0
                rodbank  D abs   0
                rodbank SA abs   0
                rodbank SB abs   0
                rodbank SC abs   0
                rodbank SD abs   0
```

Table 4 shows the sequence of state calculations that will occur at each depletion time step D for $D \in [0, 1, 2, 3, 4, 5]$. It also shows the impact of different *state_control* inputs for multiple [BRANCH] blocks. For the final depletion step, the last nominal calculation will be skipped since there is no need to prepare for an additional depletion step. This leads to a total of 107 state points for this example.

Table 4. Resulting states for control branch block example; *D* denotes depletion time step index

State Index	Boron	Tinlet	Power	Rodbank, Alphabetically	feedback	Search	Xenon
1+D*18	critical	500 K	100	226, 226, 226, 226, 226, 226, 226, 226	on	boron	equil
2+D*18	critical +200	550 K	0	226, 226, 226, 226, 226, 226, 226, 226	off	keff	equil
3+D*18	critical -200	550 K	0	226, 226, 226, 226, 226, 226, 226, 226	off	keff	equil
4+D*18	critical +200	450 K	0	226, 226, 226, 226, 226, 226, 226, 226	off	keff	equil
5+D*18	critical -200	450 K	0	226, 226, 226, 226, 226, 226, 226, 226	off	keff	equil
6+D*18	critical +200	550 K	118	226, 226, 226, 226, 226, 226, 226, 226	off	keff	equil
7+D*18	critical -200	550 K	118	226, 226, 226, 226, 226, 226, 226, 226	off	keff	equil
8+D*18	critical +200	450 K	118	226, 226, 226, 226, 226, 226, 226, 226	off	keff	equil
9+D*18	critical -200	450 K	118	226, 226, 226, 226, 226, 226, 226, 226	off	keff	equil
10+D*18	critical	500 K	100	0, 226, 226, 226, 226, 226, 226, 226	off	keff	dep
11+D*18	critical	500 K	100	230, 226, 226, 226, 226, 226, 226, 226	off	keff	dep
12+D*18	critical	500 K	100	226, 226, 226, 0, 226, 226, 226, 226	off	keff	dep
13+D*18	critical	500 K	100	226, 226, 226, 230, 226, 226, 226, 226	off	keff	dep
14+D*18	critical	500 K	100	230, 230, 230, 230, 230, 230, 230, 230	off	keff	dep
15+D*18	critical	500 K	100	0, 0, 0, 0, 230, 230, 230, 230	off	keff	dep
16+D*18	critical	500 K	100	230, 230, 230, 230, 0, 0, 0, 0	off	keff	dep
17+D*18	critical	500 K	100	0, 0, 0, 0, 0, 0, 0, 0	off	keff	dep
18+D*18	critical	500 K	100	226, 226, 226, 226 226, 226, 226, 226,	on	boron	equil

4. MATERIALS

This chapter contains a description of the material input. There are two types of materials in the input file: structural materials (input with a *mat* input) and fuel materials (input with a *fuel* input).

Structural materials can be defined in either the [CORE] block or in the geometry object blocks [ASSEMBLY], [INSERT], [CONTROL], and [DETECTOR]. If the materials are defined in the [CORE] block, they have global scope. If the materials are defined in the geometry object blocks, then they have scope only in the block in which they are defined. This maintains the modularity of the geometry objects.

Fuel materials can be defined only in [ASSEMBLY] blocks.

Materials are used in many different inputs. They are used to define cells, nozzles, core plates, baffles, grids, reflectors, etc. Every material used in the input must be defined with either a *mat* input or a *fuel* input (see the notes on the material "mod" in Section 4.1).

4.1 STRUCTURAL MATERIALS

Structural materials are not fuel and do not deplete. Structural materials are defined with the following input:

mat *user-mat density* (*library-name*$_i$, *frac*$_i$, i=1, I),

where

- *user-mat* is a user-defined material name. The name is case sensitive. *user-mat* is used to define material names in other inputs such as *cell*, *grid*, *nozzle*, etc. (No default).
- *density* is the material density in grams per cubic centimeter (g/cc). Setting *density* to 0.0 will cause *frac* to be treated as number densities instead of fractions. (No default).
- *library-name* is a corresponding library name(s) for the user material. The library name must be defined in the cross-section library. (Default = *user-mat*). Multiple library materials can be mixed to form a single user material.
- *frac* is the fraction of the library material in the user material. If values are positive, they will be treated as weight fractions; if they are negative, they will be treated as atom fractions. (Default = 1.0 if there is only one library material in the user material).

There are three special user materials: "mod," "cool," and "vacuum." The user can use these materials in cell definitions, but the code will automatically determine the composition of these materials based on T/H feedback and soluble boron concentrations. The user is not allowed to define a user material named "mod," "cool," or "vacuum" on a *mat* input. The "mod" material will automatically be defined as borated water, with the boron concentration coming from either the `boron` input of the `[STATE]` block or from the results of a critical boron search. The "cool" material will be defined as water without boron; this input is used only for BWR models. It is crucial that the "cool" input be used anywhere that T/H feedback should be applied (e.g., inside the channel box); "mod" should be used when specifying materials for the bypass regions or outside the active core region (such as between the fuel assemblies and the shroud).

The following show some example material inputs.

```
mat zirc4 6.56                  ! library-name defaults to user-name
mat zirx  6.56 zirc4 1.0        ! user-name does not equal to library-name
mat B10   12.0 boron 1.0
```

```
mat XYZ   6.0  zirc4 0.8 ss 0.2  ! define new mixture of 80% zirc4 and 20% ss
mat ABCD  8.0  zirc4 0.8 ss 0.15 b4c 0.05
mat waba  3.65 b-10  1.36210E-02 ! creates material from isotopes in the XS-library
               b-11  6.02818E-02
               c-00  2.05259E-02
               o-16  4.26297E-01
               al-27 4.79274E-01
```

All of the material fractions must sum to either +1.0 or -1.0. If positive fractions are used, then the fractions refer to weight fractions. If negative fractions are used, then the fractions refer to atomic fractions.

4.1.1 Search Order

Structural materials can be defined in either the [CORE] block or one of the geometry object blocks. When a material is referred to in a block, it will look for the material definition in the following order:

1. The code will first look for the material name in the local block ([ASSEMBLY], [INSERT], [CONTROL], or [DETECTOR]).
2. If the material is not found in the local block, then it will look in the [CORE] block.

If materials are defined in the [CORE] block, then they have global scope over the entire input; if materials are defined in other blocks, they have scope only over the local block. This means that two geometry object blocks can use different material definitions with the same name. One example of this is that two assemblies can be defined with the material "zirc," but "zirc" can have different compositions in each of the assemblies.

4.2 DEFAULT MATERIALS

There are many default files available to users. The default materials and their compositions are defined on the initialization file CORE.ini. A list of default materials is given in Table 5.

4.3 FUEL MATERIALS

Fuel materials are defined with *fuel* inputs. Fuel materials are heavy metal oxides, usually UO_2 with different ^{235}U enrichments. Fuel materials might also include mixed oxide (MOX) fuel, which consists of mixtures of uranium, plutonium, and other actinides. Fuel materials might also contain integral burnable absorbers, such as gadolinia. Fuel materials are different from structural materials in that they deplete and have additional properties, as described subsequently.

Fuel can be defined only in [ASSEMBLY] blocks, and fuel materials can be referenced only by *cell* inputs in the [ASSEMBLY] block in which they are defined.

Fuel materials are defined with the following input:

fuel *user-mat density thden* / *U-235_enrichment* {$HM\_material_i$=$HM\_enrichment_i$, i=1, N}
{ / *gad_material=gad_fraction* },

where

- *user-mat* is a user-defined fuel name. It is case sensitive (no default).
- *density* is the fuel material density in g/cc (no default). The density is used to calculate number densities.

Table 5. Default Material List

Material	Density (g/cc)	Notes
air	1.189E-03	
aic	10.2	silver-indium-cadmium
al2o3	3.96	
b2o3	2.55	
b4c	1.7597	boron carbide
boron	2.37	
cs	7.85	carbon steel
gad	7.407	
gap	0.17860E-03	
he	0.17860E-03	
inc	8.19	inconel
pyrex	2.34249	
pyrex-vera	2.24419	
sio2	2.18	
ss	8.0	stainless steel
tungsten	19.3	
water	0.743	
waba	3.65	
zirc2	6.56	Zircaloy-2
zirc4	6.56	Zircaloy-4
clad	6.56	
zirc4-xhf	6.55934	Zircaloy-4 with no Hf
zr	6.506	natural zirconium

- *thden* is the percentage of theoretical density in the pellet (%) (no default). The theoretical density is used only to look up material properties in the fuel performance; it is not used to calculate number densities. There is no "double counting" between *density* and *thden*.
- *Uranium-235_enrichment* is the ^{235}U enrichment in the fuel in weight % (no default).
  - If ^{234}U and ^{236}U are not specified, then they will automatically be added to the fuel by a predetermined function (see the following).
  - If the sum of the heavy metal (HM) enrichments does not equal 100%, then the remainder of the HM composition will be assigned to ^{238}U.
- $HM\_material_i$ is the material name for HM isotope i (^{239}Pu, ^{241}Pu, etc.) (optional). The names of the HM materials must be valid library names.
- $HM\_enrichment_i$ is the enrichment of HM isotope i in weight % (optional).
- *gad_material* is the material name for gadolinia or other integral burnable absorber material (optional). The gad material is usually a mixture defined on a separate *mat* input.
- *gad_fraction* is the weight percentage of the gad material relative to the total fuel mass (optional).

Oxygen should not be included on the *fuel* input. The correct amount of oxygen will automatically be added to the HM to create an oxide (either UO_2 or $(HM)O_2$).

The *density* is the "stack density" or "smeared density" and should include the volume of the pellet dishing and chamfers. It is calculated as the total mass of the fuel pellets divided by the total volume of the fuel

$$\text{stack density} = \frac{\text{(fuel mass)}}{\pi(\text{pellet radius})^2\,\text{(fuel height)}} \quad . \tag{3}$$

The *thden* refers to the actual theoretical density of the pellet. This quantity can be used in fuel performance codes to evaluate material properties.

If ^{234}U or ^{236}U enrichments are not included in the fuel definition, then they are automatically added to the fuel with the following formulas:

$$W_{234} = 0.0089 \cdot W_{235} \tag{4}$$

$$W_{236} = 0.0046 \cdot W_{235} \ , \tag{5}$$

where W_{23x} is the enrichment of each of the uranium isotopes in percent.[2]

If the user specifically does NOT want ^{234}U or ^{236}U, then a ^{234}U and/or ^{236}U enrichment of zero should be specified.

The following examples are of typical *fuel* inputs. The user only has to specify the ^{235}U enrichment, and the code will automatically add ^{234}U, ^{236}U, ^{238}U, and oxygen to the fuel.

```
fuel U21 10.4 95.2 / 2.1        ! 2.1% enriched UO2 fuel, no gad
fuel UO2-35 10.297 95.0 / 3.5   ! 3.5% enriched UO2 fuel, no gad
fuel U23    10.111 / 2.3        ! fuel with default thden
```

An example of a *fuel* input with gadolinia burnable poison is shown next. In this example, the gadolinia oxide is first defined with a *mat* input and is mixed with the fuel as 5% gad oxide and 95% UO_2 (weight percents).

```
mat gad5 7.407 gd2o3 1.0                ! define gad material separately
fuel U49 10.111 94.5 / 1.8  / gad5=5.0  ! 1.8% enriched fuel with 5% gad
```

Some examples of MOX fuel inputs are shown next. In these inputs, the user specifies the ^{235}U enrichment (the ^{235}U enrichment is usually small in MOX fuel) and the plutonium isotope enrichments. The code will automatically add ^{234}U, ^{236}U, ^{238}U, and oxygen.

```
fuel MOX1 10.11 94.5 / 0.16174 u-234 0 u-236 0 pu-238 0.40232 pu-239 10.42187
                pu-240 4.78046 pu-241 1.77834 pu-242 1.22383 am-241 0.51632
```

Only oxide fuel can be defined on the *fuel* input. Metallic fuel is not supported.

[2] Earlier versions of the code used a different formula for the default ^{234}U concentration.

5. DEPLETION

This chapter describes depletion and working with restart files.

Depletion and restart files are available only with MPACT.

5.1 DEPLETION

Depletion refers to taking a step in time and calculating the change in number densities (isotopics) in the core.

A problem is depleted by including a *deplete* input in the [STATE] block, as in the following example:

```
[STATE]
  deplete EFPD 0.0 1.0 10.0 30.0
```

The first parameter on the input is the units used in the depletion and can be "EFPD" for effective full power day (EFPD), "GWDMT" for gigawatt-days per metric ton heavy metal (GWd/MT), or "hours." Following the unit is a list of depletion steps to take. Each depletion step is referred to as a "state point" calculation. The first depletion step must always be zero.

Listing multiple depletion steps on a single *deplete* input will deplete with all of the other values in the [STATE] block held constant. To change a state parameter between depletion steps (power, flow, etc.), the user can split the depletion over multiple [STATE] blocks. In the following example, the code depletes three state points at 50% power, changes the power to 100%, and depletes for four more state points. The depletion step at 10 EFPDs is run at both 50% and 100% power.

```
[STATE]
  power 50.0
  deplete EFPD 0.0 1.0 10.0
[STATE]
  power 100.0
  deplete EFPD 10.0 30.0 60.0 90.0
```

The automatic list generation feature described in Section 2.1 is especially useful when defining depletion cases. An example of a *deplete* input with automatic list generation is as follows:

```
deplete EFPD 0 1 5 <10..200x10>
```

Note that some materials, such as gad fuel, might require more refined time steps to obtain accurate solutions.

5.2 WRITING RESTART FILES

A user will often want to run a depletion and save the isotopic data to a file that can be used to restart a calculation at a later time. This feature is useful if a calculation is long-running and needs to be divided into multiple cases. At other times, a user might want to save certain state points to go back and run perturbation or flux map calculations at the saved points.

The restart file includes **only** isotopic data needed to restart a calculation and data from the [STATE] block that the file was saved. The restart file does not include the geometry description, so a regular input deck must also be used. A user should set up an input deck for a fresh core and then use the restart file to overwrite the fresh isotopic concentrations with the isotopic concentrations on the restart file.

A restart file can be written at any state point by using a *restart_write* input,

```
restart_write filename restart_label
```

where "filename" is the name of the restart file, and "restart_label" is an arbitrary user label used to differentiate multiple state points written to the same file. Examples of restart labels include "100EFPD," "HZP," "22.56," "100EFPD_ARO," etc. A restart file can include multiple state points, as long as each one uses a different restart label.

If a *restart_label* input is used with a *deplete* input, then the restart file is written at the last exposure step of the depletion.

In the following example, a depletion is performed, and restart files are written at multiple state points.

```
[STATE]
  deplete EFPD 0.0
  restart_write  restart_cyc12.h5 "BOC"
[STATE]
  deplete EFPD 20 40 80 100
 ! restart file is written at last exposure step on deplete input
  restart_write  restart_cyc12.h5 "100EFPD"
[STATE]
  deplete EFPD 150 200
  restart_write  restart_cyc12.h5 "200EFPD"
[STATE]
  deplete EFPD 250 300
  restart_write  restart_cyc12.h5 "300EFPD"
[STATE]
  deplete EFPD 350 400
  restart_write  restart_cyc12.h5 "400EFPD"
[STATE]
  op_date 1994/05/23       ! include shutdown date for EOC
  power 80.0
  deplete EFPD 423.4
  restart_write  restart_cyc12.h5 "EFPD423_EOC"
```

Another application of restart files is to write the final isotopic information at the end of cycle (EOC) so the data can be shuffled to a new cycle. (Core shuffles are discussed in a later section.) If writing a restart file at the EOC, the shutdown date should be included using the *op_date* input. The reason for including the shutdown date is so that the code will be able to calculate the isotopic decay during the outage. An example of the *op_date* input is shown in the last [STATE] block in the preceding example.

5.3 READING RESTART FILES

A restart file can be read by including a *restart_read* input in the [STATE] block

```
restart_read filename restart_label~~,
```

where "restart_label" is the label that was used to write the restart file. The *restart_read* input is used to restart an existing calculation; it is not used to do core shuffles.

In the following example, one of the restart files from the previous example is read, and a new calculation is performed with a different power and boron concentration.

```
[STATE]
  power 50.0
  boron 800
  restart_read restart_cyc12.h5 "200EFPD"
```

It is possible to write a state point in quarter symmetry and then read the restart back in full symmetry, or *vice versa*.

A current restriction states that a user should not include a *deplete* input in any [STATE] block where a restart is read. Instead, the user should divide the restart read and depletion into separate blocks, as shown here:

```
[STATE]
  restart_read restart_cycx.h5 "EFPD30"  ! read restart at 30 EFPD
[STATE]
  deplete EFPD 60 90
```

5.4 CORE SHUFFLING

A core shuffle occurs when fuel assemblies are rearranged in a core and/or new fuel is added to the core. Fuel assemblies discharged in previous cycles can be brought in from the fuel pool. Even fuel discharged from other units can be added (cross-unit shuffle).

When performing a core shuffle, the user must specify the location from which existing fuel assemblies were moved and what the new fuel assemblies look like.

When fuel isotopics are written to a restart file, the assembly locations are saved based on the *xlabel* and *ylabel* labels. The *xlabel*s start on the left side of the map and run horizontally. The *ylabel*s start at the top of the map and run down. For example, with the following labels defined

```
[CORE]
  xlabel   R  P  N  M  L  K  J  H  G  F  E  D  C  B  A
  ylabel  01 02 03 04 05 06 07 08 09 10 11 12 13 14 15
```

the assembly locations are defined as "xlabel dash ylabel":

```
                    L-01 K-01 J-01 H-01 G-01 F-01 E-01
          N-02 M-02 L-02 K-02 J-02 H-02 G-02 F-02 E-02 D-02 C-02
     P-03 N-03 M-03 L-03 K-03 J-03 H-03 G-03 F-03 E-03 D-03 C-03 B-03
     P-04 N-04 M-04 L-04 K-04 J-04 H-04 G-04 F-04 E-04 D-04 C-04 B-04
R-05 P-05 N-05 M-05 L-05 K-05 J-05 H-05 G-05 F-05 E-05 D-05 C-05 B-05 A-05
R-06 P-06 N-06 M-06 L-06 K-06 J-06 H-06 G-06 F-06 E-06 D-06 C-06 B-06 A-06
R-07 P-07 N-07 M-07 L-07 K-07 J-07 H-07 G-07 F-07 E-07 D-07 C-07 B-07 A-07
R-08 P-08 N-08 M-08 L-08 K-08 J-08 H-08 G-08 F-08 E-08 D-08 C-08 B-08 A-08
R-09 P-09 N-09 M-09 L-09 K-09 J-09 H-09 G-09 F-09 E-09 D-09 C-09 B-09 A-09
```

```
R-10 P-10 N-10 M-10 L-10 K-10 J-10 H-10 G-10 F-10 E-10 D-10 C-10 B-10 A-10
R-11 P-11 N-11 M-11 L-11 K-11 J-11 H-11 G-11 F-11 E-11 D-11 C-11 B-11 A-11
     P-12 N-12 M-12 L-12 K-12 J-12 H-12 G-12 F-12 E-12 D-12 C-12 B-12
     P-13 N-13 M-13 L-13 K-13 J-13 H-13 G-13 F-13 E-13 D-13 C-13 B-13
          N-14 M-14 L-14 K-14 J-14 H-14 G-14 F-14 E-14 D-14 C-14
                    L-15 K-15 J-15 H-15 G-15 F-15 E-15
```

The restart file also includes the cycle number (which is stored as a label), so the combination of the cycle number and location can be used to uniquely define any assembly location in any cycle. For example, "3K-12" refers to location "K-12" of cycle "3." If no cycle number is specified, then the cycle label defaults to the previous cycle number (i.e., cycle N-1) if the cycle label is an integer; for this reason, it is recommended to use integers for the cycle labels. If the cycle label is not an integer, then no default can be calculated and the code will print an error before exiting.

New fresh assemblies are defined by using a plus sign followed by an optional string. (The string is not currently used for anything, but it could be used in the future to refer to the fresh fuel assembly type.) For example, "+ASMA" signifies a fresh fuel assembly.

Using these naming conventions, a new core loading pattern can be defined using a *shuffle_label* map. The *shuffle_label* map is a core map showing the previous assembly locations and new assembly fuel types. Assembly inserts can also be independently shuffled in a similar fashion using a separate *insert_shuffle_label* map.

The following example is the full-core loading pattern for cycle 2 of the Benchmark for Evaluation and Validation of Reactor Simulations benchmark. The cycle numbers are not used in the location labels because all of the assemblies were moved from the previous cycle (cycle 1), and the default behavior is to use the previous cycle number if no cycle label is specified.

```
[CORE]
  cycle 2
  op_date 1996/03/02     ! cycle startup date
[STATE]
  shuffle_label
                      L-10 +X34 +X32 +X34 +X32 +X34 E-10
           G-10 +X32 +X32 L-02 P-12 N-03 B-12 E-02 +X32 +X32 J-10
      F-09 +X34 N-02 N-10 +X32 D-11 R-10 M-11 +X32 C-10 C-02 +X34 K-09
      +X32 P-03 L-08 +X32 M-09 E-15 G-08 L-15 D-09 +X32 H-05 B-03 +X32
 F-05 +X32 F-03 +X32 M-04 +X32 M-03 A-10 D-03 +X32 D-04 +X32 K-03 +X32 K-05
 +X34 P-05 +X32 G-04 +X32 N-08 R-09 G-14 A-09 H-03 +X32 J-04 +X32 B-05 +X34
 +X32 D-02 E-12 A-11 N-04 G-01 B-09 H-15 J-14 J-01 C-04 R-11 L-12 M-02 +X32
 +X34 N-13 F-15 H-07 F-01 B-07 A-08 F-14 R-08 P-09 K-15 H-09 K-01 C-03 +X34
 +X32 D-14 E-04 A-05 N-12 G-15 G-02 H-01 P-07 J-15 C-12 R-05 L-04 M-14 +X32
 +X34 P-11 +X32 G-12 +X32 H-13 R-07 J-02 A-07 C-08 +X32 J-12 +X32 B-11 +X34
 F-11 +X32 F-13 +X32 M-12 +X32 M-13 R-06 D-13 +X32 D-12 +X32 K-13 +X32 K-11
      +X32 P-13 H-11 +X32 M-07 E-01 J-08 L-01 D-07 +X32 E-08 B-13 +X32
      F-07 +X34 N-14 N-06 +X32 D-05 A-06 M-05 +X32 C-06 C-14 +X34 K-07
           G-06 +X32 +X32 L-14 P-04 C-13 B-04 E-14 +X32 +X32 J-06
                      L-06 +X34 +X32 +X34 +X32 +X34 E-06
```

The next example shows a quarter-core shuffle map. This map is not realistic, but it shows how fresh assemblies are inserted, along with assemblies from cycles 8, 19, 20, and 21. The fresh assemblies all have fuel type "A12."

```
[CORE]
  cycle 22               ! new cycle number
  op_date 2012/10/02     ! cycle startup date
[STATE]
  shuffle_label
     8H-10  +A12  21E-03  +A12  21E-13 21G-02 21G-08 21N-04
     +A12  21O-08 20C-04 19L-07  +A12  21E-06  +A12  21K-03
    21C-11 20D-03 21E-08  +A12  21M-04  +A12  21K-04 21A-07
     +A12  19G-10  +A12  21P-08  +A12  21O-06 21B-06
    21O-11  +A12  21D-11  +A12  21B-07  +A12  21G-11
    21B-09 21F-05  +A12  21F-13  +A12  21L-06
    21H-09  +A12  21D-09 21F-02 21M-07
    21D-04 21C-09 21G-01
```

The *shuffle_label* must cover the entire model. For full symmetry calculations, the map must be entered in full symemtry; for quarter symmetry calculations, the map must be entered in quarter or full symmetry. The code will not unfold the map like it does for other inputs such as *assm_map*. Octant symmetry is never allowed for *shuffle_label*. These rules also apply ti *insert_shuffle_label*.

A current restriction also requires the user to include an *assm_map* input in the input to specify the fresh fuel assemblies. This restriction will be removed in the future so that the fresh assembly types specified after the plus sign on the *shuffle_label* input will be used.

In addition to the loading patterns, a list of restart files must be included to define the restart search path. The order of the restart files is important: they must be in reverse chronological order.

```
restart_shuffle
  restart_file_12.h5 EOC12
  restart_file_11.h5 EOC11
  restart_file_10.h5 EOC10
  restart_file_5.h5  EOC5
```

The first restart file is used to define the "previous" cycle number. The cycle number from this file will be used as the default cycle number in the shuffle map. The code will search for the assembly on the first file. If the assembly is not found, then the code will go to the second restart file, and so on.

The next section gives an example of a core shuffle.

5.4.1 Core Shuffle Example

Consider an example of a core shuffle occuring at the beginning of cycle 3. There are two EOC restart files that have been written from cycles 1 and 2.

These examples are not complete; they show only the pertinent inputs needed to perform the core shuffle.

The EOC 1 restart file was generated with the following input:

```
[CORE]
  cycle 1    ! could be any arbitrary string like CYC1, etc.
  xlabel   R  P  N  M  L  K  J  H  G  F  E  D  C  B  A
  ylabel  01 02 03 04 05 06 07 08 09 10 11 12 13 14 15
[STATE]
```

```
  deplete EFPD ... 327.3   ! only last depletion date shown
  op_date "1993/03/01"     ! shutdown date
  restart_write restart_cyc1.h5 "EOC1"
[ASSEMBLY]
  ! this input includes a definition of assembly type ASMA
```

The EOC 2 restart file was generated with the following input:

```
[CORE]
  cycle 2
  xlabel   R  P  N  M  L  K  J  H  G  F  E  D  C  B  A
  ylabel  01 02 03 04 05 06 07 08 09 10 11 12 13 14 15
[STATE]
  deplete EFPD ... 426.3
  op_date "1994/03/05"    ! shutdown date cycle 2
  restart_write restart_cyc2.h5 "EOC_with_coastdown"
[ASSEMBLY]
 ! this input includes a definition of assembly type ASMB
 ! and ASMA from cycle 1
```

The following input is used to shuffle to cycle 3:

```
[CORE]
  cycle 3
  op_date "1994/04/07"    ! start-up date of cycle 3
  xlabel   R  P  N  M  L  K  J  H  G  F  E  D  C  B  A
  ylabel  01 02 03 04 05 06 07 08 09 10 11 12 13 14 15

[STATE]
  shuffle_label
   1H-10 +ASMC  E-03 +ASMC  E-13  G-02  G-08  N-04
   +ASMC  O-08  C-04  L-07 +ASMC  E-06 +ASMC  K-03
    C-11  D-03  E-08 +ASMC  M-04 +ASMC  K-04  A-07
   +ASMC  G-10 +ASMC  P-08 +ASMC  O-06  B-06
    O-11 +ASMC  D-11 +ASMC  B-07 +ASMC  G-11
    B-09  F-05 +ASMC  F-13 +ASMC  L-06
    H-09 +ASMC  D-09  F-02  M-07
    D-04  C-09  G-01

 ! One assembly was loaded from cycle 1 (in the center)
 ! This assembly had to have the cycle number prepended to it

 ! All of the other assemblies came from cycle 2.  This is the default cycle,
 ! and the cycle number did not have to be prepended.

 ! restart using the EOC restart files from cycles 1 and 2
  restart_shuffle
     restart_cyc2.h5 EOC_with_coastdown
     restart_cyc1.h5 EOC1

[ASSEMBLY]
 ! include descriptions for ASMA, ASMB, ASMC if they are
```

```
! all used in cycle 3
```

5.4.2 Shutdown Decay

When performing a core shuffle, a shutdown decay is performed on each assembly to account for the shutdown decay time. The shutdown decay calculation is important for calculating the decay and buildup of fission products such as xenon and samarium.

The shutdown decay time is calculated using the shutdown date from when the assembly was discharged and the new cycle startup date. The discharge date is the *op_date* on the restart file to which the assembly data was written. The cycle startup date is the *op_date* in the core shuffle deck.

5.4.3 Cross Unit Shuffle

The shuffling methodology can support cross-unit shuffles.

To use cross-unit shuffling, the unit number must be specified in the [CORE] block.

```
unit 1    ! unit 1 of a 2 unit site
```

To read an assembly from a different unit, the unit label is prepended to the front of the location label in the *shuffle_label* input using a colon. For example, "U2:C3G-04" is used to read the assembly from Unit "U2," cycle "C3," and location "G-04."

Once the location labels have been defined, the user can mix and match restart files from different units in the *restart_shuffle* input:

```
restart_shuffle
  restart_file_U1_12.h5 EOC12
  restart_file_U2_5.h5  EOC
  restart_file_U1_11.h5 EOC11
  restart_file_U2_4.h5  EOC
  restart_file_U1_10.h5 EOC10
  restart_file_U2_3.h5  EOC
  restart_file_U1_5.h5  EOC5
```

The only "trick" is to list the restart points in the correct reverse chronological order since an assembly could theoretically go from U2:CYC3 to U1:CYC10 and then back to U2:CYC6. Therefore, the restarts must be in the correct reverse chronological order. Remember that the cycle numbers are arbitrary strings, so there is no natural "order" to them. The order is defined by the order specified in the *restart_shuffle* input.

The shutdown dates are written to each restart file so that the shutdown decay will be correctly calculated for each assembly. It does not matter what unit the assembly came from—the correct shutdown dates will be used.

5.5 JUMPIN-IN CALCULATIONS

Another option for core loading is a jump-in calculation, using the *restart_jumpin* input. This type of calculation manually loads assemblies from restart files one location at a time. Each assembly can come from its own restart file, or several assemblies can come from a single restart file. This capability is useful for modeling reactors that are many cycles past their first; it allows the user to skip many of the early cycles

by running individual assembly calculations to the proper burnup and then loading all the restart files into a core to begin a new cycle in the middle of the reactor's life.

A shuffle calculation can also be executed using *restart_jumpin* instead of *restart_shuffle* since *restart_jumpin* is effectively a more flexible, verbose form of *restart_shuffle*. As an example, the cycle 3 shuffle example from Section 5.4.1 is repeated subsequently using the *restart_jumpin* input. This input would produce identical results to the first version. If a true jump-in calculation were performed, there would be many more unique *.h5* files in the list and the source locations would be *A-01* for many or all of the source assemblies, but this example is sufficient to illustrate the use of the input.

```
[CORE]
  cycle 3
  op_date "1994/04/07"    ! start-up date of cycle 3
  xlabel   R  P  N  M  L  K  J  H  G  F  E  D  C  B  A
  ylabel  01 02 03 04 05 06 07 08 09 10 11 12 13 14 15

[STATE]
  restart_jumpin H-08 restart_cyc1.h5 EOC1               H-10
                 F-08 restart_cyc2.h5 EOC_with_coastdown E-03
                 D-08 restart_cyc2.h5 EOC_with_coastdown E-13
                 C-08 restart_cyc2.h5 EOC_with_coastdown G-02
                 B-08 restart_cyc2.h5 EOC_with_coastdown G-08
                 A-08 restart_cyc2.h5 EOC_with_coastdown N-04
                 G-09 restart_cyc2.h5 EOC_with_coastdown O-08
                 F-09 restart_cyc2.h5 EOC_with_coastdown C-04
                 E-09 restart_cyc2.h5 EOC_with_coastdown L-07
                 C-09 restart_cyc2.h5 EOC_with_coastdown E-06
                 A-09 restart_cyc2.h5 EOC_with_coastdown K-03
                 H-10 restart_cyc2.h5 EOC_with_coastdown C-11
                 G-10 restart_cyc2.h5 EOC_with_coastdown D-03
                 F-10 restart_cyc2.h5 EOC_with_coastdown E-08
                 D-10 restart_cyc2.h5 EOC_with_coastdown M-04
                 B-10 restart_cyc2.h5 EOC_with_coastdown K-04
                 A-10 restart_cyc2.h5 EOC_with_coastdown A-07
                 G-11 restart_cyc2.h5 EOC_with_coastdown G-10
                 E-11 restart_cyc2.h5 EOC_with_coastdown P-08
                 C-11 restart_cyc2.h5 EOC_with_coastdown O-06
                 B-11 restart_cyc2.h5 EOC_with_coastdown B-06
                 H-12 restart_cyc2.h5 EOC_with_coastdown O-11
                 F-12 restart_cyc2.h5 EOC_with_coastdown D-11
                 D-12 restart_cyc2.h5 EOC_with_coastdown B-07
                 B-12 restart_cyc2.h5 EOC_with_coastdown G-11
                 H-13 restart_cyc2.h5 EOC_with_coastdown B-09
                 G-13 restart_cyc2.h5 EOC_with_coastdown F-05
                 E-13 restart_cyc2.h5 EOC_with_coastdown F-13
                 C-13 restart_cyc2.h5 EOC_with_coastdown L-06
                 H-14 restart_cyc2.h5 EOC_with_coastdown H-09
                 F-14 restart_cyc2.h5 EOC_with_coastdown D-09
                 E-14 restart_cyc2.h5 EOC_with_coastdown F-02
                 D-14 restart_cyc2.h5 EOC_with_coastdown M-07
                 H-15 restart_cyc2.h5 EOC_with_coastdown D-04
                 G-15 restart_cyc2.h5 EOC_with_coastdown C-09
                 F-15 restart_cyc2.h5 EOC_with_coastdown G-01
```

```
 ! One assembly was loaded from cycle 1 (in the center)
 ! The cycle number is unnecessary because every assembly is
 ! directed at a specific file.  The true is for the other assemblies
 ! that came from cycle 2.

 ! Assemblies not listed in the restart_jumpin input will be treated as fresh

[ASSEMBLY]
 ! include descriptions for ASMA, ASMB, ASMC if they are
 ! all used in cycle 3
```

6. EDITS

A wide range of output edits can be enabled by the user. This chapter briefly describes the possible edits that can be enabled by the user, along with several other useful input options related to controlling the edits.

6.1 THE EDIT INPUT

6.1.1 Enabling Edits through the edit Input

Most output edits are enabled using the `edit` input in the `[STATE]` block. The `edit` input should be used only once per `[STATE]` block, with a list of all the edits the user wishes to enable. Once edits are enabled in a `[STATE]` block, they will remain enabled in all subsequent states. If a user wants to disable them later, then including the keyword `none` will disable all previously enabled edits. There is a list of default edits that cannot be disabled; those are described in Section 6.2. If `none` and other valid edits appear next to each other in the same `edit` input, then `none` will disable all previously enabled edits first, then the other edits listed alongside `none` will be enabled.

As an example, one regression test uses the following `[STATE]` blocks:

```
[STATE]
  power    0.0
  tinlet   565 K
  tfuel    565 K
  modden   0.743          ! g/cc
  boron    1300           ! ppm
  sym      full           ! full symmetry
  feedback off
  thexp    off
[STATE] edit pin_flux
[STATE] power 0.0
[STATE] edit none
[STATE] edit pin_isotopes_U-235
[STATE] edit pin_isotopes_U-238
[STATE] edit none pin_isotopes_U-235 pin_isotopes_U-238
[STATE] power 0.0
[STATE] edit pin_flux
[STATE] power 0.0
[STATE] edit none
[STATE] edit pin_powers
[STATE] edit pin_isotopes_U-235
```

This produces 13 states, with the following edits enabled for each state:

1. default edits
2. default edits + `pin_flux`
3. default edits + `pin_flux`
4. default edits
5. default edits + `pin_isotopes_U-235`
6. default edits + `pin_isotopes_U-235` + `pin_isotopes_U-238`
7. default edits + `pin_isotopes_U-235` + `pin_isotopes_U-238`

8. default edits + `pin_isotopes_U-235` + `pin_isotopes_U-238`
9. default edits + `pin_isotopes_U-235` + `pin_isotopes_U-238` + `pin_flux`
10. default edits + `pin_isotopes_U-235` + `pin_isotopes_U-238` + `pin_flux`
11. default edits
12. default edits (because `pin_powers` is a default edit)
13. default edits + `pin_isotopes_U-235`

This illustrates enabling and disabling various edits separately and simultaneously.

A few other edits are not enabled in the `[STATE]` block by the `edit` input but rather through other code-specific options. These are discussed separately in Section 6.3.

6.1.2 Edit Groups

Another useful option is the `edit_group` input in the `[EDITS]` block. This allows the user to create a group of edits that can be enabled or disabled together. The name of the group is then used in the `edit` input of the `[STATE]` block just like any of the other edits. When the group name appears in the `edit` input, each component of the group is enabled as if it were explicitly named. The `none` input will disable groups the same way it disables individual edits.

6.1.3 Point Edit Locations

One specific category of edits is a point edit, which is used to return a particular mesh or solution value at one point in the mesh. To use point edits, the `points` input must be specified in the `[EDITS]` block. This input takes a set of four values. Each set contains the coordinate type and three values. The coordinate type can be either `cart` or `rtheta`. If `cart`, the three values are the x, y, and z coordinates in the mesh; if `rtheta`, the three values are the radius, angle (degrees counterclockwise from the positive x axis), and z coordinate. In both cases, the origin is the center of the reactor. There is no limit on the number of points specified in the `points` input, and each one can use a different coordinate type if desired. The actual point edits supported by the codes are described in Section 6.1.4.7.

6.1.4 Supported Edits

A wide range of supported edits exists. They can be grouped according to the level of resolution of the edit. Doing so results in the following categories: `fsr`, `intrapin`, `pin`, `channel`, `core`, and `point`. Any edit that can be enabled from input will fall into one of these categories; the category is always used as a prefix for the name of the edit in the input (e.g., `pin_powers` is part of the `pin` category).

Grouping edits by resolution category is useful because it is guaranteed that all edits of a particular category will have the same shape. The following terms are used to describe the shape of the edits:

- `nFuelReg` the number of burnup regions in the model
- `nxpin` the number of pins across an assembly in the x direction
- `nypin` the number of pins across an assembly in the y direction
- `nz` the number of axial levels in the active fuel region
- `nasy` the number of assemblies in the model
- `nxchan` the number of channels across an assembly (usually equal to `nxpin` + 1)
- `nychan` the number of channels across an assembly (usually equal to `nypin` + 1)

The following sections provide the shape of the edit category and a list of supported edits in that category. Additional information about the output formats can found in the VERAOut specifications [1]. Note that the shape and units are provided in the tables as a reference, but all hierarchical data format 5 (HDF5) datasets also have HDF5 attributes containing units, descriptions, and the name of the code that produced it.

Several edits used indexes, which refer to the following:

- <group> the neutron energy group
- <gamma group> the gamma energy group
- <isotope> the isotope using the element name and mass number separated by a hyphen (e.g., U-235, B-10, etc.)
- <delayed group> the delayed neutron precursor group
- <reaction> the reaction type: abs, fis, or nufis

6.1.4.1 FSR Edits

The flat source region (fsr) edits are unique compared with the rest of the categories because they are not placed in the VERAOut (HDF5) file. Instead, they are used for visualization. The name of the edit is placed in the [STATE] block's edit input like the others, but the vis_edits input in the [MPACT] block must also be set to either fsr to obtain VTK edits or fsrvtu to obtain VTU edits. If the vis_edits input is not set, then the fsr edits will not do anything. The resulting VTK or VTU files can be opened in a visualization program, such as VisIt or ParaView, to view the fine mesh solution data produced as an fsr edit. Table 6 lists the allowed fsr edits.

Table 6. List of `fsr` edits in VERA

Name	Description	Units
fsr_flux_<group>	Region-wise neutron flux distribution for group <group>	Neutrons/(cm^2-s)
fsr_flux_fast	Region-wise neutron fast flux distribution	Neutrons/(cm^2-s)
fsr_flux_thermal	Region-wise neutron thermal flux distribution	Neutrons/(cm^2-s)
fsr_gammaflux_<gamma group>	Region-wise gamma flux distribution for group <gamma group>	Gammas/(cm^2-s)
fsr_gammaflux_total	Region-wise gamma total flux distribution	Gammas/(cm^2-s)
fsr_power	Region-wise power density	W/cm^3
fsr_temperature	Region-wise temperature	C
fsr_density	Region-wise material density	g/cm^3
fsr_burnup	Region-wise exposure	WGd/MT
fsr_isotopes_<isotope>	Region-wise isotopic number densities for isotope <isotope>	#/(barn*cm)
fsr_rr-total_<group>	Region-wise total reaction rate for group <group>	Reactions/cm^3
fsr_rr-absorption_<group>	Region-wise absorption reaction rate for group <group>	Reactions/cm^3
fsr_rr-fission_<group>	Region-wise fission reaction rate for group <group>	Reactions/cm^3
fsr_rr-nufission_<group>	Region-wise ν-fission reaction rate for group <group>	Fission Neutrons/cm^3
fsr_rr-kappafission_<group>	Region-wise κ-fission reaction rate for group <group>	W/cm^3
fsr_rr-outscatter_<group>	Region-wise out-scatter reaction rate for group <group>	Reactions/cm^3
fsr_lambda_<delayed group>	Region-wise delayed neutron group decay constant for delayed group <delayed group>	Decays/s
fsr_dnpy_<delayed group>	Region-wise delayed neutron group yield (β) for delayed group <delayed group>	Unitless
fsr_delayed-chi_<delayed group>	Region-wise delayed neutron fission spectrum for delayed group <delayed group>	Unitless
fsr_chi_<group>	Region-wise neutron fission spectrum for delayed group <delayed group>	Unitless

6.1.4.2 Intrapin Edits

The `intrapin` edits are the only HDF5 dataset type that provides intrapin resolution. If any `intrapin` edits are enabled, there are some additional support datasets that are generated to support indexing through the regions of each pin; those datasets are not listed here. The shape of the `intrapin` datasets is a 1D array of all the regions; the support dataset has the shape `(nasy, nz, nxpin, nypin)` and contains the number of each regions for each axial level of each pin; this can be used to unfold the `intrapin` dataset for a particular rod and level. The supported intrapin datasets are listed in Table 7.

Table 7. List of `intrapin` edits in VERA

Name	Description	Units
intrapin_all_dens	Intrapin region densities for all regions	g/cm^3
intrapin_all_flux_<group>	Region-wise neutron scalar flux for all regions	path-length/(cm^2-s)
intrapin_all_flux_fast	Region-wise fast neutron scalar flux for all regions	path-length/(cm^2-s)
intrapin_all_flux_thermal	Region-wise thermal neutron scalar flux for all regions	path-length/(cm^2-s)
intrapin_all_isotopes_<isotope>	Intrapin volume-average isotopic number densities for all regions	atoms/(cm*10^{24})
intrapin_all_temps	Intrapin region temperatures for all regions	C
intrapin_all_volumes	Intrapin region volumes for all regions	cm^3
intrapin_clad_dens	Intrapin region densities for clad regions	g/cm^3
intrapin_clad_isotopes_<isotope>	Intrapin volume-average isotopic number densities for clad regions	atoms/(cm*10^{24})
intrapin_clad_temps	Intrapin region temperatures for all regions	C
intrapin_clad_volumes	Intrapin region volumes for clad regions	cm^3
intrapin_cool_dens	Intrapin region densities for cool regions	g/cm^3
intrapin_cool_isotopes_<isotope>	Intrapin volume-average isotopic number densities for cool regions	atoms/(cm*10^{24})
intrapin_cool_temps	Intrapin region temperatures for all regions	C
intrapin_cool_volumes	Intrapin region volumes for cool regions	cm^3
intrapin_fluence	Cumulative region-wise neutron fluence for all regions	path-length/cm^2
intrapin_fuel_dens	Intrapin region densities for fuel regions	g/cm^3
intrapin_fuel_isotopes_<isotope>	Intrapin volume-average isotopic number densities for fuel regions	atoms/(cm*10^{24})
intrapin_fuel_exposure	Intrapin fuel region exposures	GWd/MT
intrapin_fuel_temps	Intrapin region temperatures for all regions	C
intrapin_fuel_volumes	Intrapin region volumes for fuel regions	cm^3
intrapin_gap_dens	Intrapin region densities for gap regions	g/cm^3
intrapin_gap_isotopes_<isotope>	Intrapin volume-average isotopic number densities for gap regions	atoms/(cm*10^{24})

Name	Description	Units
intrapin_gap_temps	Intrapin region temperatures for all regions	C
intrapin_gap_volumes	Intrapin region volumes for gap regions	cm^3
intrapin_mod_dens	Intrapin region densities for mod regions	g/cm^3
intrapin_mod_isotopes_<isotope>	Intrapin volume-average isotopic number densities for mod regions	atoms/(cm*10^{24})
intrapin_mod_temps	Intrapin region temperatures for all regions	C
intrapin_mod_volumes	Intrapin region volumes for mod regions	cm^3

6.1.4.3 Pin Edits

The `pin` datasets have the shape `(nasy, nz, nxpin, nyping)`. Supported datasets are listed in Table 8.

Table 8. List of `pin` edits in VERA

Name	Description	Units
pin_clad_all_power	Pin cladding power	W/cm
pin_clad_fast_flux	Pinwise fast fluxes in the clad	Neutrons/(cm^2-s)
pin_clad_temp	Volume average fuel clad temperature	C
pin_cool_all_power	Pin coolant power	W/cm
pin_crud_rr_<isotope>_<reaction>	Microscopic isotopic reaction rates in Chalk River unidentified deposit (CRUD) regions	Reactions/(atom*s)
pin_decay_heat	Fuel rod volume averaged decay heat	W/cm
pin_flux_<group>	Pinwise fluxes	Neutrons/(cm^2-s)
pin_fuel_all_power	Pin fuel power	W/cm
pin_gammaflux	Gamma flux distribution	Neutrons/(cm^2-s)
pin_gammaheat	Gamma heat deposition	W
pin_gap_temp	Volume average fuel-clad gap temperature	C
pin_gt_all_power	Pin guide tube power	W/cm
pin_isotopes_<isotope>	Pinwise isotopics: volume-averaged number densities divided by height, multiplied by 10^{24}	atoms/(cm*10^{24})
pin_macrorr_<isotope>_<reaction>	Macroscopic isotopic reaction rates	(Reactions/(cm^3*s)
pin_mod_all_power	Pin moderator power	W/cm
pin_neutronflux	Neutron flux distribution	Neutrons/(cm^2-s)
pin_powers_allRegions	Normalized pin powers	Unitless
pin_prompt_heat	Prompt linear heat generation	W/cm
pin_prompt_powers	Normalized prompt linear power generation	Unitless
pin_rr_<isotope>_<reaction>	Microscopic isotopic reaction rates	Reactions/(atom*s)

6.1.4.4 Channel Edits

The `channel` datasets have the shape `(nasy, nz, nxchan, nychan)`. Supported datasets are listed in Table 9.

Table 9. List of `channel` edits in VERA

Name	Description	Units
channel_liquid_density	Liquid density in the channel level	kg/m**3
channel_liquid_temps	Coolant temperature of channel level	C
channel_mixture_mass_flux	Coolant mass flux in the axial direction in the center of the channel level	kg/m**2/s
channel_pressure	Absolute pressure in channel level	bar
channel_vapor_void	Vapor void fraction in channel level	n/a
equilibrium_quality	Equalibrium quality in channel level	n/a

6.1.4.5 Assembly Edits

The `assembly` datasets have the shape `(nasy, nz)`. Currently the only `assembly` datasets that are generated by VERA are not controlled through the `edit` input. They are discussed in Section 6.3.3.

6.1.4.6 Core Edits

At this time, the only available `core` edit is `avg_flux`, which is a default edit and is therefore always enabled. The units of `avg_flux` are neutrons/cm^2*s. Its shape is a 1D array with length equal to the number of neutron energy groups.

6.1.4.7 Point Edits

The `point` edits are 1D arrays whose length is equal to the number of coordinate sets in the `points` input of the `[EDITS]` block. The values in the `point` edits are given in the same order that the `points` coordinates were specified by the user. Supported datasets are listed in Table 10.

Table 10. List of `point` edits in VERA

Name	Description	Units
point_dens	Point densities	g/cm^3
point_flux_<group>	Point fluxes	Neutrons/(cm^2-s)
point_flux_fast	Point fast fluxes	Neutrons/(cm^2-s)
point_flux_thermal	Point thermal fluxes	Neutrons/(cm^2-s)
point_fsr_volume	Flux mesh region volume at point	cm^3
point_hm_mass	Point exposures	GWd/MT
point_isotopes_<isotope>	Point isotopic number densities	atoms/(cm*10^{24}
point_matid	Material ID	Unitless
point_power	Point power density	W/cm^3
point_temp	Point temperatures	C
point_xsr_volume	Cross section mesh region volume at point	cm^3

6.1.5 Edit Collections

Several special edits are merely a convenient shorthand for a group of edits. These edits are internally unfolded into a list of edits by the code and allow the user to enable or disable a large number of edits

at once. These collections of edits behave identically to a group defined in the `edit_group` input. The supported edit collections and their constituents are listed in Table 11.

Table 11. List of edit collections in VERA

Name	Component Datasets
fsr_flux	fsr_flux_<group> for every neutron energy group
fsr_flux_2g	fsr_flux_fast, fsr_flux_thermal
fsr_gammaflux	fsr_gammaflux_<gamma group> for every gamma energy group
fsr_isotopes_all	fsr_isotopes_<isotope> for every isotope
fsr_rr-total	fsr_rr-total_<isotope> for every isotope
fsr_rr-absorption	fsr_rr-absorption_<isotope> for every isotope
fsr_rr-fission	fsr_rr-fission_<isotope> for every isotope
fsr_rr-nufission	fsr_rr-nufission_<isotope> for every isotope
fsr_rr-kappafission	fsr_rr-kappafission_<isotope> for every isotope
fsr_rr-outscatter	fsr_rr-outscatter_<isotope> for every isotope
fsr_lambda	fsr_lambda_<delayed group> for every delayed neutron precursor group
fsr_dnpy	fsr_dnpy_<delayed group> for every delayed neutron precursor group
fsr_delayed-chi	fsr_delayed-chi_<delayed group> for every delayed neutron precursor group
fsr_chi	fsr_chi_<group> for every neutron energy group
intrapin_clad_isotopes_all	intrapin_clad_isotopes_<isotope> for every isotope
intrapin_cool_isotopes_all	intrapin_cool_isotopes_<isotope> for every isotope
intrapin_flux	intrapinpin_flux_<group> for every neutron energy group
intrapin_flux_2g	intrapinpin_flux_fast, intrapinpin_flux_thermal
intrapin_fuel_isotopes_all	intrapin_fuel_isotopes_<isotope> for every isotope
intrapin_gap_isotopes_all	intrapin_gap_isotopes_<isotope> for every isotope
intrapin_isotopes_all	intrapin_isotopes_<isotope> for every isotope
intrapin_mod_isotopes_all	intrapin_mod_isotopes_<isotope> for every isotope
pin_flux	pin_flux_<group> for every neutron energy group
pin_flux_2g	pin_flux_fast, pin_flux_thermal
pin_isotopes_all	pin_isotopes_<isotope> for every isotope
point_flux	point_flux_<group> for every neutron energy group
point_flux_2g	point_flux_fast, point_flux_thermal
point_isotopes_all	point_isotopes_<isotope> for every isotope

6.2 DEFAULT EDITS

The code always generates many default edits regardless of the input or type of calculation. These edits are always enabled by the codes and cannot be disabled from the user input. The shape of each of these edits is the same as others in the resolution category and can be found in subsequent sections.

6.2.1 `[CORE]` Block Edits

Several datasets are written to the `CORE` block and reflect fixed model parameters that do not change over time. However, these are useful for edits and postprocessing, so they are listed in Table 12. This list is meant to highlight datasets that are commonly useful for postprocessing; it is not meant to be an exhaustive list.

Table 12. List of `[CORE]` block edits in VERA

Name	Description	Units	Notes
Pin edits; shape described in Section 6.1.4.3			
initial_mass	Initial pinwise masses	kg	
pin_volumes	Volume of fuel per axial region	cm^3	
Radial assembly edits; shape is a 2D map			
core_map	Core assembly map	Unitless	
detector_map	Core detector map	Unitless	
Axial edits			
axial_mesh	Axial fuel plane boundaries, post thermal expansion	cm	Length is one greater than number of fuel planes
Scalar edits			
apitch	Assembly pitch, post thermal expansion	cm	
nominal_linear_heat_rate	Average linear heat rate across the core	W/cm	
rated_flow	Rated flow of the core, adjusted for symmetry	kg/s	
rated_power	Rated power of the core, adjusted for symmetry	MW	

6.2.2 `[STATE]` Block Edits

The other set of default edits are placed in the normal `STATE_####` blocks of the VERAOut file and are listed in Table 13. A `times` group is also written to each `STATE_####` group to provide the timing breakdown for each part of the solve during that state. A `times` group is also written to the `MPACT/times` that contains cumulative timing data. Finally, a `memory` group is written to `MPACT/memory` to provide parallel memory data for the calculation.

Table 13. List of default edits in VERA

Name	Description	Units	Notes
Pin edits; shape described in Section 6.1.4.3			
pin_powers	Normalized pinwise reaction rates	Unitless	
pin_exposure	Pinwise volume averaged total fuel exposure	GWd/MT	
pin_mod_dens	Pincell averaged moderator density	g/cm^3	default only for PWRs
pin_mod_temp	Pincell averaged moderator temperatures	C	default only for PWRs
pin_cool_dens	Pincell averaged coolant density	g/cm^3	default only for BWRs
pin_cool_temp	Pincell averaged clad temperatures	C	default only for BWRs

Name	Description	Units	Notes
pin_fuel_temp	Volume averaged pinwise fuel temperatures	C	
pin_isotopes_Xe-135	Pinwise isotopics: volume-averaged number densities divided by height, multiplied by 10^{24}	atoms/(cm*10^{24})	
pin_cool_void	Pincell averaged void fraction.	n/a	default only for BWRs
Core edits			
avg_flux	Core averaged groupwise fluxes	Neutrons/(cm^2*s)	1D array; length equal to number of neutron energy groups
Scalar or other small datasets			
b10	Boron-10 fraction in coolant		Could be echo of input or calculated by code
bank_pos	Steps withdrawn for each bank in `bank_labels`		Could be echo of input or calculated by code
boron	Soluble boron concentration (ppmB)		Could be echo of input or calculated by code
bypass	% Bypass		Could be echo of input or calculated by code via table
cool_max_liquid_temp	Maximum liquid temperature in the model	C	
core_avg_density	Volume-averaged mixture density in the core.	kg/m**3	
core_avg_fuel_temp	Volume-averaged fuel temperature in the core	C	
core_avg_temp	Mass flow rate weighted average coolant temperature in the core	C	
core_inlet_density	Volume-averaged mixture density in the first level of the model	kg/m**3	
core_inlet_mass_flux	The core inlet mass flux for this state (adjusted for state relatve flow rate)	kg/m**2/s	
core_inlet_temp	Mass flow rate weighted average coolant temperature at bottom boundary of model	C	

Name	Description	Units	Notes
core_outlet_density	Volume-averaged mixture density in the top level of the model	kg/m**3	
core_outlet_temp	Mass flow rate weighted average coolant temperature at top boundary of model	C	
exposure_hours	End of State Core Exposure (hours); cumulative hours of combined decay/depletion time calculated by the code	h	
flow	% of rated flow (%)	%	Could be echo of input or calculated by code via table
fluxnormfactor	Normalization factor to multiply by the flux	W/Unnormalized flux	
iState	State index	Unitless	
keff	Multiplication factor resulting from eigenvalue calculation	Unitless	
outer_timer	Elapsed time for all states so far	s	
outers	Number of coupled iterations for this state point	Unitless	
power	% of rated power (%)	%	Could be echo of input or calculated by code
transient_time	Physics simulation time elapsed since transient initial condition	s	0.0 for non-transient state points

6.3 OTHER HDF5 EDITS

A few other sets of edits are enabled via individual code blocks or specific types of calculations but are never controlled through the `edit` input. Those edits are described briefly in the following sections. The details of the relevant input options are also given in the detailed input documentation in Section 7.

6.3.1 Detector Edits

If detectors are modeled, then the detector response will be placed in `STATE_####/detector_response` for each state.

6.3.2 Feedback Calculations

When performing a coupled calculation using `feedback on`, a number of additional edits are produced by default. These are listed in Table 14.

Table 14. Outputs generated by feedback calculations

channel_clad_inner_temp	Channel-wise inner clad temperatures	C
channel_clad_outer_temp	Channel-wise outer clad temperatures	C
channel_clad_temp	Channel-wise average clad temperatures	C
channel_coolant_dens	Channel-wise coolant densities	kg/m^3
channel_coolant_temp	Channel-wise average coolant temperatures	C
channel_fuel_center_temp	Channel-wise fuel centerline temperatures	C
channel_fuel_surf_temp	Channel-wise fuel surface temperatures	C
channel_fuel_temp	Channel-wise channel averaged fuel temperatures	C
channel_liquid_density	Liquid density in the channel level	kg/m**3
channel_liquid_temps	Coolant temperature of channel level	C
channel_mixture_mass_flux	Coolant mass flux in the axial direction in the center of the channel level	kg/m**2/s
channel_mod_dens	Channel-wise moderator densities	kg/m^3
channel_mod_temp	Channel-wise average moderator temperatures	C
channel_pressure	Absolute pressure in channel level	bar
channel_vapor_void	Vapor void fraction in channel level	n/a
core_pressure_drop*	Total core pressure drop, including nozzle and orifice form losses, spacer grid form losses, friction, acceleration, and gravitational losses	bar
pin_avg_clad_surface_heat_flux	Average heat flux through surface of the clad at rod level	W/m**2
pin_avg_surf_tke	Average turbulent kinetic energy at the surface of the rod level	J/kg
pin_fuel_enthalpy*	Volume average fuel pellet enthalpy	kJ/kg
pin_gtube_dens	Volume-averaged moderator density within a guide-tube	g/cm^3
pin_gtube_temp	Volume-averaged moderator temperatures within a guidetube	C
pin_min_dnbr	Minimum departure from nucleate boiling ratio (DNBR) in the model	n/a
pin_max_clad_surface_temp	Maximum rod clad surface temperature	C
pin_max_clad_temp	Maximum temperature of fuel pin clad in the model.	C
pin_max_linear_power	Maximum linear power in the model.	W/cm
pin_max_temp	Maximum centerline temperature in fuel pins.	C
pin_steamrate	Total steam generation (does not consider vapor that condenses due to subcooled boiling	kg/m**2/s

*Only when CTF Fuel conduction solve is enabled.

6.3.3 BWR Calculations

BWR calculations have several edits that are enabled when setting `bypass_treatment` to `fixed_heating` or `explicit_heating`. These are listed in Table 15. Some entries are available for either value of `bypass_treatment`, but the remaining entries are enabled only for `explicit_heating`; the latter group is noted with a footnote.

Table 15. List of BWR edits in VERA

Name	Description	Units
bypass_inlet_orifice_loss_coefficient	The inlet loss orifice coefficient for the bypass flow that was found by iterating on the bypass pressure drop	normalized
radial_assembly_bypass_exit_dens	Assembly-wise distribution of exit bypass flow density; Shape: (assemblies)	g/cc
radial_assembly_bypass_exit_temp	Assembly-wise distribution of exit bypass flow temperature; Shape: (assemblies)	C
radial_assembly_bypass_exit_void	Assembly-wise distribution of exit bypass flow void; Shape: (assemblies)	fraction
radial_assembly_bypass_flow_dist	Assembly-wise distribution of inlet bypass flow; Shape: (assemblies)	kg/s
assembly_bypass_dens	Assembly-wise axial distribution of bypass flow density; Shape: (assemblies, axial levels)	g/cc
assembly_bypass_temp	Assembly-wise axial distribution of bypass flow temperature; Shape: (assemblies, axial levels)	C
assembly_bypass_void	Assembly-wise axial distribution of bypass flow void; Shape: (assemblies, axial levels)	fraction
assembly_bypass_power*	Assembly-wise axial distribution of linear power deposition in the bypass flow; Shape: (assemblies, axial levels)	W/cm
assembly_channelbox_power*	Assembly-wise axial distribution of power conducted from channel box to bypass flow, including both conduction from active flow and from direct energy deposition; Shape: (assemblies, axial levels)	W/cm
assembly_channelbox_temp*	Axial temperature distribution for the channel box in each assembly; Shape: (assemblies, axial levels)	C
assembly_controlblade_power*	Assembly-wise axial distribution of linear power deposition in the control blades; Shape: (assemblies, axial levels)	W/cm

*Produced only for `bypass_treatment explicit_heating`.

6.3.4 Transient Calculations

If `transient` is set to `on` to perform a transient calculation, several datasets will be produced, as shown in Table 16. Some of those are enabled only if the `rx_components` input in the `[MPACT]` block is also used.

Table 16. Outputs generated by transient calculations

Name	Description	Units
beta	Total delayed neutron yield	Unitless
control_rod_reactivity*	Reactivity due to control rod movement	$
decay_power	% of rated power due to decay heat (%)	%
doppler_reactivity*	Reactivity due to Doppler feedback	$
flux_shape_reactivity*	Reactivity due to change in flux shape	$
generation_time	Average neutron generation time	s
material_reactivity*	Reactivity due to material changes	$
mod_dens_reactivity*	Reactivity due to moderator density changes	$
mod_temp_reactivity*	Reactivity due to moderator temperature changes	$
prompt_power	% of rated power due to prompt fission heat (%)	%
total_power	Total core power for modeled portion of core	W
total_reactivity	Total reactivity	$

*These outputs are generated only if `rx_components` is used.

6.3.5 Ex-Core Transport

The `STATE_####/excore_detector_response_PWR` dataset will be produced if VeraShift coupling is enabled with `excore_transport on`. This dataset containins the results of the Shift ex-core detector calculations.

6.3.6 MPACT Inputs

6.3.6.1 STH Edits

For feedback calculations that set `coupling_method simplified` in the `[MPACT]` block, the list of feedback edits from Section 6.3.2 will not be generated. Instead, the system thermal hydraulic (STH) solver will be used, which generates a smaller set of outputs. Specifically, a `radial_assembly_flow_dist` dataset will be produced for BWR calculations, which has the flow in kilograms/second for each assembly in the core.

If the `[BRANCH]` block is used to generate the nodal cross sections, then a group called `BRANCHES` is placed at the root of the VERAOut file, and it contains directories for each unique branch case. Each `STATE_####` group will then have an integer `active_branch` that identifies which entry in `BRANCHES` that state point corresponds to; a value of 0 indicates nominal conditions. Additional detail on branch calculations is given in Section 3.

6.3.6.2 Nodal Cross-Section Edits

Nodal cross-section edits can be enabled using the `nodal_edits` input described in Section 7.13. When enabled, each `STATE_####` group in the VERAOut file will contain the following new groups:

1. `CORE_XS`, which contains a few core-homogenized datasets;
2. `ASSEMBLY_XS`, which contains a full set of nodal cross-section data for every axial level and assembly in the model, including reflector regions; and
3. `NODAL_XS`, which is the same as `ASSEMBLY_XS` but provides four nodes of data for each axial level and assembly.

These data can be used directly to drive the 3D nodal solver in MPACT, or they can be postprocessed to drive external nodal codes.

6.3.6.3 Critical Buckling Calculations

If the `crit_buckling` input from Section 7.13 is used, the following datasets are produced for use in postprocessing:

- `critical_buckling`,
- `critical_buckling_method`,
- `critical_keff`, and
- `critical_spectrum`.

If nodal cross-section edits are enabled, then the critical spectrum will also be used in the generation of nodal data.

6.3.6.4 Reaction Rate Edits

The `rr_edits` and `rr_edits_opt` inputs, described in Section 7.13, can be used to enabled detailed reaction rate edits. These edits provide reaction rates as a function of isotope and reaction type. The data will be stored in `STATE_####/reaction_rates` and `STATE_####/reaction_rate_details`.

6.3.7 `[COBRATF]` Inputs

When performing feedback calculations, additional detailed T/H edits can be obtained from CTF by using the `edit_detailed_th` option. These are shown in Table 17.

Table 17. Detailed outputs generated by feedback calculations

channel_lateral_liq_mass_in	Amount of liquid mass entering channel from connected channels	kg/s
channel_vapor_enthalpy	Coolant vapor enthalpy of channel level	kJ/kg
channel_droplet_void	Droplet void fraction in channel level	n/a
channel_mdotv	Coolant vapor mass flow rate in the axial direction at the bottom of the channel level	kg/s
channel_mdotl	Coolant liquid mass flow rate in the axial direction at the bottom face of the channel level	kg/s
channel_liquid_velocity	Coolant liquid velocity of channel level	m/s
channel_lateral_vap_mass_in	Amount of vapor mass entering channel from connected channels	kg/s
channel_vapor_velocity	Coolant vapor velocity of channel level	m/s
channel_liquid_enthalpy	Coolant liquid enthalpy of channel level	kJ/kg

6.3.7.1 DNB Calculations

When performing DNB calculations, the `edit_dnb` option can be used to produce additional edits, as shown in Table 18.

Table 18. Detailed outputs generated by DNB calculations

Name	Description	Units
clad_outer_heatflux	Heat flux at azimuthal location where DNBR is minimum	kW/m**2
pin_dnbr	Minimum departure from nucleate boiling ratio at rod level	n/a
clad_outer_criticalheatflux	Critical heat flux adjacent azimuthal location where DNBR is minimum	kW/m**2

6.3.8 `[MAMBA]` Inputs

If the `crud` option is enabled, then MAMBA will generate many new output datasets. These are listed in Table 19.

Table 19. List of edits generated by MAMBA for CRUD calculations

Name	Description	Units
cleanup_flow_abs	The absolute cleanup flow for this state (adjusted for symmetry and state relatve rate	kg/s
cool_hydrogen	Global dissolved hydrogen in coolant	m**3/kg
cool_lithium	Global lithium concentration in coolant	ppm
cool_mass	Total mass of coolant in primary loop.	kg
cool_nickel_particulate	Global nickel particulate concentration in coolant	ppb
cool_outlet_pressure	Coolant pressure at the core outlet	bar
cool_soluble_iron	Global soluble iron concentration in coolant	ppb
cool_soluble_nickel	Global soluble nickel concentration in coolant	ppb
core_avg_linear_heatrate	Core average linear heat rate	W/cm
core_crud_boron_mass	Total boron mass trapped in CRUD layer in model at end of this STATE	kg
core_crud_mass	Total CRUD mass in model at end of this STATE	kg
pin_avg_boron_thickness	Volume-averaged boron thickness at rod axial level	micrometers
pin_avg_crud_borondensity	Surface area weighted average boron mass density at rod axial level	g/cm**2
pin_avg_crud_massdensity	Surface area weighted average crud mass density at rod axial level	g/cm**2
pin_avg_crud_thickness	Volume-averaged crud thickness at rod axial level	micron
pin_crud_inner_surface_temp	Temperature at the crud/clad interface	C

7. INPUT DESCRIPTIONS

This chapter contains a complete list of the available inputs.

The input for each block is given in separate subsections.

In this chapter, inputs are given in **bold** text followed by the parameters on the input. Following each input is a description of the parameters on that input.

7.1 BLOCK CASEID

title case_name

case_name	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Problem name		
Notes: None		

7.2 BLOCK BRANCH

title branch_name

branch_name	Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Name of the set of branch cases defined by this [BRANCH] block		
Notes: None		

branch_set branch_set

branch_set	Array of mixed types	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Defines one set of branch calculations. Every permutation of values listed in the branch_set input will generate a new state. For detailed documentation and examples, please see the section titled Branch Cases		
Notes: This input does nothing unless the [BRANCH] block title is named in the texttt[STATE] block's branch input		

state_control state_control

state_control	Array of Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Applies temporary modifications to state variables; these modifications will only be applied during the branch calculations, not during the depletion and nominal calculations. For detailed documentation and examples, please see the section titled Branch Cases		
Notes: This input does nothing unless the [BRANCH] block title is named in the texttt[STATE] block's branch input		

7.3 BLOCK STATE

branch branch

branch	Array of Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Names the [BRANCH] blocks that should be applied after each state point defined by this [STATE] block		
Notes: This input does not persist to following [STATE] blocks		

title state_name

state_name	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: State name		
Notes: None		

op_date operating_date

operating_date	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): Limited to MM/DD/YYYY or YYYY/MM/DD		
Description: This input contains the operating date of this statepoint. It is used when writing restart files. The operating date must be entered for any restart file that is used in a core shuffle so that the isotopic decay can be calculated during an outage		
Notes: None		

power percent_power

percent_power	Float	Optional
Units: Percent (default)		
Applicable Value(s): 1.0×10^{-8} (default), ≥ 0		
Limitation(s): None		
Description: Percent of rated operating power		
Notes: Cannot be zero when depleting		

flow percent_flow

percent_flow	Float	Optional
Units: Percent (default)		
Applicable Value(s): 1.0×10^{-8} (default), ≥ 0		

continued on next page...

percent_flow, continued...

Limitation(s): None
Description: Percent of rated operating flow
Notes: None

flow_dist nominal_flow_multiplier

nominal_flow_multiplier	2D Float Map	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		
Description: This is a 2D array that must match the shape of assm_map in [[CORE]]. It gives a multiplier that will be applied to nominal inlet mass flow rate in each assembly		
Notes: This map is not normally used		

blade_pos blade_pos

blade_pos	2D Float Map	Optional
Units: N/A		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Steps withdrawn for each blade location		
Notes: The map must be in full symmetry, regardless of how other maps in the [CORE] block are entered		

pout_dist outlet_pressure_adder

outlet_pressure_adder	2D Float Map	Optional
Units: psi (default)		
Applicable Value(s): 0.0 (default), Any float		
Limitation(s): None		
Description: This is a 2D array that must match the shape of assm_map in [CORE]. It gives an adder that will be added to nominal outlet pressure in each assembly		
Notes: This map is not normally used		

bypass bypass_option

bypass_option	Float or String	Optional
Units: N/A, Percent		
Applicable Value(s): 0 (default), ≥ 0, table		
Limitation(s): None		
Description: This is the bypass flow fraction applied to the actual flow, or the word table, indicating that a bypass flow rate table specified in [CORE] should be used		
Notes: None		

tinlet inlet_temperature units

inlet_temperature	Float or String	Optional
Units: °C (default), °F, K		
Applicable Value(s): 326.85 C (default), > 0, table		
Limitation(s): None		
Description: This is the core inlet temperature in given units. Examples of this input are `tinlet 560 F` or `tinlet 600 K`. Alternatively, `tinlet table` can be used to invoke the tinlet_table		
Notes: This is required when coupling to CTF		

tinlet_dist inlet_temperature_adder

inlet_temperature_adder	2D Float Map	Optional
Units: C (default)		
Applicable Value(s): 0 (default)		
Limitation(s): None		
Description: This is a 2D array that must match the shape of `assm_map` in `[CORE]`. It gives an adder that will be applied to the nominal inlet temperature in each assembly		
Notes: This map is not normally used		

subcool inlet_subcooled_enthalpy

inlet_subcooled_enthalpy	Float	Optional
Units: BTU/lbm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): Cannot be used along with `tinlet` input. Requires `pressure` input		
Description: The enthalpy below the saturated liquid enthalpy at the inlet		
Notes: `tinlet` or `subcool` inputs are required and are exclusive		

void void_distribution

void_distribution	Float	Optional
Units: Percent (default)		
Applicable Value(s): > 0, < 100		
Limitation(s): None		
Description: Assembly-wise radial void distribution in percent		
Notes: BWR only		

axial_void axial_void_map axial_void_bounds

axial_void_map	Float	Optional
Units: Percent (default)		
Applicable Value(s): ≥ 0, ≤ 100		
Limitation(s): None		
Description: List of axial void fractions		
Notes: BWR only		

axial_void_bounds	Float	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: List of axial elevations for axial void fractions		
Notes: BWR only		

tfuel fuel_temperature units

fuel_temperature	Float	Optional
Units: K (default), °F, °C		
Applicable Value(s): 600 K (default), $> 0K$, $< 1600K$		
Limitation(s): None		
Description: Fixed fuel temperatures		
Notes: This is used only if feedback is turned OFF. Examples of this input are `900 K` or `1200 F`		

modden mod_density

mod_density	Float	Optional
Units: g/cc (default)		
Applicable Value(s): 0.743 (default), > 0.01, < 1.2		
Limitation(s): None		
Description: Fixed moderator density		
Notes: Used only if feedback is turned OFF		

xenon xenon_treatment

xenon_treatment	Character String	Optional
Units: N/A		
Applicable Value(s): dep (default), zero, equil		
Limitation(s): None		
Description: Xenon treatment option: • `zero`: sets ^{135}I and ^{135}Xe number densities to zero • `equil`: sets ^{135}I and ^{135}Xe number densities to calculated equilibrium values • `dep`: treats ^{135}I and ^{135}Xe explicitly as other isotopes in transport calculation		
Notes: None		

samar samarium_treatment

samarium_treatment	Character String	Optional
Units: N/A		
Applicable Value(s): dep (default), zero, equil, peak		
Limitation(s): None		

continued on next page...

`samarium_treatment`, continued...

Description: Samarium treatment option: • `zero`: sets ^{149}Pm and ^{149}Sm number densities to zero • `equil`: sets ^{149}Pm and ^{149}Sm number densities to calculated equilibrium values • `dep`: treats ^{149}Pm and ^{149}Sm explicitly as other isotopes in transport calculation • `peak`: adds ^{149}Pm number density to ^{149}Sm number density and then sets ^{149}Pm number density to zero
Notes: None

rlx_xesm Xe-Sm_relaxation

`Xe-Sm_relaxation`	Float	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), > 0		
Limitation(s): None		
Description: Xenon-samarium equilibrium relaxation factor		
Notes: Recommend value: 1.0		

pred_order predictor_order

`predictor_order`	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), ≥ 0		
Limitation(s): None		
Description: This input is used to specify the order of polynomial approximation to use for extrapolation of microscopic cross sections and fluxes over predictor depletion substeps		
Notes: The methodology employed for high-order depletion is described in the article by G. G. Davidson et al., "Nuclide Depletion Capabilities in the Shift Monte Carlo Code," *Annals of Nuclear Energy*, 114, pp. 259–276 (2018). For any given time step, the code will attempt the highest polynomial order approximation without exceeding the user specification, as is allowed by the generated data thus far. For example, if the user designates order 2, then on the first time step, order 0 will be used since no previous time data are available. On the second time step, order 1 will be used since only one previous set of time data is available, and on the third and subsequent time steps order 2 will be used since sufficient data from previous time steps are available to perform an order 2 fit		

corr_order corrector_order

`corrector_order`	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), ≥ 0		
Limitation(s): None		
Description: This input is used to specify the order of polynomial approximation to use for interpolation of microscopic cross sections and fluxes over corrector depletion substeps		
Notes: This follows the same methodology as described for `pred_order`		

boron boron_concentration

boron_concentration	Float	Optional
Units: ppm (default)		
Applicable Value(s): 0.0 (default), ≥ 0		
Limitation(s): None		
Description: Soluble boron concentration in the moderator		
Notes: None		

b10 b10_fraction b10_depletion

b10_fraction	Float	Optional
Units: N/A, Atom fraction of B-10 in boron		
Applicable Value(s): 0.199 (default), ≥ 0		
Limitation(s): None		
Description: Boron-10 fraction in coolant		
Notes: None		

b10_depletion	Boolean	Optional
Units: N/A		
Applicable Value(s): False (default), True		
Limitation(s): None		
Description: Flag to enable B-10 depletion in coolant		
Notes: Required when using input parameter b10		

kcrit target_eigenvalue

target_eigenvalue	Float	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), ≥ 0		
Limitation(s): None		
Description: Target eigenvalue used in boron, rod, power, flow, and tinlet search		
Notes: None		

search search_option

search_option	Character String	Optional
Units: N/A		
Applicable Value(s): keff (default), boron, rod, power, flow, tinlet		
Limitation(s): None		
Description: Search option		
Notes: None		

search_bank rod_search_bank

rod_search_bank	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Control rod bank to be moved in rod search problems		
Notes: Required when input parameter search is set to rod		

pressure outlet_pressure

outlet_pressure	Float	Optional
Units: psia (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Core exit pressure		
Notes: This is required for BWR calculations. For PWR calculations, the default is 2,250 psia. When using simplified T/H calculations for acppwr, this value must be 2,250 psia if it is specified		

deplete deplete_units depletion_steps

deplete	Float	Optional
Units: N/A, GWDMT, MWDMT, EFPD, hours		
Applicable Value(s): ≥		
Limitation(s): depletion_steps must be listed in ascending order		
Description: Specification of depletion units and a single or multiple depletion steps		
Notes: Recommended that depletion step sizes are less than 1 GWDMT, 1,000 MWDMT, or 30 EFPD		

jump_in_file file_name

jump_in_file	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Name of h5 file containing data needed to perform detailed isotopic burn for cycle jump in. The inclusion of this input/file name will initiate an ORIGEN point depletion based “burn in” according to the data in the h5 file		
Notes: ORIGEN must be present and enabled in order to use this feature		

edit state_edits

state_edits	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		

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`state_edits`, continued...

Description: This is a list of state variables to be edited. There are numerous other edits that can be enabled or disabled as needed, along with other related options. Consult Chapter 6 of the VERAIn User's Manual for detailed information about default and applicable values, units, and other features
Notes: One limitation in this input occurs when a user enables an edit using its name, a user-defined group, and an internal group of edits in MPACT all in the same calculation. For example, enabling `pin_flux_001` by referring to `pin_flux_001`, `pin_flux`, and a user-defined `edit_group` option that includes `pin_flux_001` will result in unpredictable behavior and potentially crash the code. It is recommended that if any of the above built-in shorthand options are used, then the user should not name any of the components inside an `edit_group` option. However, in this example, if the `edit_group` option included `pin_flux` instead of `pin_flux_001`, then the references would be correctly resolved

reset_sol solution_reset_bool

`solution_reset_bool`	Boolean	Optional
Units: N/A		
Applicable Value(s): False (default), True		
Limitation(s): None		
Description: Resets the initial guess of the flux in MPACT		
Notes: None		

rodbank bank_labels bank_pos

`bank_labels`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a list of control rod banks to position. The labels correspond to `crd_map` in `[CORE]` block		
Notes: Every `bank_label` must have a corresponding `bank_pos`		

`bank_pos`	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Steps withdrawn for each bank in list		
Notes: Every `bank_pos` must have a corresponding `bank_label`. Example: `rodbank SA 228 SB 50 SD 0 A 228`		

feedback feedback_option

`feedback_option`	Character String	Optional
Units: N/A		
Applicable Value(s): `off` (default), `on`		

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`feedback_option`, continued...

Limitation(s): None
Description: Flag to turn on and off T/H feedback
Notes: None

decay_heat decay_heat_option

`decay_heat_option`	Character String	Optional
Units: N/A		
Applicable Value(s): `off` (default), `on`		
Limitation(s): Does nothing if `feedback` is off		
Description: Flag to turn on and off coupling of decay heat calculation with T/H feedback and transient		
Notes: Should only be used in the first `STATE` block. It is strongly recommended to use the full depletion chain if this option is enabled. To do so, set `dep_filename` in the `[MPACT]` block to `origen_data_paths_scale62.txt`		

neutron_transport neutron_transport_option

`neutron_transport_option`	Character String	Optional
Units: N/A		
Applicable Value(s): `on` (default), `off`		
Limitation(s): None		
Description: Flag to turn on and off neutron transport		
Notes: If not specified, value carries forward from previous state or restart file		

transient transient_option

`transient_option`	Character String	Optional
Units: N/A		
Applicable Value(s): `on` (default), `off`		
Limitation(s): None		
Description: Flag to turn on and off transient		
Notes: The presence of the transient block implies that this option is on. Set this option to off to disable transient when a transient block is specified		

natcirc natcirc

`natcirc`	Character String	Optional
Units: N/A		
Applicable Value(s): `off` (default), `on`		
Limitation(s): None		
Description: Flag to turn on and off natural circulation calculation		
Notes: None		

crud crud_option

crud_option	Character String	Optional
Units: N/A		
Applicable Value(s): off (default), on		
Limitation(s): None		
Description: Flag to turn on and off MAMBA CRUD deposition coupling		
Notes: None		

excore_transport excore_transport_option

excore_transport_option	Character String	Optional
Units: N/A		
Applicable Value(s): off (default), on		
Limitation(s): None		
Description: Flag to turn on and off Shift excore transport coupling		
Notes: Additional SHIFT options are included in [SHIFT] block		

thexp thermal_expansion_option

thermal_expansion_option	Character String	Optional
Units: N/A		
Applicable Value(s): on (default), off		
Limitation(s): None		
Description: Flag to turn on and off thermal expansion		
Notes: Additional thermal expansion options are given on other inputs		

thexp_tfuel fuel_thermal_expansion_temperature units

fuel_thermal_expansion_temperature	Float	Optional
Units: K (default), F, C		
Applicable Value(s): 293 K (default)		
Limitation(s): None		
Description: This is the temperature to use for thermal expansion of fuel. If not present, tfuel is used instead. If both thexp_tfuel and tfuel are not specified, tinlet will be used		
Notes: Example: 900 K		

thexp_tclad clad_thermal_expansion_temperature units

clad_thermal_expansion_temperature	Float	Optional
Units: K (default), F, C		
Applicable Value(s): 293 K (default)		
Limitation(s): None		
Description: This is the temperature to use for thermal expansion of clad. If not present, thexp_tmod is used instead. If both thexp_tfuel and thexp_tmod are not specified, tinlet will be used		
Notes: Example: 560 F		

thexp_tmod moderator_thermal_expansion_temperature units

moderator_thermal_expansion_temperature	Float	Optional
Units: N/A, F, C		
Applicable Value(s): 293 K (default)		
Limitation(s): None		
Description: This is the temperature to use for thermal expansion of moderator and structural materials. If not present, tinlet is used instead		
Notes: Example: 560 F		

expand3D 3D_thermal_expansion_option

3D_thermal_expansion_option	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: This is an option to perform 3D thermal expansion. If set to false, thermal expansion will only be performed in the radial direction. When set to true, both radial and axial thermal expansion will be performed		
Notes: None		

thexp_outfile thermal_expansion_outfile

thermal_expansion_outfile	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is the name of the thermally expanded XML output. If the name of the outfile is the same as the XML input used to execute MPACT, the input file will be renamed to input_filename.bak, and the thermally expanded XML output will be in the output file. If not specified, no thermally expanded XML output file will be generated		
Notes: None		

thexp_info thermal_expansion_info

thermal_expansion_info	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Logical flag to edit additional thermal expansion information to the output file		
Notes: None		

apitch_tec assembly_pitch_expansion_coefficient

assembly_pitch_expansion_coefficient	Float	Optional
Units: K^{-1} (default)		
Applicable Value(s): $\geq 0, < 50.0 \times 10^{-6}$		

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assembly_pitch_expansion_coefficient, continued...

Limitation(s): None
Description: This is the thermal expansion coefficient to be used when expanding the assemblies in the problem. If not specified, the expansion coefficient will be calculated internally assuming a core plate nominal density for SS 304
Notes: None

ppitch_tec pin_pitch_expansion_coefficient

pin_pitch_expansion_coefficient	Float	Optional
Units: K^{-1} (default)		
Applicable Value(s): $\geq 0, < 50.0 \times 10^{-6}$		
Limitation(s): None		
Description: This is the thermal expansion coefficient to be used when expanding the pins in the problem. If not specified, the expansion coefficient will be calculated internally assuming Zircaloy-4 for grid materials		
Notes: None		

axial_tec axial_tec

axial_tec	Float	Optional
Units: K^{-1} (default)		
Applicable Value(s): $\geq 0, < 50.0 \times 10^{-6}$		
Limitation(s): None		
Description: This is the thermal expansion coefficient to be used when expanding the axial dimension of the problem. If not specified, the expansion coefficient will be calculated internally using the UO_2 thermal expansion coefficient and the fuel temperature. This is only done if 3D expansion is enabled		
Notes: None		

sym symmetry_option

symmetry_option	Character String	Optional
Units: N/A		
Applicable Value(s): full (default), qtr, south		
Limitation(s): None		
Description: This is an option for specifying the symmetry of the problem. The full option specifies that the problem will be modeled in full and that ray tracing will be performed across the whole geometry. The qtr option will model only the south-east quarter of the geometry. The south option will model only the southern half of the geometry. In quarter or half symmetry, the boundary conditions along the symmetry boundary are determined by the bc_sym input		
Notes: For multistate simulations, if sym is not specified in the first state, any sym options specified in future states will be ignored		

kmul_beta kmul_beta

kmul_beta	Float	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), real numbers on the interval (0.0,1.0]		
Limitation(s): Cannot specify exactly 0		
Description: This option is used to specify the direct multiplier on beta, the delayed neutron fraction. This option is used to apply conservatism to transient calculations specifically for RIA		
Notes: None		

kmul_doppler kmul_doppler

kmul_doppler	Double	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), real numbers on the interval (0.0,1.0]		
Limitation(s): Cannot specify exactly 0		
Description: This option is used to specify the direct multiplier on the temperature difference that the fuel experiences when evaluating cross sections. It is used to apply conservatism to transient calculations. It can be used in steady-state calculations to iterate to the desired value		
Notes: None		

kmul_modtemp kmul_modtemp

kmul_modtemp	Double	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), real numbers on the interval (0.0,1.0]		
Limitation(s): Cannot specify exactly 0		
Description: This option is used to specify the direct multiplier on the temperature difference that the moderator experiences when evaluating cross sections. It is used to apply conservatism to transient calculations. It can be used in steady-state calculations to iterate to the desired value		
Notes: None		

kmul_crw kmul_crw

kmul_crw	Double	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), real numbers on the interval (0.0,1.0]		
Limitation(s): Cannot specify exactly 0		
Description: This option is used to specify the direct multiplier on the critical rod worth. This option is used to apply conservatism to transient calculations specifically for RIA		
Notes: None		

restart_shuffle_errorchecking restart_shuffle_errorchecking

restart_shuffle_errorchecking	Character String	Optional
Units: N/A		
Applicable Value(s): on (default), off, true, false		

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`restart_shuffle_errorchecking`, continued...

Limitation(s): None
Description: This input is used to toggle more thorough geometry input checking between the `shuffle_label` map and the `assm_map`. If the unexpanded XML input parameter list is stored on the restart file, then the assembly parameter list at a shuffle label position is compared with the corresponding assembly parameter list at the same core `assm_map` position
Notes: None

restart_jumpin target_location restart_file restart_label source_location

`restart_jumpin`	Array of Strings	Optional
Units: N/A		
Applicable Value(s): `none` (default)		
Limitation(s): None		
Description: This input is used to specify sets of assembly isotopic data for assembly batches that do not have full simulation histories. These assemblies have approximated histories, so a user can "jump in" to any later cycle without explicitly simulating all previous cycles. The user is required to specify all of the following parameters. • `target_location`: location to load isotopics in current model • `restart_file`: the end time of perturbation • `restart_label`: restart label in restart file with assembly data • `source_location`: core label coordinate for assembly position when restart data were written		
Notes: This is a multiline input, so multiple entries may be given		

restart_shuffle restart_shuffle_file restart_shuffle_label

`restart_shuffle`	Arrays of Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: To perform a restart shuffle, the user is required to specify the restart files to use, as well as the labels from within those files to use during the shuffle. They must be listed in matching file-label pairs		
Notes: See Section 4.4 for more information and examples		

restart_read restart_read_file restart_read_label

`restart_read`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: To perform a restart, the user is required to specify the restart file to use, as well as the label from that file to use to begin the restart. The file and label must be listed as a matching file-label pair		
Notes: See Section 4.3 for more information and examples		

restart_write restart_write_file restart_write_label

restart_write	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: To write a restart file, the user is required to specify a restart file name to write to, as well as a label to call that state in the restart. The file and label must be listed as a matching file-label pair		
Notes: See Section 4.2 for more information and examples		

restart_isotope_set restart_isotope_set_option

restart_isotope_set_option	Character String	Optional
Units: N/A		
Applicable Value(s): transport (default), depletion		
Limitation(s): None		
Description: This option selects the isotope set to be edited to the restart file		
Notes: None		

shuffle_label shuffle_label

shuffle_label	2D map of Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The label of the assembly or assemblies to be used in the restart shuffle. The shape of the shuffle_label must match core_shape, and any assembly that is not to be shuffled uses a - in place of the assembly label to maintain the core_shape		
Notes: See Section 4.4 for more information and examples		

insert_shuffle_label insert_shuffle_label

insert_shuffle_label	2D map of Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The label of the assembly inserts to be used in the restart shuffle. The shape of insert_shuffle_label must match core_shape, and any inserts that are not to be shuffled use a - in place of the insert label to maintain the core_shape		
Notes: None		

shuffle_homog shuffle_homog

shuffle_homog	Character String	Optional
Units: N/A		
Applicable Value(s): none (default), center, all		
Limitation(s): None		

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shuffle_homog, continued...

Description: The homogenization option for quarter-symmetric restart shuffle cases. By default, no homogenization occurs. If the `center` option is used, the center assembly alone will be homogenized, and then a quarter of it is used in the calculation with reflective boundary conditions. The `all` option does not currently have a function
Notes: None

crud_cleaning crud_cleaning_map

`crud_cleaning_map`	2D Float Map	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a 2D array that must match the shape of `assm_map` in `[CORE]`. Map specifies the assembly-wise crud cleaning fractions. For any assemblies that are not to be cleaned, use a dash - in place of the cleaning fraction		
Notes: For shuffle cases only		

crud_removal crud_removal

`crud_removal`	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0, ≤ 1		
Limitation(s): None		
Description: Core-wide crud removal fraction		
Notes: Does not carry over from state to state		

crud_replenish_b10 crud_replenish_b10

`crud_replenish_b10`	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0, ≤ 1		
Limitation(s): None		
Description: Crud b10 replenishment fraction. A value of 1 resets the crud b10 to the coolant b10 ratio		
Notes: Does not carry over from state to state		

cool_chem h_conc li_conc ni_sol ni_par fe_sol

`cool_chem`	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0		
Limitation(s): None		

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`cool_chem`, continued...

Description: Coolant chemistry concentrations to be used for crud formation: • `h_conc`: dissolved hydrogen in coolant [parts per million (usually boron) (PPM)] • `li_conc`: coolant lithium concentration [PPM] • `ni_sol`: coolant soluble nickel concentration [parts per billion (PPB)] • `ni_par`: coolant particulate nickel concentration [PPB] • `fe_sol`: coolant soluble iron concentration [PPB]
Notes: None

vh2 h2_specific_volume

`h2_specific_volume`	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Specific volume of hydrogen in the coolant to be used for crud formation		
Notes: None		

ni_s soluble_ni_concentration

`soluble_ni_concentration`	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Soluble nickel concentration in the coolant to be used for crud formation		
Notes: None		

ni_p particulate_ni_concentration

`particulate_ni_concentration`	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Particulate nickel concentration in the coolant to be used for crud formation		
Notes: None		

cleanup_flow cleanup_flow

`cleanup_flow`	Float	Optional
Units: Percent (default)		
Applicable Value(s): ≥ 0, ≤ 100		
Limitation(s): None		
Description: Percent of rated chemistry cleanup flow rate		
Notes: Used only when coupled to CTF		

temp_pert temperature_multiplier temperature_adder

temp_pert	Float	Optional
Units: C(adder) (default)		
Applicable Value(s):		
Limitation(s): None		
Description: A multiplier and adder to be used to perform fuel temperature perturbations. The variables are used in the following equation: `perturbTemp=fuelTemp*multiplier+adder`		
Notes: This option is used only when using fuel temperature tables		

7.4 BLOCK CORE

name core_name

core_name	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Name of the reactor core		
Notes: None		

cycle cycle_num

cycle_num	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): The label can be alphanumeric, but integers are recommended. The previous cycle's label can be inferred for shuffling if an integer is used; otherwise, the user must specify the cycle label for every shuffle location		
Description: Cycle number		
Notes: None		

unit unit

unit	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is the reactor plant unit name. It is used only for multiunit sites with cross-unit shuffle		
Notes: None		

op_date operation_date

operation_date	Character String	Optional
Units: N/A		
Applicable Value(s):		

continued on next page...

`operation_date`, continued...

Limitation(s): Limited to `MM/DD/YYYY` or `YYYY/MM/DD`
Description: Startup date of core reload
Notes: Used only when performing core shuffle

size core_size

`core_size`	Integer	Required
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Number of assemblies across one axis in full-core geometry		
Notes: None		

rated rated_power rated_flow

`rated_power`	Float	Required
Units: MW (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Rated thermal power at 100% power		
Notes: None		

`rated_flow`	Float	Required
Units: Mlbs/hr (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Rated vessel flow at 100% flow		
Notes: None		

bypass_flow_table bypass_flow_table

`bypass_flow_table`	2D Float Table	Optional
Units: Percent (default)		
Applicable Value(s): 0 (default), ≥ 0		
Limitation(s): None		

Description: This is a 2D array with % rated power as the left-most column, % rated flow as the top row, with the remainder of the table being bypass flow rate as a percent of full-core flow at the corresponding data points. For example:
 	
`bypass_flow_table`
`30 70 100 105`
`50 13.3 14.2 14.8 15.0`
`100 13.0 13.9 14.5 14.7`
`105 12.9 13.8 14.4 14.6`		

continued on next page...

`bypass_flow_table`, continued...

Notes: BWR only

tinlet_table_unit temperature_unit

`tinlet_table_unit`	String	Optional
Units: N/A		
Applicable Value(s): K (default), C, F		
Limitation(s): None		
Description: This is the unit for inlet temperature defined in the `tinlet_table` input		
Notes: None		

tinlet_table inlet_temperature

`tinlet_table`	2D Float Table	Optional
Units: K (default), C, F		
Applicable Value(s): ≥ 0		
Limitation(s): None		

Description: This is a 2D array with % rated power as the left-most column, % rated flow as the top row, with the remainder of the table being inlet temperature at the corresponding data points. For example:
 	
`tinlet_table`
`20 598 K`
`50 595 K`
`70 593 K`
`90 590 K`
`100 587 K`		

Notes: Units of table are defined in the `tinlet_table_unit` input		

rcs_volume rcs_volume

`rcs_volume`	Float	Optional
Units: m^3 (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Volume of the reactor coolant system		
Notes: Used only with B-10 depletion		

apitch apitch

`apitch`	Float	Required
Units: cm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Assembly pitch		
Notes: None		

baffle baffle_mat baffle_gap baffle_thick

`baffle_mat`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Baffle material		
Notes: The `baffle` input is not valid for BWR calculations		

`baffle_gap`	Float	Optional
Units: cm (default)		
Applicable Value(s): = 0, or ≥ assembly gap and ≤ apitch − assembly gap		
Limitation(s): None		
Description: Gap between outside assembly (including assembly gap) and baffle		
Notes: The end of the `baffle_gap` must not fall in the assembly gap portion of the reflector assembly, as specified previously. Additionally, `baffle_gap` + `baffle_thick` must also not fall in the assembly gap portion of the assembly. Their sum must be exactly 0.0, exactly the assembly pitch, or between the assembly gap and the assembly pitch minus the assembly gap. In this context, the assembly gap is defined as $\frac{\text{apitch}-\text{npin}*\text{ppitch}}{2}$		

`baffle_thick`	Float	Optional
Units: cm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Thickness of baffle		
Notes: Restrictions on `baffle_thick` values are dependent on the `baffle_gap` value. See notes on `baffle_gap` for further detail		

pad pad_mat pad_inner_radius pad_outer_radius pad_arc pad_azi_locs

`pad_mat`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This input defines the material to be used for all neutron pads		
Notes: None		

`pad_inner_radius`	Float	Optional
Units: cm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: This input defines the inner radius to be used to construct all neutron pads		
Notes: None		

pad_outer_radius	Float	Optional
Units: cm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: This input defines the outer radius to be used to construct all neutron pads		
Notes: None		

pad_arc	Float	Optional
Units: degrees (default)		
Applicable Value(s):		
Limitation(s): None		
Description: This input defines the arc length to be used to construct all neutron pads		
Notes: None		

pad_azi_locs	Array of Floats	Optional
Units: degrees (default)		
Applicable Value(s):		
Limitation(s): None		
Description: This input defines the azimuthal angle location of each pad. These values should correspond to the centerpoint of each arc		
Notes: None		

pad_nonuniform_arc pad_nonuniform_arc

pad_nonuniform_arc	Array of Floats	Optional
Units: degrees (default)		
Applicable Value(s):		
Limitation(s): None		
Description: This input is used to define the arc length for each corresponding neutron pad location defined in the pad input. Therefore, pads can be of different arc lengths. If all pads are the same arc length, this input is not needed, and the single pad_arc value from the pad input will suffice		
Notes: This input requires the pad input to be defined		

vessel vessel_mats vessel_radii

vessel_mats	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Vessel materials		
Notes: Every vessel_mats must have a corresponding vessel_radii		

vessel_radii	Float	Optional
Units: cm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Vessel radii		
Notes: Every vessel_radii must have a corresponding vessel_mats. Example: vessel mod 187.9 ss 193.7 mod 219.1 ss 219.7 cs 241.3		

hole hole_x hole_y hole_radius

hole_x	Float	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: This input is used to specify the *x* location of the centerpoint of the hole being defined		
Notes: None		

hole_y	Float	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: This input is used to specify the *y* location of the centerpoint of the hole being defined		
Notes: None		

hole_radius	Float	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: This input is used to specify the radius of the hole being defined		
Notes: None		

core_shape core_shape

core_shape	2D Integer Map	Required
Units: N/A		
Applicable Value(s): 0 or 1		
Limitation(s): None		
Description: This is a square map showing the fuel assembly locations. Enter 1 for fuel assembly locations and 0 for empty locations		
Notes: None		

assm_map assm_map

assm_map	2D Character String Map	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a core map of the fuel assembly types. The assembly types correspond to assembly labels in the [ASSEMBLY] block. All fuel assemblies must have a type defined		
Notes: None		

inlet_orifice_map inlet_orifice_map

inlet_orifice_map	2D Character String Map	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a 2D array that must match the shape of assm_map in [CORE]. It specifies an ID for the inlet loss in that core location. The actual loss for the ID is later defined on the inlet_orifice_loss input. This input is only valid for BWRs		
Notes: None		

inlet_orifice_loss label form_loss_coefficient / area

label	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a label for the form loss being defined. It must match a label given in inlet_orifice_map		
Notes: All labels in the inlet_orifice_map array must be defined in the inlet_orifice_loss input		

form_loss_coefficient	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0.0		
Limitation(s): None		
Description: Form loss coefficient for the loss		
Notes: None		

area	Float	Optional
Units: cm^2 (default)		
Applicable Value(s): 64.516 (default), > 0.0		
Limitation(s): None		
Description: Flow area of the orifice being modeled by this loss. This input shall be identified by keyword as area=value		
Notes: This input is optional on this input and will default if not provided		

inlet_orifice_bypass_map inlet_orifice_map

inlet_orifice_map	2D Character String Map	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a 2D array that must match the shape of assm_map in [CORE]. It specifies an ID for the inlet loss in that core location's bypass. The actual loss for the ID is later defined on the inlet_orifice_bypass_loss input. This input is only valid for BWRs		
Notes: This map does nothing unless bypass_treatment is set to heating		

inlet_orifice_bypass_loss label form_loss_coefficient / area

label	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a label for the form loss being defined. It must match a label given in inlet_orifice_bypass_map		
Notes: All labels in the inlet_orifice_bypass_map array must be defined in the inlet_orifice_bypass_loss input		

form_loss_coefficient	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0.0		
Limitation(s): None		
Description: Form loss coefficient for the loss		
Notes: None		

area	Float	Optional
Units: cm^2 (default)		
Applicable Value(s): 64.516 (default), > 0.0		
Limitation(s): None		
Description: Flow area of the orifice being modeled by this loss. This input shall be identified by keyword as area=value		
Notes: This input is optional on this input and will default if not provided		

rotate_map rotate_map

rotate_map	2D Integer Map	Optional
Units: N/A		
Applicable Value(s): 0, 1, 2, or 3		
Limitation(s): None		
Description: Core map of clockwise 90-degree assembly rotations		

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`rotate_map`, continued...

Notes: None

insert_rotate_map insert_rotate_map

`insert_rotate_map`	2D Integer Map	Optional
Units: N/A		
Applicable Value(s): 0, 1, 2, or 3		
Limitation(s): None		
Description: Core map of clockwise 90-degree assembly insert rotations		
Notes: None		

insert_map insert_map

`insert_map`	2D Character String Map	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a core map of the fuel insert types and locations. The insert types correspond to insert labels in the `[INSERT]` block. Use a dash to specify assemblies with no inserts		
Notes: None		

det_map det_map

`det_map`	2D Character String Map	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a core map of the detector types and locations. The detector types correspond to detector labels in the `[DETECTOR]` block. Use a dash to specify assemblies with no detectors		
Notes: None		

crd_map crd_map

`crd_map`	2D Character String Map	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a core map of the control rod types and locations. The control rod types correspond to control rod labels in the `[CONTROL]` block. Use a dash to specify assemblies with no control rods		
Notes: None		

crd_bank crd_bank

crd_bank	2D Character String Map	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a core map of the control rod bank labels. These labels are used to position groups of control rods by bank label. Use a dash to specify assemblies with no control rods		
Notes: None		

nblade blade_size

blade_size	Integer	Required
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Maximum number of blades across one axis in full-core geometry		
Notes: None		

blade_map blade_map

blade_map	2D Character String Map	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a core map of the control blade types and locations. The control blade types correspond to control rod labels in the [CONTROL] block. Use a dash to specify assemblies with no control blades. The map must be in full symmetry, regardless of how other maps in the [CORE] block are entered		
Notes: None		

nbwrdet bwrdet_size

bwrdet_size	Integer	Required
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Maximum number of detectors across one axis in full-core geometry		
Notes: None		

bwrdet_map bwrdet_map

bwrdet_map	2D Character String Map	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a core map of the detector types and locations. The detector types correspond to detector labels in the [DETECTOR] block. Use a dash to specify assemblies with no detectors		

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`bwrdet_map`, continued...

Notes: None

lower_plate lower_mat lower_thick lower_vfrac

`lower_mat`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Lower core plate material		
Notes: None		

`lower_thick`	Float	Optional
Units: cm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Lower core plate thickness		
Notes: None		

`lower_vfrac`	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0,≤ 1		
Limitation(s): None		
Description: This is the lower core plate material volume fraction. The remainder of the volume fraction will be filled with moderator for PWRs and coolant for BWRs		
Notes: None		

upper_plate upper_mat upper_thick upper_vfrac

`upper_mat`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Upper core plate material		
Notes: None		

`upper_thick`	Float	Optional
Units: cm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Upper core plate thickness		
Notes: None		

upper_vfrac	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0,≤ 1		
Limitation(s): None		
Description: This is the upper core plate material volume fraction. The remainder of the volume fraction will be filled with moderator for PWRs and coolant for BWRs		
Notes: None		

bc_sym bc_sym

bc_sym	Character String	Optional
Units: N/A		
Applicable Value(s): rot (default), mir		
Limitation(s): None		
Description: This is the symmetry flag for the core when using quarter symmetry. This flag is not used in full symmetry		
Notes: None		

bc_bot bc_bot

bc_bot	Character String	Optional
Units: N/A		
Applicable Value(s): vacuum (default), reflecting		
Limitation(s): None		
Description: Bottom neutron transport boundary condition		
Notes: None		

bc_top bc_top

bc_top	Character String	Optional
Units: N/A		
Applicable Value(s): vacuum (default), reflecting		
Limitation(s): None		
Description: Top neutron transport boundary condition		
Notes: None		

bc_rad bc_rad

bc_rad	Character String	Optional
Units: N/A		
Applicable Value(s): vacuum (default), reflecting, periodic		
Limitation(s): None		
Description: Radial neutron transport boundary condition		
Notes: None		

xlabel xlabel

xlabel	Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a list of 2-character assembly position labels in the x direction. These values are used in the edit maps		
Notes: See Section 4.4 for more information and Section 6.1 for examples		

ylabel ylabel

ylabel	Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a list of 2-character assembly position labels in the y direction. These values are used in the edit maps		
Notes: See Section 4.4 for more information and Section 6.1 for examples		

label_format label_format

label_format	Character String	Optional
Units: N/A		
Applicable Value(s): x-y (default), y-x, .x-y, .y-x		
Limitation(s): None		
Description: This is the format of label entries in shuffle_label input		
Notes: None		

height height

height	Float	Required
Units: cm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: This is the total axial distance from bottom core plate to upper core plate. Distance does not include core plate thicknesses		
Notes: None		

boron_search_range min_boron max_boron

min_boron	Float	Optional
Units: ppm (default)		
Applicable Value(s): 0.1 (default), > 0		
Limitation(s): None		
Description: Minimum boron concentration for search		
Notes: None		

max_boron	Float	Optional
Units: ppm (default)		
Applicable Value(s): > 0		
Limitation(s): Must be larger than minium value		
Description: Maximum boron concentration for search		
Notes: None		

power_search_range min_power max_power

min_power	Float	Optional
Units: Percent (default)		
Applicable Value(s): 0.1 (default), > 0		
Limitation(s): None		
Description: Minimum percent power allowed in search		
Notes: None		

max_power	Float	Optional
Units: Percent (default)		
Applicable Value(s): > 0		
Limitation(s): Must be larger than minium value		
Description: Maximum percent power allowed in search		
Notes: None		

flow_search_range min_flow max_flow

min_flow	Float	Optional
Units: Percent (default)		
Applicable Value(s): 0.1 (default), > 0		
Limitation(s): None		
Description: Minimum percent flow allowed in search		
Notes: None		

max_flow	Float	Optional
Units: Percent (default)		
Applicable Value(s): > 0		
Limitation(s): Must be larger than minium value		
Description: Maximum percent flow allowed in search		
Notes: None		

tinlet_search_range min_tinlet max_tinlet temperature_units

min_tinlet	Float	Optional
Units: N/A		
Applicable Value(s): 0 (default), > 0		

continued on next page...

`min_tinlet`, continued...

Limitation(s): None
Description: Minimum inlet temperature used in search
Notes: None

`max_tinlet`	Float	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): Must be larger than minium value		
Description: Maximum inlet temperature used in search		
Notes: None		

`temperature_units`	String	Optional
Units: N/A		
Applicable Value(s): F, C, K		
Limitation(s): None		
Description: Inlet temperature units used for setting range		
Notes: None		

steam_gen_natcirc sg_height sg_flow_area sg_dh sg_length / sg_kf sg_epsr

`sg_height`	Float	Optional
Units: m (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Total axial distance from bottom core plate to steam generator exit. Required if natural circulation is turned on and reactor is a PWR		
Notes: None		

`sg_flow_area`	Float	Optional
Units: m^2 (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Total flow area of steam generator section. Required if natural circulation is turned on and reactor is a PWR		
Notes: None		

`sg_dh`	Float	Optional
Units: m (default)		
Applicable Value(s): > 0		
Limitation(s): None		

continued on next page...

sg_dh, continued...

Description: Steam generator hydraulic diameter. Required if natural circulation is turned on and reactor is a PWR
Notes: None

sg_length	Float	Optional
Units: m (default)		
Applicable Value(s): sg_length – sg_height (default), ≥ chimney_height – sg_height		
Limitation(s): None		
Description: Total flow length of the steam generator		
Notes: This input is not required on this input		

sg_kf	Float	Optional
Units: N/A		
Applicable Value(s): 0 (default), ≥ 0		
Limitation(s): None		
Description: Steam generator forms loss coefficient. This input shall be identified as loss=value		
Notes: This input is not required on this input		

sg_epsr	Float	Optional
Units: m (default)		
Applicable Value(s): 2.5E-6 (default), ≥ 0		
Limitation(s): None		
Description: Steam generator roughness. Not used if friction_correlation is 1 or 2. Default value is in the range of the absolute roughness of stainless steel. This input shall be identified as roughness=value		
Notes: This input is not required on this input		

chimney chimney_height chimney_area chimney_dh / chimney_kf chimney_epsr

chimney_height	Float	Optional
Units: m (default)		
Applicable Value(s): height (default), ≥ height		
Limitation(s): None		
Description: Total axial distance from bottom core plate to chimney exit. Absence means assumption that chimney is modeled in core model		
Notes: None		

chimney_area	Float	Optional
Units: m^2 (default)		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		

continued on next page...

`chimney_area`, continued...

Description: Chimney flow area. Required if `chimney_height` is given
Notes: None

`chimney_dh`	Float	Optional
Units: m (default)		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		
Description: Chimney hydraulic diameter. Required if `chimney_height` is given		
Notes: None		

`chimney_kf`	Float	Optional
Units: N/A		
Applicable Value(s): 0 (default), ≥ 0		
Limitation(s): None		
Description: Chimney forms loss coefficient. This input shall be identified as `loss=value`		
Notes: None		

`chimney_epsr`	Float	Optional
Units: m (default)		
Applicable Value(s): 2.5E-6 (default), ≥ 0		
Limitation(s): None		
Description: Chimney roughness. Not used if `friction_correlation` is 1 or 2. Default value is in the range of the absolute roughness of stainless steel. This input shall be identified as `roughness=value`		
Notes: None		

downcomer dc_height dc_area dc_dh / dc_kf dc_epsr

`dc_height`	Float	Optional
Units: m (default)		
Applicable Value(s): ≤ 0		
Limitation(s): None		
Description: Negative axial distance from top of the bottom core plate to downcomer exit. Required if natural circulation is turned on. Should usually be 0		
Notes: None		

`dc_area`	Float	Optional
Units: m^2 (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Downcomer flow area. Required if natural circulation is turned on		
Notes: None		

dc_dh	Float	Optional
Units: m (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Downcomer hydraulic diameter. Required if natural circulation is turned on		
Notes: None		

dc_kf	Float	Optional
Units: N/A		
Applicable Value(s): 0 (default), ≥ 0		
Limitation(s): None		
Description: Downcomer forms loss coefficient. This input shall be identified as `loss=value`		
Notes: None		

dc_epsr	Float	Optional
Units: m (default)		
Applicable Value(s): 2.5E-6 (default), ≥ 0		
Limitation(s): None		
Description: Downcomer roughness. Not used if `friction_correlation` is 1 or 2. Default value is in the range of the absolute roughness of stainless steel. This input shall be identified as `roughness=value`		
Notes: None		

mat mat

mat	Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Refer to the detailed materials description given in Chapter 4		
Notes: None		

lower_ref lower_refl_mats lower_refl_thicks lower_refl_vfracs

lower_refl_mats	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Lower reflector materials		
Notes: None		

lower_refl_thicks	Float	Optional
Units: cm (default)		
Applicable Value(s): ≥ 0		

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`lower_refl_thicks`, continued...

Limitation(s): None
Description: Lower reflector thicknesses
Notes: None

`lower_refl_vfracs`	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0,≤ 1		
Limitation(s): None		
Description: Lower reflector volume fractions. If less than one, the remainder of the volume fraction will be filled with moderator for PWRs and coolant for BWRs		
Notes: None		

upper_ref upper_refl_mats upper_refl_thicks upper_refl_vfracs

`upper_refl_mats`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Upper reflector materials		
Notes: None		

`upper_refl_thicks`	Float	Optional
Units: cm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Upper reflector thicknesses		
Notes: None		

`upper_refl_vfracs`	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0,≤ 1		
Limitation(s): None		
Description: Upper reflector volume fractions. If less than one, the remainder of the volume fraction will be filled with moderator for PWRs and coolant for BWRs		
Notes: None		

reactor_type reactor_type

`reactor_type`	Character String	Optional
Units: N/A		
Applicable Value(s): PWR (default), BWR		
Limitation(s): None		

continued on next page...

`reactor_type`, continued...

Description: Model reactor type
Notes: None

source mat_id iso_id iso_scal / spectrum(:) / stt_str str_mult

`mat_id`	Integer	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is an integer ID corresponding to the material of external source		
Notes: None		

`iso_id`	Integer	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is an integer value representing an isotope on whose absolute atom quantity the source strength will be scaled. The input should follow the format ZZAAA. Omitting this value indicates that no isotope will be used, and the user will provide an absolute strength flux spectrum		
Notes: None		

`iso_scale`	Float	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a positive real number corresponding to the scaling factor to use when scaling the fractional flux spectrum to its absolute strength. This scaling is in terms of the number of atoms of the scaling isotope in a given FSR. Units are in neutrons per second per unit volume (cc) per number of isotope atoms. This value is required only if the user provides `iso_id(i)`		
Notes: None		

`spectrum`	Float	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This contains positive real values corresponding to the either the fractional or absolute source spectrum. If scaling isotope information is provided, this represents a fractional spectrum; otherwise, it represents an absolute spectrum in units of neutrons per second per unit of volume (cc). The number of values must match the number of energy groups of the problem. Values cannot be negative and must sum to nearly 1.0 if the input corresponds to a fractional spectrum		
Notes: None		

stt_str	Float	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a real number greater than 0.0 and less than or equal to 1.0 corresponding to the fractional starting strength of the source. This is how much of the source will be applied during the first external source iteration. If this value is not provided, it will default to full strength		
Notes: None		

str_mult	Float	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a real number greater than 1.0 corresponding to the multiplicative increase of the source strength. If stt_str is provided, then this value must be provided		
Notes: None		

steam_generator sg_type sg_alloy sg_area sg_plug_frac

sg_type	Character String	Optional
Units: none (default)		
Applicable Value(s): oncethrough, utube		
Limitation(s): None		
Description: Steam generator type		
Notes: Used in the chemistry source term calculation to calculate coolant temperatures		

sg_alloy	Integer	Optional
Units: none (default)		
Applicable Value(s): 600, 690, 800, 304		
Limitation(s): None		
Description: Steam generator tubing stainless steel alloy number		
Notes: This is used in the chemistry source term calculation to determine surface material properties		

sg_area	Float	Optional
Units: m^2 (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Total surface area of steam generator tubing		
Notes: This is used in the chemistry source term calculation to determine amount of source term created		

sg_plug_frac	Float	Optional
Units: none (default)		

continued on next page...

sg_plug_frac, continued...

Applicable Value(s): ≥ 0,≤ 1
Limitation(s): None
Description: Steam generator plugged area fraction
Notes: The effective area of the steam generator used in the chemistry source term calculation is $sg\_area * (1 - plug\_frac)$

hot_leg_piping hot_leg_alloy hot_leg_area

hot_leg_alloy	Integer	Optional
Units: none (default)		
Applicable Value(s): 600, 690, 800, 304		
Limitation(s): None		
Description: Hot leg piping stainless steel alloy number		
Notes: This is used in the chemistry source term calculation to determine surface material properties		

hot_leg_area	Float	Optional
Units: m^2 (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Total surface area of hot leg piping		
Notes: This is used in the chemistry source term calculation to determine amount of source term created		

cold_leg_piping cold_leg_alloy cold_leg_area

cold_leg_alloy	Integer	Optional
Units: none (default)		
Applicable Value(s): 600, 690, 800, 304		
Limitation(s): None		
Description: Cold leg piping stainless steel alloy number		
Notes: This is used in the chemistry source term calculation to determine surface material properties		

cold_leg_area	Float	Optional
Units: m^2 (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Total surface area of cold leg piping		
Notes: This is used in the chemistry source term calculation to determine amount of source term created		

cleanup_rated_flow cleanup_rated_flow

cleanup_rated_flow	Float	Optional
Units: kg/s (default)		

continued on next page...

`cleanup_rated_flow`, continued...

Applicable Value(s): ≥ 0
Limitation(s): None
Description: Rated flow rate of coolant chemistry cleanup system
Notes: None

material_perturbation_file material_perturbation_file

`material_perturbation_file`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Name of HDF5 file that contains material perturbation information		
Notes: None		

bioshield bioshield

`bioshield`	Strings and Doubles	Optional
Units: N/A		
Applicable Value(s): `none` (default)		
Limitation(s): None		
Description: Bioshield materials and radii beyond the vessel used to automatically generate an Omnibus excore input		
Notes: Materials must be defined in the Omnibus template input		

det det

`det`	Strings and Doubles	Optional
Units: N/A		
Applicable Value(s): `none` (default)		
Limitation(s): None		
Description: These are the defined detector types for automatic generation of an Omnibus excore input—requires `bioshield` input		
Notes: Materials must be defined in the Omnibus template input		

det_locations det_locations

`det_locations`	Strings and Doubles	Optional
Units: N/A		
Applicable Value(s): `none` (default)		
Limitation(s): None		
Description: These are the defined detector locations for automatic generation of an Omnibus excore input—requires `bioshield` and `det` inputs		
Notes: Materials must be defined in the Omnibus template input		

7.5 BLOCK ASSEMBLY

title title

`title`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Long descriptive title for assembly		
Notes: None		

npin npin

`npin`	Integer	Required
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The number of rods along the edge of an assembly		
Notes: None		

ppitch ppitch

`ppitch`	Float	Required
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Pincell pitch		
Notes: None		

cell cell

`cell`	Character Strings and Floats	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Refer to the cell description given in Section 2.3.2		
Notes: None		

lattice lattice

`lattice`	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is an obsolete alias for `rodmap`. Use `rodmap` instead		
Notes: None		

rodmap axial_label cell_map

`axial_label`	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Label for this axial elevation description		
Notes: See Section 2.3.3 for examples		

`cell_map`	2D Character String Map	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is the lattice map for this axial elevation. Use a dash for an empty location		
Notes: See Section 2.3.3 for examples		

axial Label axial_labels axial_elevations

`Label`	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is the label for this assembly. The label corresponds to `assm_map` in `[CORE]` block		
Notes: See Section 2.3.4 for examples		

`axial_labels`	Character Strings	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a list of axial labels for this assembly description, corresponding to labels in lattice maps		
Notes: See Section 2.3.4 for examples		

`axial_elevations`	Float	Required
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: List of axial elevations for this assembly description		
Notes: See Section 2.3.4 for examples		

rpdlm label rpdlm_exposure rpdlm_power

label	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Label for this assembly. Label corresponds to assm_map in [CORE] block		
Notes: None		

rpdlm_exposure	Float	Optional
Units: GWDMT (default)		
Applicable Value(s): ≥ 0		
Limitation(s): Values must be listed in increasing order		
Description: Assembly-averaged exposure values that form the intervals of the piecewise rpdlm function. The first exposure value is implied to be zero. Consecutive exposure points form an exposure interval over which the provided linear heat rate limits are interpolated. The last exposure value is taken to be infinity		
Notes: None		

rpdlm_power	Float	Optional
Units: kW/ft (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Linear heat rate limit values that will be used to form the piecewise rpdlm function. The first rpdlm segment is assumed to be constant at the first provided heat rate over the exposure interval from 0.0 GWd/MT to the first exposure value. Subsequent limits are defined by the line segment between consecutive exposure/power pairs. The final segment is constant at the last specified heat rate from the last specified exposure through infinite exposure		
Notes: None		

grid label material height mass / loss lossmap blockage gridmap yhl1 yhl2 area

label	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Grid label for a single grid type		
Notes: See Section 2.3.5 for examples		

material	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Grid material for this grid type		
Notes: See Section 2.3.5 for examples		

height	Float	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Grid height for this grid type		
Notes: See Section 2.3.5 for examples		

mass	Float	Optional
Units: g (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Grid mass for this grid type		
Notes: See Section 2.3.5 for examples		

loss	Float	Optional
Units: N/A		
Applicable Value(s): 0.0 (default), ≥ 0.0		
Limitation(s): None		
Description: Loss coefficient for the spacer grid. Do not provide `lossmap` input if providing this input. This input shall be identified by keyword as `loss=value`		
Notes: This input is not required on this input		

lossmap	String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Provides the name of a loss coefficient map to be entered elsewhere in the [ASSEMBLY] block. This name must match a `lossmap_name` entered in a `lossmap` entry of the input. This optional input shall be identified by keyword as `lossmap=lossmap_name`		
Notes: This input is not required on this input		

blockage	Float	Optional
Units: N/A		
Applicable Value(s): 0.0 (default), ≥ 0.0 and <1.0		
Limitation(s): None		
Description: Provides the blockge ratio of this spacer grid. A value of zero means the spacer grid does not block the flow area and a value of 0.1 means it blocks 10% of the flow area (for example). Do not provide this input if providing the `gridmap` optional input. This input shall be identified by keyword as `blockage=value`		
Notes: This input is not required on this input		

gridmap	String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Provides the name of the ROTHCON dataset to use for modeling grid heat transfer and turbulence enhancement effects. Do not provide a `blockage` input for this grid if specifying this input. The specified name must exist in a ROTHCON data file that is in the directory where the simulation will be run. This input shall be identified by keyword as `gridmap=value`		
Notes: This input is not required on this input		

yhl1	Float	Optional
Units: N/A		
Applicable Value(s): 5.55 (default), ≥0.0		
Limitation(s): None		
Description: This is a coefficient in the Yao-Hochreiter-Leech grid spacer heat transfer enhancement model. The model has the form, $M = \left(1 + yhl_1 \epsilon^2 \exp\left[yhl_2 \frac{z}{D}\right]\right)$, where M is the heat transfer coefficient multiplier, z is the downstream distance from the grid location, and D is the hydraulic diameter. The ϵ (blockage ratio), yhl_1, and yhl_2 terms are all user inputs that can be set for this spacer grid. This input provides the yhl_1 value. All parameters will default if not set by the user. This input shall be identified by keyword as `yhl1=value`		
Notes: This input is not required on this input. Do not enter this input if using a *gridmap*		

yhl2	Float	Optional
Units: N/A		
Applicable Value(s): -0.13 (default)		
Limitation(s): None		
Description: This is a coefficient in the Yao-Hochreiter-Leech grid spacer heat transfer enhancement model. The model has the form, $M = \left(1 + yhl_1 \epsilon^2 \exp\left[yhl_2 \frac{z}{D}\right]\right)$, where M is the heat transfer coefficient multiplier, z is the downstream distance from the grid location, and D is the hydraulic diameter. The ϵ (blockage ratio), yhl_1, and yhl_2 terms are all user inputs that can be set for this spacer grid. This input provides the yhl_2 value. All parameters will default if not set by the user. This input shall be identified by keyword as `yhl2=value`		
Notes: This input is not required on this input. Do not enter this input if using a *gridmap*		

area	Float	Optional
Units: cm^2 (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Provides the reference area for the spacer grid loss coefficient. If this is a BWR model and this input is not provided, then this will have a default of 64.516 cm^2 (10 in^2). If this is a PWR model, this input has no effect. This reference area is used to adjust the form loss coefficient for a reference area. If the form loss coefficient provided is the actual form loss coefficient, then the true flow area of the bundle should be provided		
Notes: None		

lossmap lossmap_name loss_coeff_map

`lossmap_name`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The name for this map of loss coefficients		
Notes: None		

`loss_coeff_map`	2D Float Map	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: A 2D map of loss coefficients. The shape of the map shall be identical to the rod lattice shape for the assembly which the loss map is being defined. Each loss coefficient will be applied to the flow adjacent to the rod for which it is defined		
Notes: None		

grid_axial grid_map grid_elev

`grid_map`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a list of spacer grid labels for all grids in an assembly. All labels must correspond to `grid` input		
Notes: See Section 2.3.5 for examples		

`grid_elev`	Float	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: This is a list of spacer grid elevations for all grids in an assembly. Elevations refer to the grid midpoint		
Notes: See Section 2.3.5 for examples		

lower_nozzle lower_nozzle_comp lower_nozzle_height lower_nozzle_mass / loss area

`lower_nozzle_comp`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Lower nozzle material		
Notes: None		

lower_nozzle_height	Float	Optional
Units: cm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Lower nozzle height		
Notes: None		

lower_nozzle_mass	Float	Optional
Units: g (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: This is the lower nozzle mass. The code will calculate the volume of the nozzle given the nozzle mass and will fill the remaining volume with either moderator for PWRs or coolant for BWRs		
Notes: None		

loss	Float	Optional
Units: N/A		
Applicable Value(s): 0.0 (default), ≥ 0.0		
Limitation(s): None		
Description: Loss coefficient associated with the lower nozzle. The input shall be identified by keyword as `loss=value`		
Notes: This input is optional on this input and will default if not provided		

area	Float	Optional
Units: cm^2 (default)		
Applicable Value(s): 64.516 (default), > 0.0		
Limitation(s): None		
Description: Area associated with the lower nozzle. This input shall be identified by keyword as `area=value`		
Notes: This input is optional on this input and will default if not provided		

upper_nozzle upper_nozzle_comp upper_nozzle_height upper_nozzle_mass / loss area

upper_nozzle_comp	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Upper nozzle material		
Notes: None		

upper_nozzle_height	Float	Optional
Units: cm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Upper nozzle height		
Notes: None		

upper_nozzle_mass	Float	Optional
Units: g (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: This is the upper nozzle mass. The code will calculate the volume of the nozzle given the nozzle mass and will fill the remaining volume with either moderator for PWRs or coolant for BWRs		
Notes: None		

loss	Float	Optional
Units: N/A		
Applicable Value(s): 0.0 (default), ≥ 0.0		
Limitation(s): None		
Description: Loss coefficient associated with the upper nozzle. The input shall be identified by keyword as `loss=value`		
Notes: This input is optional on this input and will default if not provided		

area	Float	Optional
Units: cm^2 (default)		
Applicable Value(s): 64.516 (default), > 0.0		
Limitation(s): None		
Description: Area associated with the upper nozzle. The input shall be identified by keyword as `area=value`		
Notes: This input is optional on this input and will default if not provided		

fuel fuel

fuel	Character String and Floats	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Refer to the detailed fuel materials description given in Section 3.3		
Notes: None		

mat mat

mat	Character Strings and Floats	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Refer to the detailed materials description given in Section 3.1		
Notes: None		

gap gapw gapn

gapw	Float	Optional
Units: cm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Wide-gap width		
Notes: BWR only		

gapn	Float	Optional
Units: cm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Narrow-gap width		
Notes: BWR only		

channel_box chanmat cornerth chanrad

chanmat	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Channel box material		
Notes: None		

cornerth	Float	Optional
Units: cm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Channel box corner thickness		
Notes: None		

chanrad	Float	Optional
Units: cm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		

continued on next page...

chanrad, continued...

Description: Channel box inside corner radius
Notes: None

channel_box_segments chanth chanlen chanramp

chanth	Float	Optional
Units: cm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Thickness of a channel box segment		
Notes: Addition information provided in Section 2.3.1		

chanlen	Float	Optional
Units: cm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Length of channel box segment		
Notes: Addition information provided in Section 2.3.1		

chanramp	Float	Optional
Units: N/A, cm		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Length of channel box segment ramp		
Notes: Addition information provided in Section 2.3.1		

temptable temptable

temptable	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): Requires a temperature table file to be included		
Description: This flag defines a temperature table in the assembly block that can be used in the cell definitions; each cell can have a separate table if desired		

continued on next page...

`temptable`, continued...

Notes: Tables as generated through the BISON temperature table process, which define `temptable_boundary`, `temptable_qprime`, and `temptable_polynomial`, can be included after the tag is specified. See the following example for usage with specification in the cell flag: temptable U26 include u26.tab temptable GAD include ug3.tab cell 2 0.4096 0.418 0.475 / U26 he zirc4 / U26 cell 3 0.4096 0.418 0.475 / UG3 he zirc4 / GAD

xcentoffset xcentoffset

`xcentoffset`	2D Float Map	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): This input cannot cause the pin to be clipped by the surrounding cell		
Description: This input will shift the pin centroid along the x axis. Positive values will shift the pin to the right, and negative values will shift to the left		
Notes: None		

ycentoffset ycentoffset

`ycentoffset`	2D Float Map	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): This input cannot cause the pin to be clipped by the surrounding cell		
Description: This input will shift the pin centroid along the y axis. Positive values will shift the pin up, and negative values will shift it down		
Notes: None		

7.6 BLOCK CONTROL

title title

`title`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Long descriptive title for control rod description		
Notes: None		

npin num_pins

num_pins	Integer	Required
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The number of rods along the edge of an assembly		
Notes: None		

stroke stroke maxstep

stroke	Float	Required
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Control rod stroke—distance between full insertion and full withdrawal		
Notes: See Section 2.4.1 for examples		

maxstep	Float	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Total number of steps between full insertion and full withdrawal		
Notes: See Section 2.4.1 for examples		

cell cell

cell	Character Strings and Floats	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Refer to the cell description given in Section 2.4		
Notes: None		

lattice lattice

lattice	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is an obsolete alias for rodmap. Use rodmap instead		
Notes: None		

rodmap label cell_map

label	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Label for this axial elevation description		
Notes: See Section 2.4 for examples		

cell_map	2D Character String Map	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a lattice map for this axial elevation. Use a dash for no control rod		
Notes: See Section 2.4 for examples		

axial control_label axial_labels axial_elevations

control_label	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is the label for this control rod description—corresponds to crd_map in [CORE] block		
Notes: See Section 2.4 for examples		

axial_labels	Character Strings	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: List of axial labels for this control rod description—corresponds to labels in rod maps		
Notes: See Section 2.4 for examples		

axial_elevations	Float	Required
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: List of axial elevations for this control rod description		
Notes: See Section 2.4 for examples		

mat mat

mat	Character Strings and Floats	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		

continued on next page...

mat, continued...

Description: Refer to the detailed materials description given in Section 3.1
Notes: None

bladegeom bladegeomlabel span thickness tipradius sheaththickness winglength

bladegeomlabel	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Unique label name for each blade geometry specification		
Notes: None		

span	Float	Optional
Units: cm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Control blade span from center to wing tip		
Notes: None		

thickness	Float	Optional
Units: cm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Control blade wing thickness		
Notes: None		

tipradius	Float	Optional
Units: cm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Radius of control blade tip		
Notes: None		

sheaththickness	Float	Optional
Units: cm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Control blade sheath thickness		
Notes: None		

winglength	Float	Optional
Units: cm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Blade central structure wing length		
Notes: None		

bladetype bladetypelabel bladegeomlabel blademat tubeorient ntube tubecelllist

bladetypelabel	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Unique label name for each blade geometry, material, and absorber loading		
Notes: None		

bladegeomlabel	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Unique label name for each blade geometry specification		
Notes: None		

blademat	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Sheath and wing material		
Notes: None		

tubeorient	Character String	Optional
Units: N/A		
Applicable Value(s): vert (default), hor		
Limitation(s): None		
Description: This specifies whether the tubes are inserted vertically or horizontally in the control blade. If the option is horizontal, MPACT will internally rotate and adjust them to model them vertically		
Notes: None		

ntube	Integer	Optional
Units: N/A		
Applicable Value(s): ≥ 0		
Limitation(s): None		

continued on next page...

ntube, continued...

Description: Number of rodlets in control blade wing
Notes: None

tubecelllist	Character String Array	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: A spatially dependent list of cell (rodlet) labels. The list of cells are added from left to right from the center of the control blade to the tip. The number of labels in the list must match the value of ntube		
Notes: None		

7.7 BLOCK INSERT

title title

title	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Long descriptive title for assembly insert description		
Notes: None		

npin num_pins

num_pins	Integer	Required
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The number of rods along the edge of an assembly		
Notes: None		

cell cell

cell	Character Strings and Floats	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Refer to the cell description given in Section 2.5		
Notes: None		

lattice lattice

lattice	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is an obsolete alias for `rodmap`. Use `rodmap` instead		
Notes: None		

rodmap label cell_map

label	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Label for this axial elevation description		
Notes: See Section 2.5 for examples		

cell_map	2D Character String Map	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is the lattice map for this axial elevation. Use a dash for no insert rod		
Notes: See Section 2.5 for examples		

axial control_label axial_labels axial_elevations

control_label	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is the label for this assembly insert description. It corresponds to `insert_map` in `[CORE]` block		
Notes: See Section 2.5 for examples		

axial_labels	Character Strings	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a list of axial labels for this assembly insert description. It corresponds to labels in rod maps		
Notes: See Section 2.5 for examples		

axial_elevations	Float	Required
Units: cm (default)		

continued on next page...

`axial_elevations`, continued...

Applicable Value(s):
Limitation(s): None
Description: List of axial elevations for this assembly insert description
Notes: See Section 2.5 for examples

mat mat

`mat`	Character Strings and Floats	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Refer to the detailed materials description given in Section 3.1		
Notes: None		

7.8 BLOCK DETECTOR

title title

`title`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Long descriptive title for detector		
Notes: None		

type detector_type

`detector_type`	Character String	Optional
Units: N/A		
Applicable Value(s): u235 (default), v, rh, gamma, gamma_approx		
Limitation(s): None		
Description: This is a flag used to specify the type of detector to be modeled. `u235` is the ^{235}U fission reaction rate, `v` is the absorption reaction rate in vanadium, `rh` is the absorption reaction rate in rhodium, `gamma` is the total gamma reaction rate in titanium, and `gamma_approx` is an approximate gamma response using the fastest neutron flux		
Notes: None		

npin num_pins

`num_pins`	Integer	Required
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The number of rods along the edge of an assembly		
Notes: None		

cell cell

`cell`	Character Strings and Floats	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Refer to the cell description given in Section 2.6		
Notes: None		

lattice lattice

`lattice`	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is an obsolete alias for `rodmap`. Use `rodmap` instead		
Notes: None		

rodmap label cell_map

`label`	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Label for this axial elevation description		
Notes: See Section 2.6 for examples		

`cell_map`	2D Character String Map	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is the lattice map for this axial elevation. Use a dash for no detector rod		
Notes: See Section 2.6 for examples		

axial detector_label axial_labels axial_elevations

`detector_label`	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is the label for this detector description. It corresponds to `det_map` in `[CORE]` block		
Notes: See Section 2.6 for examples		

axial_labels	Character Strings	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is the list of axial labels for this detector description. It corresponds to labels in rod maps		
Notes: See Section 2.6 for examples		

axial_elevations	Float	Required
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: List of axial elevations for this detector description		
Notes: See Section 2.6 for examples		

mat mat

mat	Character Strings and Floats	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Refer to the detailed materials description given in Section 3.1		
Notes: None		

7.9 BLOCK EDITS

axial_edit_bounds axial_edit_bounds

axial_edit_bounds	Float	Required
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: The boundaries of the axial regions over which axial information should be printed		
Notes: See Section 2.8 for examples		

axial_edit_mesh_delta axial_edit_mesh_delta

axial_edit_mesh_delta	Float	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Produces a uniform axial output grid (integrates pin powers over a uniform axial mesh)		
Notes: None		

points points_type points_dim1 points_dim2 points_dim3

points_type	Character String	Optional
Units: N/A		
Applicable Value(s): CART,RTHETA		
Limitation(s): None		
Description: Type of coordinate system to be used to define point edits		
Notes: None		

points_dim1	Float	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: This is the first dimension in point edit. If points_type is CART, then dim1 represents X. If points_type is RTHETA, then dim1 represents R		
Notes: None		

points_dim2	Float	Optional
Units: cm(CART), degrees(RTHETA) (default)		
Applicable Value(s):		
Limitation(s): None		
Description: This is the second dimension in point edit. If points_type is CART, then dim2 represents Y. If points_type is RTHETA, then dim2 represents Theta		
Notes: None		

points_dim3	Float	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: This is the third dimension in point edit. If points_type is CART, then dim3 represents Z. If points_type is RTHETA, then dim3 represents Z		
Notes: None		

edit_group edit_group

edit_group	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is a list of edits that can be turned on or off as a group using the edit input in the [STATE] block		
Notes: There are known issues with naming the same edit in multiple groups. It is best to name each edit in at most one edit_group input to prevent unpredictable behavior		

edit_scrape edit_scrape

edit_scrape	Table of String, Doubles and ints. Each row in the table has length 8	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This input specifies an area on the specified rod surface over which a crud scrape is generated. The scrape location is specified as follows: • <scrape_id>: String. Unique scrape identifier • <asm_col_row>: String. Assembly label. Dashed delimited ex: 'H-2' • <pin_row>: Int. CTF pin row in assembly • <pin_col>: Int. CTF pin column in assembly • <min_th>: Float. Minimum azimuthal scrape angle in degrees, 0 degrees points due east • <max_th>: Float. Maximum azimuthal scrape angle in degrees • <min_z>: Float. Minimum axial scrape location in cm • <max_z>: Float. Maximum axial scrape location in cm		
Notes: This is needed only for specifying crud scrape locations		

detector_mesh detector_mesh_type detector_mesh

detector_mesh_type	Character String	Optional
Units: N/A		
Applicable Value(s): pointwise, integral		
Limitation(s): None		
Description: Defines which detector responses should be edited. pointwise will edit the detector response at the meshes provided, whereas integral will provide the integral detector response between meshes		
Notes: None		

detector_mesh	Array of Floats	Optional
Units: cm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): Must be listed in ascending order		
Description: Axial heights used to define detector response		
Notes: None		

7.10 BLOCK SHIFT

num_threads num_threads

num_threads	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		
Description: Number of threads per processor		
Notes: Applicable to threaded machines		

num_rejection_samples num_rejection_samples

num_rejection_samples	Integer	Optional
Units: N/A		
Applicable Value(s): 1000 (default), > 0		
Limitation(s): None		
Description: Number of allowed initial source sampling rejections		
Notes: None		

seed seed

seed	Integer	Optional
Units: N/A		
Applicable Value(s): 121434 (default), > 0		
Limitation(s): None		
Description: Initial seed for random number generator (global)		
Notes: None		

ce_lib_path ce_lib_path

ce_lib_path	String	Optional
Units: N/A		
Applicable Value(s): ce_v7.1_endf.h5 (default)		
Limitation(s): None		
Description: Path to SCALE continuous energy (CE) data library file		
Notes: None		

transfer transfer

transfer	String	Optional
Units: N/A		
Applicable Value(s): Depends on coupling (default), all, fiss_src, isotopics, temps		
Limitation(s): None		
Description: What to transfer with VERA		
Notes: None		

temp_transfer temp_transfer

temp_transfer	String	Optional
Units: N/A		
Applicable Value(s): all (default), all, none, pin		
Limitation(s): None		
Description: Which temperatures to couple with CTF		
Notes: None		

verbosity verbosity

verbosity	String	Optional
Units: N/A		
Applicable Value(s): none (default), none, low, medium, high		
Limitation(s): None		
Description: How often to print about particles being transported		
Notes: None		

balance_tol balance_tol

balance_tol	Double	Optional
Units: N/A		
Applicable Value(s): 0.5 (default), (0,1)		
Limitation(s): None		
Description: Tolerance for checking balance of CE cross sections		
Notes: None		

n_energy_min n_energy_min

n_energy_min	Double	Optional
Units: eV (default)		
Applicable Value(s): 0.00001 (default), > 0		
Limitation(s): None		
Description: Minimum neutron energy for transport		
Notes: None		

n_energy_max n_energy_max

n_energy_max	Double	Optional
Units: eV (default)		
Applicable Value(s): 20.0e6 (default), > 0		
Limitation(s): None		
Description: Maximum neutron energy for transport		
Notes: None		

broaden_xs broaden_xs

broaden_xs	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Cross section Doppler broadening for temperature		
Notes: None		

temperature_tol temperature_tol

temperature_tol	Double	Optional
Units: K (default)		
Applicable Value(s): 4.0 (default), > 0		
Limitation(s): None		
Description: Tolerance for reusing existing broadened cross sections		
Notes: None		

union_energy union_energy

union_energy	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: Unionize lower and upper library temperature energy grids		
Notes: None		

delta_t delta_t

delta_t	Double	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), > 0		
Limitation(s): None		
Description: Finite difference grid spacing for Leal-Hwang temperature interpolation of cross sections		
Notes: None		

energy_tol energy_tol

energy_tol	Double	Optional
Units: N/A		
Applicable Value(s): 1.0E-10 (default), (0,1)		
Limitation(s): None		
Description: Relative difference for considering two energy points equal		
Notes: None		

kinematics kinematics

kinematics	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Apply broadening to collision data		
Notes: None		

dbrc dbrc

dbrc	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: Apply Doppler broadening resonance correction		
Notes: None		

global_log global_log

global_log	String	Optional
Units: N/A		
Applicable Value(s): info (default), debug, diagnostic, status, info, warning, error, critical		
Limitation(s): None		
Description: Level of global log information		
Notes: None		

local_log local_log

local_log	String	Optional
Units: N/A		
Applicable Value(s): error (default), debug, diagnostic, status, info, warning, error, critical		
Limitation(s): None		
Description: Level of local node log information		
Notes: None		

do_debug_history_tally do_debug_history_tally

do_debug_history_tally	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Output a particle history diagnostic tally if error occurs		
Notes: None		

log_memory log_memory

log_memory	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Output debug memory usage to stderr		
Notes: None		

do_micro_tally do_micro_tally

do_micro_tally	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Tally micro-reactions in eigenvalue mode		
Notes: Eigenvalue mode only		

do_transport do_transport

do_transport	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: Perform Monte Carlo transport		
Notes: None		

do_output do_output

do_output	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: Do Shift output		
Notes: None		

micro_zaids micro_zaids

micro_zaids	Array of Integers	Optional
Units: N/A		
Applicable Value(s): 92235, 92238 (default)		
Limitation(s): None		
Description: Nuclides to tally micro-reactions in eigenvalue mode		
Notes: Eigenvalue mode only		

micro_rxns micro_rxns

micro_rxns	Array of Integers	Optional
Units: N/A		
Applicable Value(s): 18, 102 (default)		
Limitation(s): None		
Description: MT of micro-reactions to tally in eigenvalue mode		
Notes: Eigenvalue mode only		

gamma_flux gamma_flux

gamma_flux	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Tally the photon flux in each pincell		
Notes: None		

lost_particle_error_tol lost_particle_error_tol

lost_particle_error_tol	Double	Optional
Units: N/A		
Applicable Value(s): 1E-06 (default), > 0		
Limitation(s): None		
Description: Fraction of lost particles to tolerate before aborting		
Notes: None		

num_cycles num_cycles

num_cycles	Integer	Optional
Units: N/A		
Applicable Value(s): 50 (default), > 0		
Limitation(s): None		
Description: Number of eigenvalue cycles		
Notes: None		

num_inactive_cycles num_inactive_cycles

num_inactive_cycles	Integer	Optional
Units: N/A		
Applicable Value(s): 10 (default), > 0		
Limitation(s): None		
Description: Number of inactive eigenvalue cycles		
Notes: None		

Np Np

Np	Double	Optional
Units: N/A		
Applicable Value(s): 1000 (default), > 0		
Limitation(s): None		
Description: Number of particles to transport		
Notes: None		

transport transport

transport	String	Optional
Units: N/A		
Applicable Value(s): ce (default), ce, mg		
Limitation(s): None		
Description: Type of physics		
Notes: None		

problem_mode problem_mode

problem_mode	String	Optional
Units: N/A		
Applicable Value(s): eigenvalue (default), cadis, eigenvalue, forward, fwcadis		
Limitation(s): None		
Description: Run mode		
Notes: None		

problem_name problem_name

problem_name	String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Base prefix name for all Shift-produced output files		
Notes: None		

mode mode

mode	String	Optional
Units: N/A		
Applicable Value(s): n (eigenvalue), np (forward) (default), n, np		
Limitation(s): None		
Description: Type of particles to transport		
Notes: None		

output_geometry output_geometry

output_geometry	Boolean	Optional
Units: N/A		
Applicable Value(s): true (default), false		
Limitation(s): None		
Description: Output HDF5 files of ray-traced geometry (initial) and compositions (each state)		
Notes: None		

output_fission_source output_fission_source

output_fission_source	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Output the initial fission source for each state		
Notes: None		

output_external_source output_external_source

output_external_source	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Output the external source for each state		
Notes: None		

output_micro_tally output_micro_tally

output_micro_tally	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Output micro-reaction tallies		
Notes: None		

output_ww output_ww

output_ww	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Output the weight windows		
Notes: None		

thermal_energy_cutoff thermal_energy_cutoff

thermal_energy_cutoff	Double	Optional
Units: eV (default)		
Applicable Value(s): 10.0 (default), > 0		
Limitation(s): None		
Description: Cutoff for treatment of thermal neutrons		
Notes: None		

excore_filename excore_filename

excore_filename	String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Name of Omnibus XML file with excore features and tallies		
Notes: None		

raytrace_levels raytrace_levels

raytrace_levels	Array of Doubles	Optional
Units: N/A		
Applicable Value(s): midpoint of active fuel (default)		
Limitation(s): None		
Description: Z levels to raytrace geometry and output		
Notes: None		

raytrace_resolution raytrace_resolution

raytrace_resolution	Integer	Optional
Units: N/A		
Applicable Value(s): 1024 (default), > 0		
Limitation(s): None		
Description: Resolution for geometry raytrace		
Notes: None		

vera_pressure_vessel vera_pressure_vessel

vera_pressure_vessel	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Pull in the pressure vessel from the VERA geometry		
Notes: Applicable to excore only		

fiss_src_spectrum fiss_src_spectrum

fiss_src_spectrum	String	Optional
Units: N/A		
Applicable Value(s): nuclide_watt (default), u235_watt,mpact,nuclide_watt		
Limitation(s): None		
Description: The type of fission source spectrum to use		
Notes: None		

rtk_output_format rtk_output_format

rtk_output_format	String	Optional
Units: N/A		
Applicable Value(s): hdf5 (default), hdf5,xml		
Limitation(s): None		
Description: The type of file format for the core dumped geometry description		
Notes: Applicable to eigenvalue and CADIS modes with `output_geometry` on		

use_pole_data use_pole_data

use_pole_data	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Use the pole data for on-the-fly Doppler broadening		
Notes: None		

use_reduced_xs use_reduced_xs

use_reduced_xs	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): Applies only to CADIS and FWCADIS		
Description: Use reduced number of multigroup cross sections for adjoint		
Notes: None		

use_fission_source use_fission_source

use_fission_source	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: Use the fission source provided by MPACT		
Notes: None		

use_external_source use_external_source

use_external_source	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: Use the external source provided by MPACT		
Notes: None		

hybrid_tally_names hybrid_tally_names

hybrid_tally_names	Array of Strings	Required if problem mode is CADIS
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Excore tally name to optimize for CADIS		
Notes: Applicable to hybrid simulations		

hybrid_multiplier_names hybrid_multiplier_names

hybrid_multiplier_names	Array of Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Excore tally multipliers to optimize for CADIS		
Notes: Applicable to hybrid simulations		

src_disc_l2_error src_disc_l2_error

src_disc_l2_error	Double	Optional
Units: N/A		
Applicable Value(s): 0.01 (default), (0,1)		
Limitation(s): None		
Description: Maximum L2 error for point-sampling discretization		
Notes: Applicable to hybrid simulations		

src_disc_samples_per_batch src_disc_samples_per_batch

src_disc_samples_per_batch	Integer	Optional
Units: N/A		
Applicable Value(s): 1E05 (default), > 0		
Limitation(s): None		
Description: Number of samples per point-sampling batch		
Notes: Applicable to hybrid simulations		

src_disc_max_samples src_disc_max_samples

src_disc_max_samples	Integer	Optional
Units: N/A		
Applicable Value(s): 1E10 (default), > 0		
Limitation(s): None		
Description: Maximum number of discretization samples		
Notes: Applicable to hybrid simulations		

ww_decomp ww_decomp

ww_decomp	String	Optional
Units: N/A		
Applicable Value(s): separable (default), full		
Limitation(s): None		
Description: Whether the weight window adjoint flux should be decomposed		
Notes: Applicable to hybrid simulations		

radial_mesh radial_mesh

radial_mesh	Array of Doubles	Optional
Units: N/A		
Applicable Value(s): vessel radii (default)		
Limitation(s): None		
Description: Radii for flux tally		
Notes: None		

num_theta num_theta

num_theta	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		
Description: Number of theta divisions for flux tallies in $[0, 2\pi]$		
Notes: None		

num_axial num_axial

num_axial	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		
Description: Number of axial levels for flux tallies		
Notes: None		

n_bounds n_bounds

n_bounds	Array of decreasing Doubles	Optional
Units: eV (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Neutron energy bounds for tallies		
Notes: None		

p_bounds p_bounds

p_bounds	Array of decreasing Doubles	Optional
Units: eV (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Photon energy bounds for tallies		
Notes: None		

homog_type homog_type

homog_type	String	Optional
Units: N/A		
Applicable Value(s): assem, rings		
Limitation(s): None		
Description: If using homogenization, homogenize each assembly or in rings		
Notes: Experimental capability		

homog_ring_radii homog_ring_radii

homog_ring_radii	List of Floats	Optional
Units: cm (default)		
Applicable Value(s): Depends on create_unique_pins (default)		
Limitation(s): None		
Description: Radii of rings for homogenization		
Notes: Applicable if homog_type is rings; experimental capability		

homog_pin_rings homog_pin_rings

homog_pin_rings	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Homogenize according to pin locations or assembly locations		
Notes: Applicable when homog_type is rings; experimental capability		

homog_explicit_ring homog_explicit_ring

homog_explicit_ring	Integer	Optional
Units: cm (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Radius within which to homogenize within and to have explicit pins outside		
Notes: Experimental capability		

bc_bnd_mesh bc_bnd_mesh

bc_bnd_mesh	Array of 6 Strings	Optional
Units: N/A		
Applicable Value(s): vacuum, vacuum, vacuum, vacuum, vacuum, vacuum (default), vacuum, reflect		
Limitation(s): None		
Description: Boundary mesh boundary conditions on -x, +x, -y, +y, -z, +z		
Notes: None		

x_bnd_mesh x_bnd_mesh

x_bnd_mesh	Array of increasing Doubles	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Boundary mesh x-axis edges		
Notes: None		

y_bnd_mesh y_bnd_mesh

y_bnd_mesh	Array of increasing Doubles	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Boundary mesh y-axis edges		
Notes: None		

z_bnd_mesh z_bnd_mesh

z_bnd_mesh	Array of increasing Doubles	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Boundary mesh z-axis edges		
Notes: None		

subblock_procs subblock_procs

subblock_procs	Array of Integers	Optional
Units: N/A		
Applicable Value(s): Unit array of size number of Shift blocks (default), ≥ 1		
Limitation(s): Applies only to domain-decomposed problems		
Description: Number of subblock processors per domain block		
Notes: This is an advanced parameter to further specify how to domain decompose the Shift problem to handle load imbalance		

overlap overlap

overlap	Double	Optional
Units: N/A		
Applicable Value(s): 0.0 (default), [0,1]		
Limitation(s): Applies only to domain-decomposed problems		
Description: Overlap percentage of domain blocks		
Notes: This is an advanced parameter to help with message passing at domain boundaries in domain-decomposed problems		

core_translate core_translate

core_translate	Array of 3 Doubles	Optional
Units: cm (default)		
Applicable Value(s): 0.0, 0.0, 0.0 (default)		
Limitation(s): None		
Description: Position to translate center of core		
Notes: None		

rtk_corner_translate rtk_corner_translate

rtk_corner_translate	Array of 3 Doubles	Optional
Units: cm (default)		
Applicable Value(s): 0.0, 0.0, 0.0 (default)		
Limitation(s): Applies only to non-excore problems		
Description: Translation of RTK geometry bottom left corner		
Notes: None		

create_unique_pins create_unique_pins

create_unique_pins	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: Make all pincells unique compositions		
Notes: None		

track_isotopes track_isotopes

track_isotopes	String	Optional
Units: N/A		
Applicable Value(s): short (default), full		
Limitation(s): None		
Description: Which set of isotopes to transfer		
Notes: None		

xs_library xs_library

xs_library	String	Required if problem mode is CADIS
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Name of SCALE multigroup data library file		
Notes: Applicable to hybrid simulations		

mesh mesh

mesh	Integer	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Number of mesh cells per pincell		
Notes: Applicable to hybrid simulations		

refl_mesh_size refl_mesh_size

refl_mesh_size	Double	Optional
Units: N/A		
Applicable Value(s): > 0.0		
Limitation(s): None		
Description: Radial reflector region mesh size		
Notes: Applicable to hybrid simulations		

extend_axial_mesh_size extend_axial_mesh_size

extend_axial_mesh_size	Double	Optional
Units: N/A		
Applicable Value(s): > 0.0		
Limitation(s): None		
Description: Axial excore region mesh size		
Notes: Applicable to hybrid simulations		

output_adjoint output_adjoint

output_adjoint	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Output adjoint flux to Shift HDF5 file and adjoint source to a separate HDF5 file		
Notes: Applicable to hybrid simulations		

adjoint adjoint

`adjoint`	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: Perform adjoint solve		
Notes: Applicable to hybrid simulations		

num_blocks_i num_blocks_i

`num_blocks_i`	Integer	Optional
Units: N/A		
Applicable Value(s): depends on number of processors (default), > 0		
Limitation(s): None		
Description: Number of partitions (processors) in x		
Notes: Applicable to hybrid simulations		

num_blocks_j num_blocks_j

`num_blocks_j`	Integer	Optional
Units: N/A		
Applicable Value(s): depends on number of processors (default), > 0		
Limitation(s): None		
Description: Number of partitions (processors) in y		
Notes: Applicable to hybrid simulations		

num_z_blocks num_z_blocks

`num_z_blocks`	Integer	Optional
Units: N/A		
Applicable Value(s): depends on mesh (default), > 0		
Limitation(s): None		
Description: Number of pipelining blocks in z		
Notes: Applicable to hybrid simulations		

num_sets num_sets

`num_sets`	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		
Description: Number of energy sets		
Notes: Applicable to hybrid simulations		

num_groups num_groups

num_groups	Integer	Required for hybrid
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Number of energy groups		
Notes: Applicable to hybrid simulations		

max_delta_z max_delta_z

max_delta_z	Double	Optional
Units: N/A		
Applicable Value(s): > 0.0		
Limitation(s): None		
Description: Maximum mesh size in z		
Notes: Applicable to hybrid simulations		

partition_upscatter partition_upscatter

partition_upscatter	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Partition energy over upscatter groups only		
Notes: Applicable to hybrid simulations		

store_fulcrum_string store_fulcrum_string

store_fulcrum_string	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` if using 35 nodes or fewer (default), `false`		
Limitation(s): None		
Description: Save Fulcrum string as file		
Notes: Applicable to hybrid simulations		

upscatter_solver upscatter_solver

upscatter_solver	String	Optional
Units: N/A		
Applicable Value(s): gauss_seidel (default), gauss_seidel, gmres		
Limitation(s): None		
Description: Which upscatter solver to use		
Notes: Applicable to hybrid simulations		

within_group_solver within_group_solver

within_group_solver	String	Optional
Units: N/A		
Applicable Value(s): gmres (default)		
Limitation(s): None		
Description: Which within group solver to use		
Notes: Applicable to hybrid simulations		

iterate_downscatter iterate_downscatter

iterate_downscatter	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Iterate over downscatter groups		
Notes: Applicable to hybrid simulations		

downscatter downscatter

downscatter	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Downscatter only		
Notes: Applicable to hybrid simulations		

Pn_order Pn_order

Pn_order	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), > 0		
Limitation(s): None		
Description: Order of moments		
Notes: Applicable to hybrid simulations		

upscatter_subspace_size upscatter_subspace_size

upscatter_subspace_size	Integer	Optional
Units: N/A		
Applicable Value(s): 30 (default), > 0		
Limitation(s): None		
Description: Maximum subspace size for upscatter solver		
Notes: Applicable when upscatter_solver is gmres		

within_group_subspace_size within_group_subspace_size

within_group_subspace_size	Integer	Optional
Units: N/A		
Applicable Value(s): 20 (default), > 0		
Limitation(s): None		
Description: Maximum subspace size for within group solver		
Notes: Applicable when within_group_solver is gmres		

upscatter_max_itr upscatter_max_itr

upscatter_max_itr	Integer	Optional
Units: N/A		
Applicable Value(s): 1000 (default), > 0		
Limitation(s): None		
Description: Maximum number of iterations for upscatter solve		
Notes: Applicable to hybrid simulations		

within_group_max_itr within_group_max_itr

within_group_max_itr	Integer	Optional
Units: N/A		
Applicable Value(s): 1000 (default), > 0		
Limitation(s): None		
Description: Maximum number of iterations for within group solve		
Notes: Applicable to hybrid simulations		

eq_set eq_set

eq_set	String	Optional
Units: N/A		
Applicable Value(s): sc (default), bld, bld_2d, ld, sc		
Limitation(s): None		
Description: Solution method or spatial discretization		
Notes: Applicable to hybrid simulations		

upscatter_verbosity upscatter_verbosity

upscatter_verbosity	String	Optional
Units: N/A		
Applicable Value(s): low (default), none, low, medium, high		
Limitation(s): None		
Description: Solver verbosity		
Notes: Applicable to hybrid simulations		

within_group_verbosity within_group_verbosity

within_group_verbosity	String	Optional
Units: N/A		
Applicable Value(s): low (default), none, low, medium, high		
Limitation(s): None		
Description: Solver verbosity		
Notes: Applicable to hybrid simulations		

new_grp_bounds new_grp_bounds

new_grp_bounds	Array of decreasing Doubles	Optional
Units: eV (default)		
Applicable Value(s): > 0.0		
Limitation(s): None		
Description: Collapsed group boundaries		
Notes: Applicable to hybrid simulations		

grp_collapse_src grp_collapse_src

grp_collapse_src	Array of Doubles	Optional
Units: N/A		
Applicable Value(s): depends on xs_library (default)		
Limitation(s): None		
Description: Source to do group collapse		
Notes: Applicable to hybrid simulations		

quad_type quad_type

quad_type	String	Optional
Units: N/A		
Applicable Value(s): qr (default), qr, levelsym, galerkin, glproduct, ldfe		
Limitation(s): None		
Description: Type of S_N quadrature		
Notes: Applicable to hybrid simulations		

polars_octant polars_octant

polars_octant	Integer	Optional
Units: N/A		
Applicable Value(s): 6 (2 if adjoint) (default), > 0		
Limitation(s): None		
Description: Number of polar angles per octant for S_N quadrature		
Notes: Applicable to hybrid simulations		

azimuthals_octant azimuthals_octant

azimuthals_octant	Integer	Optional
Units: N/A		
Applicable Value(s): 8 (4 if adjoint) (default), > 0		
Limitation(s): None		
Description: Number of azimuthal angles per octant for S_N quadrature		
Notes: Applicable to hybrid simulations		

Sn_order Sn_order

Sn_order	Integer	Optional
Units: N/A		
Applicable Value(s): 4 (default), > 0		
Limitation(s): None		
Description: Level-symmetric quadrature set order		
Notes: Applicable to hybrid simulations		

upscatter_tolerance upscatter_tolerance

upscatter_tolerance	Double	Optional
Units: N/A		
Applicable Value(s): 1E-04 (default), (0,1)		
Limitation(s): None		
Description: Upscatter solver convergence tolerance		
Notes: None		

within_group_tolerance within_group_tolerance

within_group_tolerance	Double	Optional
Units: N/A		
Applicable Value(s): 1E-04 (default), (0,1)		
Limitation(s): None		
Description: Within group solver convergence tolerance		
Notes: None		

cell_homogenize cell_homogenize

cell_homogenize	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Homogenize material in cells		
Notes: None		

Pn_correction Pn_correction

Pn_correction	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Use outscatter-corrected diffusion coefficient to reduce memory in solve		
Notes: None		

pin_partitioning pin_partitioning

pin_partitioning	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Partition mesh over pincells		
Notes: None		

7.11 BLOCK COBRATF

nfuel nfuel

nfuel	Integer	Optional
Units: N/A		
Applicable Value(s): 10 (default), > 0		
Limitation(s): None		
Description: The number of rings in the fuel rod pellet (only effective when nc> 0)		
Notes: None		

min_steps min_steps

min_steps	Integer	Optional
Units: N/A		
Applicable Value(s): 4 (default), ≥ 0		
Limitation(s): None		
Description: The minimum number of iterations CTF should take during a solve		
Notes: None		

imox imox

imox	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1, 2, 3, 4, 5		
Limitation(s): None		
Description: The fuel thermal conductivity model to use in CTF (only effective when nc> 0). Options are: 0 - MATPRO-11 1 - Modified NFI (UO2) 2 - Halden (UO2) 3 - Duriez/Modified NFI (MOX) 4 - Halden (MOX) 5 - Amaya (MOX)		
Notes: None		

nc nc

nc	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0, 2, 3		
Limitation(s): None		
Description: This is the fuel rod conduction model. Options are (0) no conduction, power is supplied as a surface heat flux (can lead to numerical stability issues), (1) conduction in the radial direction only, (2) conduction in the radial and azimuthal directions, and (3) conduction in the radial, azimuthal and axial directions		
Notes: None		

solve_heat_end solve_heat_end

solve_heat_end	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set to 1 to perform the heat transfer and conduction solve performed by CTF after the steady-state fluid solve instead of during the fluid solve		
Notes: This option should not be used when modeling a transient. Also note that this must not be used for two-phase problems (cases in which significant void is expected) because it will cause an inaccurate vapor generation rate to be calculated		

chf chf

chf	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0, 2		
Limitation(s): None		
Description: critical heat flux (CHF) model option. Options are (0) - no CHF check during the transient (a check will be made using W-3 at the completion of the CTF steady-state solve), (1) - check CHF during transient using W-3, (2) - no CHF check during or after simulation (set CHF to infinity), and (3) - no CHF check during the transient (a check will be made using the Groeneveld lookup tables at the completion of the steady-state CTF solve)		
Notes: None		

tp_fric_model tp_fric_model

tp_fric_model	String	Optional
Units: N/A		
Applicable Value(s): wallis (default), chisholm, lockhart		
Limitation(s): None		

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`tp_fric_model`, continued...

Description: Sets the two-phase multiplier model to use in CTF. Options are as follows: • `wallis`: two-phase multiplier calculated based on void • `chisholm`: two-phase multiplier calculated using the Chisholm model • `lockhart`: two-phase multiplier calculated using the Lockhart-Martinelli model Descriptions of the models can be found in the CTF Theory Manual
Notes: None

debug debug

`debug`	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1, 2		
Limitation(s): None		
Description: Setting to 1 will cause CTF to print every power distribution it receives before doing the solve to a separate HDF5 file. Setting to 2 will cause CTF to print every power distribution it receives similar to Option 1, but it will also print the solution after the solve. This can be used to run CTF standalone on a power distribution that causes it to crash, or it can be used to observe coupled convergence behavior		
Notes: None		

disable_xml2ctf disable_xml2ctf

`disable_xml2ctf`	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Setting to 0 will allow xml2ctf to run during code initialization and generate the CTF input file. This is the normal VERA behavior. If set to 1, xml2ctf will not run. In this case, it is up to the user to ensure that a CTF input file called `deck.inp` is present in the simulation directory and that the model is consistent with the MPACT model. This option is provided so that a user can customize the CTF input file with options not provided through xml2ctf		
Notes: None		

irfc irfc

`irfc`	Integer	Optional
Units: N/A		
Applicable Value(s): 2 (default), 1, 3, 4		
Limitation(s): None		
Description: Friction model: 1 - original CTF model 2 - new CTF model 3 - Colebrook 4 - Sylvester		
Notes: None		

bwr_dp_tol bwr_dp_tol

bwr_dp_tol	Float	Optional
Units: psi (default)		
Applicable Value(s): 0.1 (default), > 0.0		
Limitation(s): None		
Description: Solver tolerance for the pressure balance iteration loop performed in CTF for BWR models. The pressure drop in all bundles must be the same to within this tolerance for the pressure loop to exit. The pressure balance loop is used for adjusting inlet flow rates to balance the pressure drops in all assemblies in the core		
Notes: None		

crud_evap_coeff crud_evap_coeff

crud_evap_coeff	Float	Optional
Units: N/A		
Applicable Value(s): 0.0 (default), ≥ 0.0 and ≤ 1.0		
Limitation(s): None		
Description: This is the amount of crud chimney boiling that results in vapor generation in CTF. A value of zero means that none of the chimney boiling results in vapor generation in CTF, and a value of 1.0 means that 100% of the chimney boiling results in vapor generation in CTF		
Notes: None		

crud_boil_coeff_model crud_boil_coeff_model

crud_boil_coeff_model	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set to 1 to switch to using the coefficient-based crud boiling model when solving crud problems. Set to 0 to use the traditional explicit crud boiling model		
Notes: None		

guide_tube_coefficient guide_tube_coefficient

guide_tube_coefficient	Float	Optional
Units: N/A		
Applicable Value(s): 0.5 (default), 0.0 ≤ guide_tube_coefficient ≤ 1.0		
Limitation(s): None		
Description: This is used to determine the temperature rise in guide tubes using the following: `T_guide_tube(z) = (T_fluid(z)-tinlet)*guide_tube_coefficient+tinlet`, where T_guide_tube is the temperature in the guide tube, T_fluid is the temperature in the channels adjacent to the guide tube, and tinlet is the inlet temperature. 0.0 means the guide tube outlet temperature will be the same as the inlet temperature, and 1.0 means it will be equal to the fluid side outlet temperature		
Notes: None		

beta_htc beta_htc

beta_htc	Float	Optional
Units: N/A		
Applicable Value(s): 0.2 (default), > 0.0		
Limitation(s): None		
Description: This is the boiling heat transfer coefficient underrelaxation coefficient. Because of the semi-implicit coupling of the fluid and energy equations in the CTF numerical solution, it is necessary to underrelax the heat transfer coefficient in time for numerical stability. For some boiling cases, it might be necessary to increase the underrelaxation		
Notes: None		

beta_clad_creep beta_clad_creep

beta_clad_creep	Float	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), > 0.0 and <= 1.0		
Limitation(s): None		
Description: This is an underrelaxation coefficient on the clad creep effect predicted by CTFFuel. Setting this less than 1.0 will slow the impact of the effect in the CTF solution, but it will not affect results for steady-state and depletion simulations. The coefficient will only have an effect if the dynamic gap model is enabled in CTF and a depletion is being modeled that would result in clad creep		
Notes: None		

fuel_gap_htc_beta fuel_gap_htc_beta

fuel_gap_htc_beta	Float	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), > 0.0 and ≤ 1.0		
Limitation(s): None		
Description: This is the underrelaxation coefficient used on the fuel rod gap heat transfer coefficient. This is used only when modeling a steady-state simulation. During transient portions of the simulation, this value will be ignored. This parameter only has an effect when using gap_model=dynamic		
Notes: None		

rothcon_temp_beta rothcon_temp_beta

rothcon_temp_beta	Float	Optional
Units: N/A		
Applicable Value(s): 0.3 (default), > 0.0 and < 1.0		
Limitation(s): None		
Description: This is the underrelaxation coefficient used when calculating rod surface temperatures on the rod surface coupling mesh set up by CTF for coupling to MAMBA. Reducing this value might be necessary if many iterations are failing during the temperature reconstruction process when using the rod thermal-hydraulic reconstruction (ROTHCON) grid files		
Notes: None		

hgap hgap

hgap	Float	Optional
Units: W/m^2/K (default)		
Applicable Value(s): 5678.3 (default), > 0.0		
Limitation(s): None		
Description: This sets the gap conductance in the fuel rod gap (applicable only when using a constant gap conductance fuel rod model)		
Notes: None		

epso epso

epso	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-4} (default), > 0.0		
Limitation(s): None		
Description: This is the relative tolerance for the linear solver (pressure matrix solve). It is applicable only when using an iterative solver. Setting this too high can lead to numerical instability		
Notes: None		

iitmax iitmax

iitmax	Integer	Optional
Units: N/A		
Applicable Value(s): 160 (default), > 0		
Limitation(s): None		
Description: This is the maximum number of iterations to take in the linear solve (pressure matrix solve). It is only applicable when using an iterative solver. Setting this too low can lead to numerical instabilities		
Notes: None		

dtmin dtmin

dtmin	Float	Optional
Units: s (default)		
Applicable Value(s): 1.0×10^{-6} (default), > 0		
Limitation(s): None		
Description: This sets the minimum allowable time step size. It is used for both transients and steady-state because CTF solves a transient to get to steady-state. If the time step size needs to be reduced smaller than this value, the code will crash with a "cannot reduce timestep size" error		
Notes: None		

dtmax dtmax

dtmax	Float	Optional
Units: s (default)		
Applicable Value(s): 0.1 (default), > 0		
Limitation(s): None		

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`dtmax`, continued...

Description: This sets the maximum allowable time step size. It is used for both transients and steady-state because CTF solves a transient to get to steady-state. CTF uses dynamic time step selection, which is mainly a function of the Courant number. This puts a ceiling on the dynamic time step size to prevent numerical instability
Notes: None

rtwfp rtwfp

`rtwfp`	Float	Optional
Units: N/A		
Applicable Value(s): 100.0 (default), ≥ 1.0		
Limitation(s): None		
Description: This sets the ratio between the conduction and fluid time step sizes. For steady-state problems, the time step sizes of the conduction equation can be set larger than the fluid time step sizes to reduce computational time. For transients, CTF will override this to be 1.0. Setting this too high can lead to numerical instability		
Notes: None		

maxits maxits

`maxits`	Integer	Optional
Units: N/A		
Applicable Value(s): 10000 (default), ≥ 1		
Limitation(s): None		
Description: This sets the maximum number of iterations CTF will take during any individual steady-state solve. If the iterations go over this maximum value, CTF will crash on an unable-to-converge exception		
Notes: None		

courant courant

`courant`	Float	Optional
Units: N/A		
Applicable Value(s): 0.8 (default), > 0.0		
Limitation(s): None		
Description: This sets the Courant number to use when setting time steps size. Setting this value lower will lead to overall smaller time step sizes being used in CTF, and setting it higher will lead to overall larger time step sizes being used. It is not recommended that the user adjust this value, as it typically is not an effective means of improving CTF convergence		
Notes: None		

solver solver

`solver`	Integer	Optional
Units: N/A		

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`solver`, continued...

Applicable Value(s): 3/5 (default), 5, 6, 7, 8
Limitation(s): None
Description: Selects the linear solver to use for the pressure matrix solve. Options are 0 - Direct 3 - Internal Krylov solver (BiCGStab) (serial runs only, default for serial run) 5 - PETSc BiCGStab (default for parallel run) 6 - PETSc with pressure matrix reduced to root and solved in serial (used only for parallel verification cases, do not use for production parallel runs) 7 - PETSc BiCGStab using block Jacobi preconditioner 8 - Trillinos BiCGStab solver
Notes: None

parallel parallel

`parallel`	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0		
Limitation(s): None		
Description: Instructs CTF to run in serial (0) or in parallel (1)		
Notes: None		

domain_decomp domain_decomp

`domain_decomp`	2D Integer Map	Optional
Units: N/A		
Applicable Value(s): ≥ 1		
Limitation(s): None		
Description: This is a core map of the assembly domains. A domain is a group of entities that will be solved by one processor in a parallel simulation. This input is required only for nodal parallel models and will have no impact on pin-resolved models. The shape shall be the same as the core map, and each entry shall define an ID for the domain. All assemblies with the same ID will be solved by the same processor. Note that domain IDs must begin at 1 and increase incrementally. Generally, domains should be organized so they are as compact as possible, meaning that `surface area` or interaction with adjacnet domains is minimized to limit the number of communications required between solution domains		
Notes: None		

nodal_subregion_map nodal_subregion_map

`nodal_subregion_map`	2D Integer Map	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: This is a core map of the subregion assembly locations. Valid values are 0 or 1. A value of 1 indicates a pin-resolved subregion assembly, while a value of 0 indicates a nodal assembly. This input will affect only nodal models. The shape shall be the same as the core map		
Notes: None		

global_energy_balance global_energy_balance

global_energy_balance	Float	Optional
Units: percent (default)		
Applicable Value(s): 0.01 (default), > 0.0		
Limitation(s): None		
Description: This sets the tolerance for energy balance (energy in minus energy out normalized to energy in) for steady-state runs		
Notes: None		

global_mass_balance global_mass_balance

global_mass_balance	Float	Optional
Units: percent (default)		
Applicable Value(s): 0.01 (default), > 0.0		
Limitation(s): None		
Description: This sets the tolerance for mass balance (mass in minus mass out normalized to mass in) for steady-state runs		
Notes: None		

fluid_energy_storage fluid_energy_storage

fluid_energy_storage	Float	Optional
Units: percent (default)		
Applicable Value(s): 0.5 (default), > 0.0		
Limitation(s): None		
Description: This sets the tolerance for energy storage in the fluid (change in energy over a time step) for steady-state runs. It is applicable only when using the storage-based convergence criteria (when use_sol_stop_crit is 0). See the CTF user manual for more details		
Notes: None		

solid_energy_storage solid_energy_storage

solid_energy_storage	Float	Optional
Units: percent (default)		
Applicable Value(s): 0.5 (default), > 0.0		
Limitation(s): None		
Description: This sets the tolerance for energy storage in the solid (change in energy over a time step) for steady-state runs. It is applicable only when using the storage-based convergence criteria (when use_sol_stop_crit is 0). See the CTF user manual for more details		
Notes: None		

mass_storage mass_storage

mass_storage	Float	Optional
Units: percent (default)		
Applicable Value(s): 0.5 (default), > 0.0		
Limitation(s): None		
Description: This sets the tolerance for mass storage in the fluid (change in mass in system over a time step) for steady-state runs. It is applicable only when using the storage-based convergence criteria (when use_sol_stop_crit is 0). See the CTF user manual for more details		
Notes: None		

pressure_criteria pressure_criteria

pressure_criteria	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-4} (default), > 0.0		
Limitation(s): None		
Description: This sets the tolerance on l-infinity of pressure change for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

Tcool_criteria Tcool_criteria

Tcool_criteria	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-3} (default), > 0.0		
Limitation(s): None		
Description: This sets the tolerance on l-infinity of coolant temperature for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

Tsolid_criteria Tsolid_criteria

Tsolid_criteria	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-3} (default), > 0.0		
Limitation(s): None		
Description: This sets the tolerance on l-infinity of solid temperature for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

void_criteria void_criteria

void_criteria	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-4} (default), > 0.0		
Limitation(s): None		
Description: This sets the tolerance on l-infinity of void for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. It is not checked for single-phase runs. See the CTF user manual for more details		
Notes: None		

vliq_criteria vliq_criteria

vliq_criteria	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-3} (default), > 0.0		
Limitation(s): None		
Description: This sets the tolerance on l-infinity of liquid velocity for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

vvap_criteria vvap_criteria

vvap_criteria	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-2} (default), > 0.0		
Limitation(s): None		
Description: This sets the tolerance on l-infinity of vapor velocity for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. It is not checked for single-phase runs. See the CTF user manual for more details		
Notes: None		

vdrop_criteria vdrop_criteria

vdrop_criteria	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-2} (default), > 0.0		
Limitation(s): None		
Description: This sets the tolerance on l-infinity of droplet velocity for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. It is not checked for single-phase runs. See the CTF user manual for more details		
Notes: None		

pressurea_criteria pressurea_criteria

pressurea_criteria	Float	Optional
Units: bar (default)		
Applicable Value(s): 1.0×10^{-3} (default), > 0.0		
Limitation(s): None		
Description: This sets the absolute tolerance on l-infinity of pressure for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

Tcoola_criteria Tcoola_criteria

Tcoola_criteria	Float	Optional
Units: K (default)		
Applicable Value(s): 1.0×10^{-3} (default), > 0.0		
Limitation(s): None		
Description: This sets the absolute tolerance on l-infinity of coolant temperature for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

Tsolida_criteria Tsolida_criteria

Tsolida_criteria	Float	Optional
Units: K (default)		
Applicable Value(s): 1.0×10^{-3} (default), > 0.0		
Limitation(s): None		
Description: This sets the absolute tolerance on l-infinity of solid temperature for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

vliqa_criteria vliqa_criteria

vliqa_criteria	Float	Optional
Units: m/s (default)		
Applicable Value(s): 1.0×10^{-3} (default), > 0.0		
Limitation(s): None		
Description: This sets the absolute tolerance on l-infinity of liquid velocity for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

vvapa_criteria vvapa_criteria

vvapa_criteria	Float	Optional
Units: m/s (default)		
Applicable Value(s): 1.0×10^{-2} (default), > 0.0		
Limitation(s): None		
Description: This sets the absolute tolerance on l-infinity of vapor velocity for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. It is not used for single-phase runs. See the CTF user manual for more details		
Notes: None		

vdropa_criteria vdropa_criteria

vdropa_criteria	Float	Optional
Units: m/s (default)		
Applicable Value(s): 1.0×10^{-2} (default), > 0.0		
Limitation(s): None		
Description: This sets the absolute tolerance on l-infinity of droplet velocity for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. It is not used for single-phase runs. See the CTF user manual for more details		
Notes: None		

pressure_criteria_l2 pressure_criteria_l2

pressure_criteria_l2	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-5} (default), > 0.0		
Limitation(s): None		
Description: This sets the relative tolerance on l-2 of pressure for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

Tcool_criteria_l2 Tcool_criteria_l2

Tcool_criteria_l2	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-4} (default), > 0.0		
Limitation(s): None		
Description: This sets the relative tolerance on l-2 of coolant temperature for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

Tsolid_criteria_l2 Tsolid_criteria_l2

Tsolid_criteria_l2	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-4} (default), > 0.0		
Limitation(s): None		
Description: This sets the relative tolerance on l-2 of solid temperature for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

void_criteria_l2 void_criteria_l2

void_criteria_l2	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-5} (default), > 0.0		
Limitation(s): None		
Description: This sets the absolute tolerance on l-2 of void for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. It is not used in single-phase runs. See the CTF user manual for more details		
Notes: None		

vliq_criteria_l2 vliq_criteria_l2

vliq_criteria_l2	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-4} (default), > 0.0		
Limitation(s): None		
Description: This sets the relative tolerance on l-2 of liquid velocity for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

vvap_criteria_l2 vvap_criteria_l2

vvap_criteria_l2	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-4} (default), > 0.0		
Limitation(s): None		
Description: This sets the relative tolerance on l-2 of vapor velocity for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. It is not used for single-phase runs. See the CTF user manual for more details		
Notes: None		

vdrop_criteria_l2 vdrop_criteria_l2

vdrop_criteria_l2	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-4} (default), > 0.0		
Limitation(s): None		
Description: This sets the relative tolerance on l-2 of droplet velocity for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. It is not used for single-phase runs. See the CTF user manual for more details		
Notes: None		

pressurea_criteria_l2 pressurea_criteria_l2

pressurea_criteria_l2	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-5} (default), > 0.0		
Limitation(s): None		
Description: This sets the relative tolerance on l-2 of pressure for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

Tcoola_criteria_l2 Tcoola_criteria_l2

Tcoola_criteria_l2	Float	Optional
Units: K (default)		
Applicable Value(s): 1.0×10^{-5} (default), > 0.0		
Limitation(s): None		
Description: This sets the absolute tolerance on l-2 of coolant temperature for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

Tsolida_criteria_l2 Tsolida_criteria_l2

Tsolida_criteria_l2	Float	Optional
Units: K (default)		
Applicable Value(s): 1.0×10^{-5} (default), > 0.0		
Limitation(s): None		
Description: This sets the absolute tolerance on l-2 of solid temperature for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

vliqa_criteria_l2 vliqa_criteria_l2

vliqa_criteria_l2	Float	Optional
Units: m/s (default)		
Applicable Value(s): 1.0×10^{-5} (default), > 0.0		
Limitation(s): None		
Description: This sets the absolute tolerance on l-2 of liquid velocity for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. See the CTF user manual for more details		
Notes: None		

vvapa_criteria_l2 vvapa_criteria_l2

vvapa_criteria_l2	Float	Optional
Units: m/s (default)		
Applicable Value(s): 1.0×10^{-4} (default), > 0.0		
Limitation(s): None		
Description: This sets the absolute tolerance on l-2 of vapor velocity for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. It is not used for single-phase runs. See the CTF user manual for more details		
Notes: None		

vdropa_criteria_l2 vdropa_criteria_l2

vdropa_criteria_l2	Float	Optional
Units: m/s (default)		
Applicable Value(s): 1.0×10^{-4} (default), > 0.0		
Limitation(s): None		
Description: This sets the absolute tolerance on l-2 of droplet velocity for steady-state runs. It is applicable only when using the change-based convergence criteria (when use_sol_stop_crit=1). Note that when using the change-based criteria, all criteria are optional. It is not used for single-phase runs. See the CTF user manual for more details		
Notes: None		

use_sol_stop_crit use_sol_stop_crit

use_sol_stop_crit	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		

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use_sol_stop_crit, continued...

Description: Selects the stopping criteria to use for steady-state runs. Options are: 0 - storage-based criteria (global_energy_balance, global_mass_balance, fluid_energy_storage, solid_energy_storage, mass_storage) 1 - change-based criteria (global_energy_balance, global_mass_balance, pressure_criteria, pressurea_criteria, Tcool_criteria, Tcoola_criteria, Tsolid_criteria, Tsolida_criteria, void_criteria, vliq_criteria, vliqa_criteria, vvap_criteria, vvapa_criteria, vdrop_criteria, vdropa_criteria, void_criteria_l2, Tcool_criteria_l2, Tcoola_criteria_l2, Tsolid_criteria_l2, Tsolida_criteria_l2, pressure_criteria_l2, pressurea_criteria_l2, vliq_criteria_l2, vliqa_criteria_l2, vvap_criteria_l2, vvapa_criteria_l2, vdrop_criteria_l2, vdropa_criteria_l2). All criteria are optional with defaults
Notes: None

proc_per_assem proc_per_assem

proc_per_assem	Integer	Optional
Units: N/A		
Applicable Value(s): 9 (default), 1, 4, 16		
Limitation(s): None		
Description: This sets the number of domains to divide each full assembly into for parallel runs. It is applicable only for parallel runs. The higher the number, the more cores CTF will use and the faster it will run in a parallel model. However, the number of cores required by CTF must be less than or equal to the number required by VERA and the number of cores available on the system		
Notes: For BWR models, proc_per_assem can only be set to 1		

edit_gaps edit_gaps

edit_gaps	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set this to 1 to write an output file from CTF specifying gap (lateral flow path) solution data. This file will be large for full-core models		
Notes: This optional only works for serial models		

edit_main_text_output edit_main_text_output

edit_main_text_output	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set this to 1 to write the main text output file from CTF summarizing solution data. This file will be large for full-core models		
Notes: This optional only works for serial models		

edit_channels edit_channels

edit_channels	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set this to 1 to write the channel text output file from CTF summarizing solution data. This file will be large for full-core models		
Notes: This optional only works for serial models		

edit_th_details edit_th_details

edit_th_details	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set this to 1 to write more detailed fluid solution data from CTF to the VERA HDF5 output file		
Notes: None		

edit_rods edit_rods

edit_rods	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set this to 1 to write rod data to the main text output file from CTF. This file will be large for full-core models		
Notes: This optional only works for serial models		

edit_dnb edit_dnb

edit_dnb	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set this to 1 to write DNB data to the VERA HDF5 file		
Notes: None		

edit_dnb_text_file edit_dnb_text_file

edit_dnb_text_file	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set this to 1 to write the DNB text file. This file will be large for full-core models		
Notes: This optional only works for serial models		

edit_convergence edit_convergence

edit_convergence	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0		
Limitation(s): None		
Description: Set this to 1 to write the convergence information output file from CTF		
Notes: None		

edit_hdf5 edit_hdf5

edit_hdf5	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0		
Limitation(s): None		
Description: Set this to 1 to write CTF data to the VERA HDF5 file		
Notes: None		

edit_native_hdf5 edit_native_hdf5

edit_native_hdf5	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set this to 1 to write the CTF native HDF5 file. This file writes information for all pins in the model in a more arbitrary way than the VERA HDF5 file, which is organized by assembly and core location. This file contains more detailed information than the VERA HDF5 file		
Notes: None		

edit_fluid_vtk edit_fluid_vtk

edit_fluid_vtk	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set this to 1 to write the CTF fluid VTK file. This allows the user to visualize solution results using a VTK reader, but this file will be large for full-core models		
Notes: None		

edit_rod_vtk edit_rod_vtk

edit_rod_vtk	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		

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edit_rod_vtk, continued...

Description: Set this to 1 to write the CTF rod VTK file. This allows the user to visualize solution results using a VTK reader, but this file will be large for full-core models
Notes: None

hi2lo_sub_axial hi2lo_sub_axial

hi2lo_sub_axial	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		
Description: This is used to set the number of sublevels to divide each CTF axial level into when forming the coupling mesh with MAMBA. It is applicable only when using ROTHCON to reconstruct rod surface temperatures and TKE		
Notes: None		

hi2lo_sub_theta hi2lo_sub_theta

hi2lo_sub_theta	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		
Description: This is used to set the number of subsectors to divide each CTF rod sector into when forming the coupling mesh with MAMBA. It is applicable only when using ROTHCON to reconstruct rod surface temperatures and TKE		
Notes: None		

hi2lo_grid hi2lo_grid

hi2lo_grid	Integer	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: This specifies which grids should have their coupling mesh refined using hi2lo_sub_theta and hi2lo_sub_axial. Leaving this out means that all grid spans will be refined. The grid span numbering ranges from 1 to the number of grid spans (number of grid_axial entries in the [ASSEMBLY] block). The region below the first grid does not count as a span		
Notes: This only has an effect when using the ROTHCON capability for reconstructing grid heat transfer and turbulence enhancement behavior		

model_corrosion model_corrosion

model_corrosion	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		

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`model_corrosion`, continued...

Description: Set this to 1 to turn on the clad corrosion model in CTF. It is applicable only for crud simulations
Notes: None

int_drag_model int_drag_model

`int_drag_model`	String	Optional
Units: N/A		
Applicable Value(s): legacy (default), drift_flux		
Limitation(s): None		
Description: Use to set the interfacial drag model that CTF shall use		
Notes: None		

flow_regime_map flow_regime_map

`flow_regime_map`	String	Optional
Units: N/A		
Applicable Value(s): legacy (default), ge_nonprop		
Limitation(s): None		
Description: Selects the flow regime map to be used in CTF		
Notes: None		

th_solver th_solver

`th_solver`	String	Optional
Units: N/A		
Applicable Value(s): ctf (default), fireant, ants		
Limitation(s): None		
Description: Selects the fluid solver to use for the TH solution. Options are `ctf`, `fireant`, or `ants`. The `fireant` and `ants` options are steady-state solvers that are much faster than `ctf`, but they only do an axial sweep, and they lack many of the more advanced models of `ctf`. Regardless of the TH solver, CTFFuel will be used for the pin temperature solution		
Notes: None		

gap_model gap_model

`gap_model`	String	Optional
Units: N/A		
Applicable Value(s): constant (default), dynamic		
Limitation(s): None		
Description: This sets the fuel rod pellet/clad gap thermal conductivity model. It can either be constant (user-specified value) or dynamic (CTF will calculate based on thermal expansion and burnup effects)		
Notes: None		

boil_ht_cor boil_ht_cor

boil_ht_cor	String	Optional
Units: N/A		
Applicable Value(s): thom (default), chen, gorenflo		
Limitation(s): None		
Description: This sets the boiling heat transfer model. Note that when gorenflo is selected, the ONB model is also used in CTF for determining when heat transfer transitioning to boiling heat transfer		
Notes: None		

property_evaluations property_evaluations

property_evaluations	String	Optional
Units: N/A		
Applicable Value(s): iapws1997_lookup (default), asme1968, iapws1997_direct, flibe		
Limitation(s): None		
Description: This sets the equation of state source to use for fluid properties. Options are: asme1968 - ASME 1968 tables iapws1997_direct - IAPWS 1997 standard using direct correlation evaluations (will be computationally slower) iapws1997_lookup - IAPWS 1997 standard lookup tables built from the direct correlation evaluations during initialization (computationally faster to evaluate) flibe - Generic properties for FLiBe salt coolant		
Notes: None		

beta_sp beta_sp

beta_sp	Float	Optional
Units: N/A		
Applicable Value(s): 0.037 (default), ≥ 0.0		
Limitation(s): None		
Description: This sets the strength of turbulent mixing causing lateral cross flow in CTF. The default is currently 0.037		
Notes: None		

k_void_drift k_void_drift

k_void_drift	Float	Optional
Units: N/A		
Applicable Value(s): 1.4 (default), ≥ 0.0		
Limitation(s): None		
Description: This sets the equilibrium distribution weighting factor in the void drift model. Decreasing this value leads to less void drift, and increasing it leads to more		
Notes: None		

crud_tool crud_tool

crud_tool	String	Optional
Units: N/A		
Applicable Value(s): MAMBA (default), cicada		

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`crud_tool`, continued...

Limitation(s): None
Description: This sets the crud modeling tool. Applicable only during a crud simulation. Note that Cicada is an experimental feature
Notes: None

max_crud_step_size max_crud_step_size

`max_crud_step_size`	Float	Optional
Units: day (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: This is the maximum number of days in a crud grow. Setting this smaller than the depletion step size will result in multiple crud grows being made during the depletion step, with source term data being updated during each substep		
Notes: None		

crud_dT_feedback crud_dT_feedback

`crud_dT_feedback`	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0		
Limitation(s): None		
Description: Set this to 0 to shut off the crud thermal resistance effect on the rod internal temperature calculation. Note that the crud thermal resistance will still affect the corrosion growth calculation		
Notes: None		

cicada_outer_radial_zone_num_cells_r cicada_outer_radial_zone_num_cells_r

`cicada_outer_radial_zone_num_cells_r`	Integer	Optional
Units: N/A		
Applicable Value(s): 100 (default), ≥ 1		
Limitation(s): None		
Description: This sets the number of rings in the oxide region of the clad for Cicada runs. It is only applicable when Cicada is used as the crud tool. It is applicable only when `cicada_dimension`=3. Note that Cicada is an experimental feature		
Notes: None		

cicada_inner_radial_zone_num_cells_r cicada_inner_radial_zone_num_cells_r

`cicada_inner_radial_zone_num_cells_r`	Integer	Optional
Units: N/A		
Applicable Value(s): 20 (default), ≥ 1		
Limitation(s): None		

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cicada_inner_radial_zone_num_cells_r, continued...

Description: This sets the number of rings in the clad region of the clad for Cicada runs. Applicable only when Cicada used as the crud tool. It is applicable only when cicada_dimension=3. Note that Cicada is an experimental feature
Notes: None

cicada_outer_radial_zone_thickness cicada_outer_radial_zone_thickness

cicada_outer_radial_zone_thickness	Float	Optional
Units: m (default)		
Applicable Value(s): 100.0×10^{-6} (default), > 0.0		
Limitation(s): None		
Description: This sets the thickness of the oxide modeling region of the clad. It is applicable only for crud simulations in which Cicada is being used as the modeling tool. It is applicable only when cicada_dimension=3. Note that Cicada is an experimental feature		
Notes: None		

cicada_dimensions cicada_dimension

cicada_dimensions	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), 3		
Limitation(s): None		
Description: This chooses the dimensions of the clad/oxide conduction solution in Cicada. It is applicable only when doing a crud simulation using Cicada as the crud tool. Can either be 1 for radial conduction only or 3 for radial/axial/azimuthal conduction. Note that Cicada is an experimental feature		
Notes: None		

enable_corrosion_lithium enable_corrosion_lithium

enable_corrosion_lithium	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set this to 1 to turn on the lithium effect on clad corrosion. It is has an effect only when modeling a crud simulation using MAMBA as the crud code		
Notes: None		

crud_details crud_details

crud_details	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set this to 1 to turn on additional edits to the VERA HDF5 file related to the crud simulation		
Notes: None		

rod_details rod_details

rod_details	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set this to 1 to turn on additional edits to the VERA HDF5 file related to the rod solution		
Notes: None		

oxide_thermal_conductivity oxide_thermal_conductivity

oxide_thermal_conductivity	Float	Optional
Units: W/cm/K (default)		
Applicable Value(s): 1.5 (default), Greater than or equal to 0.0		
Limitation(s): None		
Description: The thermal conductivity of the clad oxide layer		
Notes: None		

clad_corrosion_model clad_corrosion_model

clad_corrosion_model	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), 2, 3		
Limitation(s): None		
Description: This selects the corrosion model to use. The corrosion model is based on the clad material. Options include the following: 1 - Zirc 4 2 - M5 3 - ZIRLO		
Notes: None		

trans_dnb trans_dnb

trans_dnb	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Set this to 1 to enable the transient CHF model. It is applicable only for transients		
Notes: None		

cross_flow cross_flow

cross_flow	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0		
Limitation(s): None		
Description: Set this to 0 to shut off lateral cross flow in CTF		
Notes: None		

plr_gap_effect plr_gap_effect

plr_gap_effect	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: When modeling geometry that includes part-length fuel rods, setting this to 1 will include the effect of the gap (between adjacent fuel rods) width increasing downstream of where the part-length rod disappears. Leaving it to the default of 0 will keep the gap width constant for the entire model. It has been found that the discontinuity in the gap width axially in the model can lead to more difficulty in converging CTF. Because the effect of the gap width is less significant than the change channel area and wetted perimeter (which is always captured), this was made to be optional		
Notes: None		

allow_fuzzy_grid_placement allow_fuzzy_grid_placement

allow_fuzzy_grid_placement	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: If this is set to 1 (true), then it relaxes the requirement that mesh cell boundaries line up with the spacer grid bottom and top. In this case, the grid effects will be moved to the nearest mesh boundary in the CTF model, and a warning will be printed. If this is set to 0, then an error will be raised if the grid top and bottom do not line up with mesh cell boundaries		
Notes: None		

nodal_inter_assem_gap_width_uniform nodal_inter_assem_gap_width_uniform

nodal_inter_assem_gap_width_uniform	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0		
Limitation(s): None		
Description: If this is set to 1 (true) and it is creating a nodal model, then the widths of the gaps between assemblies will use the gap width of the gaps inside the assemblies, which results in more uniform gap widths throughout the model. This affects only nodal models		
Notes: None		

nodal_gap_len_node_centers nodal_gap_len_node_centers

nodal_gap_len_node_centers	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0		
Limitation(s): None		

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`nodal_gap_len_node_centers`, continued...

Description: If this is set to 1 (true) and it is creating a nodal model, then the lengths of the gaps will be calculated using the distance between the node centers. If it is set to 0 (false), then the distance between the actual subchannels on either side of the node boundary (pin pitch plus assembly spacing) will be used. This affects only nodal models
Notes: None

nodal_inter_assem_loss nodal_inter_assem_loss

`nodal_inter_assem_loss`	Float	Optional
Units: N/A		
Applicable Value(s): 0.5 (default), ≥ 0.0		
Limitation(s): None		
Description: Sets the form loss coefficient in the gaps between assemblies in nodal models. This affects only nodal models		
Notes: None		

7.12 BLOCK COUPLING

epsk epsk

`epsk`	Float	Optional
Units: pcm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Eigenvalue convergence criteria		
Notes: None		

epsp epsp

`epsp`	Float	Optional
Units: L2 norm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Power convergence criteria		
Notes: None		

eps_temp eps_temp

`eps_temp`	Float	Optional
Units: degrees F (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Temperature convergence criteria		
Notes: None		

ctf_iters_max ctf_iters_max

`ctf_iters_max`	Integer	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Maximum number of CTF time-steps per coupled iteration		
Notes: None		

ctf_iters_growth ctf_iters_growth

`ctf_iters_growth`	Float	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Fractional change in `ctf_iters_max` by coupled iteration		
Notes: Value of 1 is no change		

eps_boron eps_boron

`eps_boron`	Float	Optional
Units: ppm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Boron convergence criteria		
Notes: None		

rlx_power rlx_power

`rlx_power`	Float	Optional
Units: N/A		
Applicable Value(s): 0.5 (default), > 0,≤ 1		
Limitation(s): None		
Description: Power relaxation factor		
Notes: Recommend 0.5		

rlx_tfuel rlx_tfuel

`rlx_tfuel`	Float	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), > 0,≤ 1		
Limitation(s): None		
Description: Fuel temperature relaxation factor		
Notes: Recommend 1.0		

rlx_den rlx_den

rlx_den	Float	Optional
Units: N/A		
Applicable Value(s): 0.8 (BWR), 1.0 (non-BWR) (default), > 0,≤ 1		
Limitation(s): None		
Description: Density relaxation factor		
Notes: Recommend 1.0		

dhfrac dhfrac

dhfrac	Float	Optional
Units: N/A		
Applicable Value(s): 0.026 (default), ≥ 0.0, ≤ 1.0		
Limitation(s): None		
Description: Fraction of rod heat directly deposited into fluid (gamma heating)		
Notes: None		

extend_coupling_mesh extend_coupling_mesh

extend_coupling_mesh	String	Optional
Units: N/A		
Applicable Value(s): none (default), above, below, both		
Limitation(s): None		
Description: This input is used to specify whether to enable coupling above and below the active fuel when using CTF. The extended coupling can be enabled only above the fuel with above, only below it with below, or both above and below with both. Deprecated options true and false correspond to both and none, respectively		
Notes: None		

rlx_crud rlx_crud

rlx_crud	Float	Optional
Units: N/A		
Applicable Value(s): > 0,≤ 1		
Limitation(s): None		
Description: Crud relaxation factor		
Notes: Recommend 0.5		

nonlinear_coupling_method unknown_quantity method

unknown_quantity	String	Optional
Units: N/A		
Applicable Value(s): pin_powers, mod_dens		
Limitation(s): None		
Description: Specifies unknown quantities for which the user would like to choose the solution procedure		

continued on next page...

unknown_quantity, continued...

Notes: This is effective only for coupled (multiphysics) simulations. If the nonlinear_coupling_method input is not used, then all unknowns default to being solved with Picard iterations

method	String	Optional
Units: N/A		
Applicable Value(s): picard (default), anderson, partconv		
Limitation(s): None		
Description: The solution method to be used for the specified coupling unknown		
Notes: Effective only for coupled (multiphysics) simulations. When partconv is is used, anderson should not be used for the other parameters and relaxation factor should be 1		

anderson_options unknown_quantity depth mixing_parameter starting_iteration

unknown_quantity	String	Optional
Units: N/A		
Applicable Value(s): pin_powers, mod_dens		
Limitation(s): None		
Description: Specifies the unknown quantities for which the user would like to set the Anderson solver control parameters		
Notes: Effective only for coupled (multiphysics) simulations and for cases in which Anderson was chosen for the nonlinear_coupling_method corresponding to the specified unknown_quantity		

depth	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), ≥ 1, < 1000		
Limitation(s): None		
Description: In Anderson Acceleration, the depth is the number of previous iterates the solver should use in generating better future iterates. Larger choices for depth result in more aggressive acceleration; however, this can lead to instability and slower speed overall for highly nonlinear problems. A depth of 0 is equivalent to classic Picard iteration		
Notes: Effective only for coupled (multiphysics) simulations		

mixing_parameter	Float	Optional
Units: N/A		
Applicable Value(s): 0.5 (default), > 0.0, ≤ 1.0		
Limitation(s): None		
Description: The mixing_parameter can be viewed as a damping or underrelaxation factor in the Anderson solution scheme. Obviously, this means larger choices for this parameter can result in more aggressive acceleration, although that does not always translate into better performance. The optimum choice will be problem dependent, with the default of 0.5 being quite conservative		
Notes: Effective only for coupled (multiphysics) simulations		

starting_iteration	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0, < 1000		
Limitation(s): None		
Description: The starting_iteration is the iteration at which the user would like Anderson to actually start accelerating the chosen unknown. While the iteration count is below this number, the Anderson solver will proceed like classic Picard, using the mixing_parameter as an underrelaxation factor. Normally the default choice of 1 is best		
Notes: Effective only for coupled (multiphysics) simulations		

partconv_opt gammamode est_fdintense dperturb fdmul par_nchk par_multchk

gammamode	String	Optional
Units: N/A		
Applicable Value(s): hyb (default), debug, maxave		
Limitation(s): None		
Description: This input is used to define the solver method for the nearly optimal partial converged coarse-mesh finite difference (CMFD) nonlinear solver, described as • debug: print out the feedback intensity for each iteration • maxave: use either the maximum or flux-weighted feedback intensity • hyb: use maximum feedback intensity when shielding calculation has been performed; use flux-weighted feedback intensity when not		
Notes: The input is used only when partconv is specified in nonlinear_coupling_method		

est_fdintense	Float	Optional
Units: N/A		
Applicable Value(s): 1.5e-3 (default), > 0, < 1		
Limitation(s): None		
Description: This input is used to specify the estimated feedback intensity before calculating the feedback intensity		
Notes: The input is used only when partconv is specified in nonlinear_coupling_method		

dperturb	Float	Optional
Units: N/A		
Applicable Value(s): 5e-3 (default), > 0		
Limitation(s): None		
Description: This input is used to specify the perturbation factor to calculate the feedback intensity		
Notes: The input is used only when partconv is specified in nonlinear_coupling_method		

fdmul	Float	Optional
Units: N/A		
Applicable Value(s): 1.0 (default)		
Limitation(s): None		

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fdmul, continued...

Description: This input is used to specify the multiplication factor applied to the feedback intensity calculated during the perturbation. When gammamode is maxave or debug, a positive input makes the feedback intensity the maximum of all the feedback intensities; while a negative input makes value the flux-weighted of all the feedback intensities
Notes: The input is used only when partconv is specified in nonlinear_coupling_method. The multiplication factor is applied to the feedback intensities that is calculated from perturbation

par_nchk	Integer	Optional
Units: N/A		
Applicable Value(s): 4 (default), > 0		
Limitation(s): None		
Description: The initial guess of the flux is flat and far from its converged value for the single-state simulation and the first state of the multistate simulation. The par_nchk is the index of the iteration at which the user believes the flux is close to its converged value for the first state and the estimation of the feedback intensity can be performed		
Notes: The input is used only when partconv is specified in nonlinear_coupling_method, and the calculation is a multi-state simulation		

par_multchk	Integer	Optional
Units: N/A		
Applicable Value(s): 2 (default), > 0		
Limitation(s): None		
Description: The par_multchk is the index of the iteration at which the user believes the flux is close to its converged value for the states other than the first state and the estimation of the feedback intensity can be performed		
Notes: The input is used only when partconv is specified in nonlinear_coupling_method		

maxiter maxiter

maxiter	Integer	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Maximum number of coupled iterations		
Notes: None		

read_restart read_restart

read_restart	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This is the name of the coupling restart file. Leave this blank for no coupling restart		
Notes: None		

bypass_treatment bypass_treatment

bypass_treatment	Character String	Optional
Units: N/A		
Applicable Value(s): saturated (default), inlet, outlet, fixed_heating, explicit_heating		
Limitation(s): None		
Description: This controls the treatment of the bypass flow in BWR models. The default value is saturation conditions at the input pressure, but inlet and outlet conditions can also be used. A simplified bypass heating model can also be used by specifying the `fixed_heating` or `explicit_heating` options. For these options, the `bypass_heating` and `bypass` inputs should also be set to non-zero values. This input is ignored for non-BWR models or if feedback is off		
Notes: None		

channel_box_conduction channel_box_conduction

channel_box_conduction	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: This enables the channel box conduction model. This input is ignored unless `bypass_treatment` is set to `explicit`		
Notes: None		

bypass_heating bypass_heating

bypass_heating	Floating Point Number	Optional
Units: Percent (default)		
Applicable Value(s): 0.0 (default), ≥ 0.0, ≤ 1.0, explicit		
Limitation(s): None		
Description: This controls the treatment of the bypass heating in BWR models. The default value is 0.0. The `bypass_heating` fraction determines how much of the reactor power is deposited directly into the bypass region, having no impact on fuel conduction or active coolant inside the bundles. If `explicit` is input, then the neutron flux is used to calculate the actual heating; a channel box conduction model is also applied in this case		
Notes: None		

7.13 BLOCK MPACT

transport_method transport_method

transport_method	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): MOC (default), sn, nodal-nem, nodal-senm-2, nodal-senm-4		
Limitation(s): None		

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`transport_method`, continued...

Description: This input is used to specify whether the middle of cycle (MOC), Sn, or nodal diffusion transport methods are used for the global problem solution method
Notes: None

gamma_transport gamma_transport

`gamma_transport`	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: This input is used to enable/disable the gamma transport calculation		
Notes: None		

sn_numcart sn_numcart

`sn_numcart`	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default)		
Limitation(s): None		
Description: This input is used to specify the number of X and Y pincell subdivisions in which to divide each pincell into for the Sn Transport sweeper		
Notes: None		

ray_spacing ray_spacing

`ray_spacing`	Floating-Point Real Number	Optional
Units: cm (default)		
Applicable Value(s): 0.05 (default), Positive floating-point real numbers		
Limitation(s): None		
Description: This input is used to specify the characteristic ray spacing for the rays used in the MOC calculation. A finer spacing will permit a more detailed calculation (with finer spatial features) at the cost of computing time. However, the decomposition of rays across multiple threads parallelizes very efficiently. Finally, one should be cognizant of minimum feature size (i.e., minimum flat-source region size) to ensure that there are an adequate number of rays traversing each region to have an accurate solution in that region. More information regarding the MOC methodology and implications of `ray_spacing` on the overall calculation is available in the MPACT Theory Manual		
Notes: None		

gamma_ray_spacing gamma_ray_spacing

`gamma_ray_spacing`	Floating-Point Real Number	Optional
Units: cm (default)		
Applicable Value(s): 0.05 (default), Positive floating-point real numbers		
Limitation(s): None		

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gamma_ray_spacing, continued...

Description: This input is used to specify the characteristic ray spacing for the rays used in the MOC calculation for gammas
Notes: None

shield_ray_spacing shield_ray_spacing

shield_ray_spacing	Floating-Point Real Number	Optional
Units: cm (default)		
Applicable Value(s): 0.05 (default), Positive floating-point real numbers		
Limitation(s): None		
Description: This input is used to specify the characteristic ray spacing for the rays used in the middle of cycle (MOC) shielding calculation. A finer spacing will permit a more detailed calculation (with finer spatial features) at the cost of computing time. However, the decomposition of rays across multiple threads parallelizes very efficiently. Finally, one should be cognizant of minimum feature size (i.e., minimum flat-source region size) to ensure that there are an adequate number of rays traversing each region to have an accurate solution in that region. More information regarding the MOC methodology and implications of ray_spacing on the overall calculation is available in the MPACT Theory Manual		
Notes: None		

log_message log_message

log_message	Character String	Optional
Units: N/A		
Applicable Value(s): warn (default), debug, basic		
Limitation(s): None		
Description: This input is used to specify which type of messages should be written to the log file		
Notes: None		

refl_assembly_layers refl_assembly_layers

refl_assembly_layers	String	Optional
Units: N/A		
Applicable Value(s): 1 (if PWR), 2 (if BWR) (default), ≥ 0, all, none, default		
Limitation(s): None		
Description: This input is used to specify the number of assembly layers to be added for the radial reflector region, that is, anything outside of the fuel radially. A given number is used as a hard limit on the number of assembly layers added; all puts no limit on the number of assemblies added. However, only those needed for core baffle, barrel, and vessel modeling will be added		
Notes: Only features or parts of features that fit within the given reflector thickness or default thickness will be modeled		

refl_highres refl_highres

refl_highres	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: This input is used to enable the reflector high-resolution flag. If enabled, vessel components are read as holes instead		
Notes: None		

moc_kernel moc_kernel

moc_kernel	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): MG (default), 1G,kokkos		
Limitation(s): None		
Description: This input is used to specify whether one-group or multigroup MOC kernels are used for neutron transport		
Notes: None		

gamma_moc_kernel gamma_moc_kernel

gamma_moc_kernel	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): MG (default), 1G		
Limitation(s): None		
Description: This input is used to specify whether one-group or multigroup MOC kernels are used for gamma transport		
Notes: None		

shield_moc_kernel shield_moc_kernel

shield_moc_kernel	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): same value as moc_kernel (default), 1G,MG		
Limitation(s): None		
Description: This input is used to specify whether one-group or multigroup MOC kernels are used for the shielding sweeper		
Notes: None		

group_structure group_structure

group_structure	Array of Floating-Point Real Numbers, Length = User Specified	Optional
Units: eV (default)		
Applicable Value(s): same structure as provided by XS library named in xs_filename (default)		
Limitation(s): None		

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`group_structure`, continued...

Description: Gives the list of energy group boundaries to use for the multigroup transport calculations. If the input is not provided, the XS library structure is used. The list of energies must be provided in descending order. Each energy will be treated as the upper boundary of a group. The final group has a lower boundary of 0 eV, which should not be input by the user. All user-specified energy group boundaries must be equal to one of the energy boundaries in the XS library (splitting XS library groups is disallowed), and the first user-specified energy boundary must always be equal to the first group boundary in the XS library
Notes: None

moc_mg_data_passing moc_mg_data_passing

`moc_mg_data_passing`	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: This input is used to specify whether one-group or multigroup MOC data passing is used		
Notes: This is primarily to bypass the MPI issues observed with the multigroup angular flux and is applicable only when using `moc_kernel`=MG		

moc_blocking_data_passing moc_blocking_data_passing

`moc_blocking_data_passing`	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: This input is used to specify whether blocking or nonblocking MOC data passing is used		
Notes: None		

moc_rational_frac_tol moc_rational_frac_tol

`moc_rational_frac_tol`	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): $\max\left(0.001, \min\left(0.02, 10^{(-1.2653-0.0271\cdot n_{azi})}\right)\right)$ (default), Positive floating-point real numbers		
Limitation(s): None		
Description: This input is used to set the tolerance of the rational fractions calculation that is part of the modular angle-spacing pair setup. A default is defined to set reasonable values for the likely `azimuthals_octant` values ranging between 2 and 64. However, `azimuthals_octant`>= 64 might require a tighter tolerance to achieve accurate results. Therefore, the user can use this input to override the default behavior as needed		
Notes: None		

moc_min_flux moc_min_flux

moc_min_flux	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: This input is used to prevent a nonpositive MOC scalar flux. At the end of each MOC sweep, any MOC flux less than moc_min_flux is set to moc_min_flux		
Notes: A very small positive real number such as 1.0×10^{-20} is recommended		

volume_corr volume_corr

volume_corr	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): none (default), integral, angledep		
Limitation(s): None		
Description: This input is used to specify the volume correction being applied to the MOC segments		
Notes: The integral option can be used to significantly improve the convergence properties of certain transient calculations		

modular_rays modular_rays

modular_rays	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): two (default), decart, three, cactus, ratfrac		
Limitation(s): None		
Description: This input is used to specify the volume correction being applied to the MOC segments		
Notes: None		

radial_src_order radial_src_order

radial_src_order	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): Zero or positive integers		
Description: This input is used to read the source order in the radial direction		
Notes: Currently only flat(0) and linear(1) are implemented		

axial_src_order axial_src_order

axial_src_order	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): Zero or positive integers		
Description: This input is used to read the source order in the axial direction		
Notes: Currently only flat(0) and linear(1) are implemented		

power_edit power_edit

power_edit	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): KAPPA-FISSION (default), FISSION,GAMMA-SMEARED		
Limitation(s): None		
Description: This input is used to specify a cross section used for the power calculations. KAPPA-FISSION is the standard power calculation, whereas FISSION actually produces the normalized fission reaction rate distribution and GAMMA-SMEARED calculates the normalized gamma smeared power distribution		
Notes: None		

jagged jagged

jagged	Boolean	Optional
Units: N/A		
Applicable Value(s): true (default), false		
Limitation(s): See notes regarding potential inefficiencies when running a parallel-processing simulation		
Description: This input is used to specify whether the reflector region will be modeled using a jagged (stair-step) representation or by filling the full square extent of the modeling domain with moderator material		
Notes: When a jagged core is used, care should be taken if the user elects to perform manual parallel domain decomposition to ensure proper load balancing. Additional information is provided with the par_file		

rod_treatment rod_treatment

rod_treatment	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): polynomial (default), none,1dcpm		
Limitation(s): The pregenerated polynomials were generated using AIC, B4C, and tungsten control rods for Watts Bar Unit 1. Materials with any other name will be ignored, and the results might not be improved as much for reactors other than Watts Bar Unit 1		
Description: This input toggles the use of volume weighting for control rods to minimize the effect of control rod cusping on the calculated results. Rod cusping is a calculational effect that occurs when a control rod is partially inserted into a calculational plane. This causes an artificial reduction in the local flux, which in turn causes an error in the calculated eigenvalue and global power distribution. Enabling this rod treatment input will correct for these effects. The polynomial option uses pregenerated polynomials to reduce the volume fraction of the control rod material during the homogenization step, providing better solutions near the tip of the control rod. The 1D collision probabilities method (1dcpm) is used to generate radial shape functions for rodded and unrodded regions, and then these shape functions are used to flux-volume homogenize the cross sections for the MOC calculations		
Notes: This input has an effect only when used in a 3D calculation (i.e., a calculation with axial planes). Options other than none and polynomial require that one of subplane_max, subplane_target or num_subplanes be used as well. All options requiring subplane to be enabled are considered experimental		

ppm_method ppm_method

ppm_method	Character String	Optional
Units: N/A		
Applicable Value(s): 2 (default), 1		
Limitation(s): None		
Description: This input is used to specify which method should be used for computing soluble boron in the critical boron search. The options are as follows: • 1: This is the method suggested by nuclear vendors that just adds boron to water and does not conserve moderator density • 2: This is the original MPACT method that conserves moderator density		
Notes: None		

rst_compress rst_compress

rst_compress	Free-form Character String	Optional
Units: N/A		
Applicable Value(s): 0 (default), none, 0 through 9		
Limitation(s): This affects only the WRITING of the restart file. restart_read cases and restart_shuffle cases are not affected		
Description: None means the HDF5 Filter for gzip compression is NOT used when writing the restart file. The numeric value indicates the level of compression to use in gzip. The higher the number, the more aggressive the compression, and the more resources used. See documentation of gzip for information		
Notes: The primary reason for this option is to disable compression because on some platforms decompression by HDF5 while reading might lead to an allocation error in HDF5 due to heap fragmentation. See documentation on the h5repack utility installed with the HDF5 library for removing compression after the file is written (e.g., h5repack -f NONE <old_file> <new_file>)		

vis_edits vis_edits

vis_edits	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): none (default), core, fsr		
Limitation(s): None		
Description: This input is used to specify the type of visualization outputs (edits). The visualization outputs are created in the form of the VTK legacy file format, which is suitable for use with VisIt (https://wci.llnl.gov/simulation/computer-codes/visit/) or other suitable programs capable of reading the format. These options are described as follows: 1. core: will print pin level edits of power for the full core 2. none: will not print any visualization files 3. fsr: will print all available edits in the code on a flat source region-basis, which includes material boundaries, mesh identification indices, and group-wise scalar flux		
Notes: The FSR edits will be very large and might require considerable time to generate the visualization files		

rr_edits rr_edits

rr_edits	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): none (default), hdf5, out, both		
Limitation(s): None		
Description: This input is used to specify the type of reaction rate outputs (edits). The reaction rate of an isotope is currently smeared over the problem domain when being printed to the output file, but the HDF5 file contains full information of reaction rates in geometry mesh. These options are described as follows: 1. none: will not generate reaction rate edits 2. hdf5: will generate reaction rate edits in HDF5 3. out: will print reaction rate in the output file 4. both: will do both hdf5 and out		
Notes: The reaction rate edits could be slow and memory consuming for a large problem		

rr_edits_opt rr_edits_opt

rr_edits_opt	Array of Pre-defined Format Strings	Optional
Units: N/A		
Applicable Value(s): none (default), isotope_reaction (absorption, fission, nu*fission, inscatter, outscatter, selfscatter)		
Limitation(s): This input can be used only if rr_edits is turned on		
Description: This input is used to specify the reaction rate edits for user-specified isotopes and reactions. The isotope is in a format of xx-AAA, (e.g., U-235 and Pu-239). The available reaction types are absorption, fission, nu*fission, inscatter, outscatter, and selfscatter		
Notes: Selecting the important isotopes and reactions for edits can reduce the computing time and memory requirements for a large problem		

xe135m_opt xe135m_opt

xe135m_opt	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): ignore (default), combine, explicit		
Limitation(s): None		
Description: This input is used to specify the treatment of ^{135m}Xe. By default, MPACT ignores ^{135m}Xe when performing transport calculation, although the depletion solver may consider it. When combining ^{135m}Xe into ^{135}Xe, cross sections of the two isotopes are assumed to be the same. Explicit treatment can be enabled only for the latest MG library that has ^{135m}Xe data based on TENDL data. These options are described as follows: 1. ignore: will ignore ^{135m}Xe in transport calculation 2. combine: will combine ^{135m}Xe into ^{135}Xe in transport calculation 3. explicit: will treat ^{135m}Xe explicitly as other isotopes in transport calculation		
Notes: None		

azimuthal_xs azimuthal_xs

azimuthal_xs	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): none (default), full, fuel, gad		
Limitation(s): None		
Description: This input is used to specify the azimuthally dependent cross section region option. By default, MPACT will generate cross sections for radial rings only to minimize computational resource requirements. For BWR applications, or other special cases, increased accuracy might be needed by treating cross sections radially and azimuthally in the fuel pellet. These options are described as follows: 1. none: original cross section generation scheme 2. full: use azimuthal XS for all pin cell types 3. fuel: use azimuthal XS for fuel pin cell types only 4. gad: use azimuthal XS for gadolinium pin cell types only		
Notes: Several options are provided to fine tune the accuracy vs. computational resources. The full option causes the largest increase in run time and memory usage, followed by fuel and gad. The depletion calculation will be performed for specified azimuthal regions as well		

explicit_erg_deposit explicit_erg_deposit

explicit_erg_deposit	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: This input is used to specify whether the explicit energy deposition is used. Explicit energy deposition will compute the energy deposited in all regions from neutron fission, capture, and slowing down		
Notes: MPACT library uses the hard-coded values. Other libraries do not support this input		

nodal_edits nodal_edits

nodal_edits	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): false (default), nem, sanm-2, sanm-4, senm-2, senm-4		
Limitation(s): None		

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`nodal_edits`, continued...

Description: This input is used to enable or disable MPACT's nodal cross section capability. If enabled, node-averaged cross sections, flux moments, kinetics data, TH data, discontinuity factors, and other information will be written to each block of the HDF5 file. The different options will generate assembly discontinuity factors (ADFs) using different kernels. These options are described as follows: 1. `nem`: enables MPACT nodal cross section edits using a quartic NEM kernel to generate ADFs 2. `sanm-2`: enables MPACT nodal cross section edits using a quadratic SANM kernel to generate ADFs 3. `sanm-4`: enables MPACT nodal cross section edits using a quartic SANM kernel to generate ADFs 4. `senm-2`: enables MPACT nodal cross section edits using a quadratic SENM kernel to generate ADFs 5. `senm-4`: enables MPACT nodal cross section edits using a quartic SENM kernel to generate ADFs 6. `false`: disables MPACT nodal cross section edits
Notes: The SANM input options do the same thing as the SENM options

nodal_edits_energy_cutoff nodal_edits_energy_cutoff

`nodal_edits_energy_cutoff`	Float	Optional
Units: eV (default)		
Applicable Value(s): Any energy greater than 0.0 that is also an energy boundary in the transport library used for the calculation		
Limitation(s): None		
Description: This input is used to set the energy cutoff between the two groups when generating nodal data. The default cutoff is the energy between the last group with no up-scatter and the first group with up-scatter. This value is library dependent and is automatically determined during the calculation. The user can specify any of the energy group boundaries defined by the transport library as an input to this input		
Notes: None		

nodal_data_filename nodal_data_filename

`nodal_data_filename`	Free-Form Character String, Max. Length = 200	Optional
Units: N/A		
Applicable Value(s): N/A (default), Filename of any valid HDF5 file with user-defined nodal data		
Limitation(s): This input must be present if using the Nodal transport method, and nodal data must be provided for every state		
Description: This input is used to indicate the name of the file containing the nodal data for each state		
Notes: The format of the HDF5 file must follow the same format as the HDF5 output nodal edits. The head dataset of the file must contain `[STATE]` datasets following the *STATE_####* nomenclature, which are populated with `NODAL_XS` datasets. `NODAL_XS` must include *ADF*, *CHI*, *KXSF*, *NXSF*, *XSF*, *XSRM*, *XSS*, and *XSTR*. These nodal datasets must have the same shapes as their corresponding output counterparts		

nodal_edits_adapt_adf nodal_edits_adapt_adf

nodal_edits_adapt_adf	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: This input is used to enable or disable MPACT's adaptive ADF calculations. When enabled, MPACT will adjust the outgoing current on vacuum boundaries until the ADF is equal to 1.0. The removal cross section will then be modified to preserve neutrons, and the diffusion cross section will be modified to be consistent with the removal cross section. These options are described as follows: 1. `true`: enables MPACT adaptive ADF calculations 2. `false`: disables MPACT adaptive ADF calculations		
Notes: Has no effect if `nodal_edits` is set to `false`		

nodal_edits_transient_data nodal_edits_transient_data

nodal_edits_transient_data	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: This input is used to enable or disable editing transient data in the nodal edits. When enabled, MPACT will solve for the adjoint flux and collapse all transient data such as velocity, delayed neutron fraction and decay rate, and delayed fisison spectrum. These options are described as follows: 1. `true`: enables MPACT editing transient data 2. `false`: disables MPACT editing transient data		
Notes: Has no effect if `nodal_edits` is set to `false`		

nodal_edits_collapse_axial_reflectors nodal_edits_collapse_axial_reflectors

nodal_edits_collapse_axial_reflectors	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: This input is used to enable or disable collapsing the axial reflector nodal data. When enabled, each reflector will be collapsed into a single plane, regardless of how many planes are in the reflector. These options are described as follows: 1. `true`: collapses each axial reflector into a single plane 2. `false`: treats each axial reflector plane separately		
Notes: Has no effect if `nodal_edits` is set to `false`		

crit_buckling crit_buckling

crit_buckling	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `none` (default), fmode, B1, P1		
Limitation(s): The input must be a single square lattice		

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crit_buckling, continued...

Description: This input calls for use of a critical buckling calculation. The solver can be choosen for use on the fundamental mode, P1, or B1 equations. The MOC scalar flux is corrected with the critical spectrum. Generated homogenized cross sections are representative of a critical configuration. These inputs are as follows: 1. `fmode` — Corrects the scalar flux with a critical spectrum obtained from the solution of the fundamental mode equation 2. `B1` — Corrects the scalar flux with a critical spectrum obtained from the solution of the B1 equations 3. `P1` — Corrects the scalar flux with a critical spectrum obtained from the solution of the P1 equations 4. `none` — No critical buckling calculation
Notes: None

native_excore_detector native_excore_detector

`native_excore_detector`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: This input is used to specify whether to perform the excore detector edits using the native simplified MPACT solver		
Notes: None		

grid_treatment grid_treatment

`grid_treatment`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `equal_mass` (default), `homogenize`, `equal_thickness`		
Limitation(s): For grids with large masses that fall within axially narrow lattices, there is a possibility that the grid will intersect one or more pins for the `equal_thickness` and `equal_mass` options. If this occurs, then MPACT will raise an error, and the user will be required to change the axial meshing options, change the geometry of the lattice, or simply use the `homogenize` option for the `grid_treatment` input. These options are described as follows: • `homogenize`: will take the mass specified in the grid input, calculate the moderator volume of the lattice where the grid is located, and use the two values to compute the density of the material. This option applies the grid material uniformly throughout the lattice. • `equal_thickness`: uses the grid mass and the corresponding grid material density to compute the total grid volume for that lattice. The volume is then used to determine what the grid thickness would be within each pin cell and is modeled as an additional rectangular mesh around the perimeter of each pin cell in the lattice. • `equal_mass`: similar to the `equal_thickness` option, except that the thickness of the grid in each pin cell is changed throughout the lattice so that every pin cell contains the same grid material mass.		

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`grid_treatment`, continued...

Description: This input is used to indicate the method of applying the grid structure in a lattice on the mesh
Notes: None

axial_buckling axial_buckling

`axial_buckling`	Float	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Value used for critical buckling calculations		
Notes: None		

uniform_crud uniform_crud

`uniform_crud`	Floating-Point Real Numbers	Optional
Units: microns, mg/cm^2, mg/cm^2 (default)		
Applicable Value(s): 0.0, 0.0, 0.0 (default)		
Limitation(s): None		
Description: This input is used to define a uniform layer of CRUD on all fuel pins. The `thickness` is the CRUD thickness in microns, the `crud_mass` is the surface mass density of Ni Fe_2 O_4 in mg/cm^2, and the `boron_mass` is the surface mass density of Li B_4 O_7 in mg/cm^2		
Notes: None		

crud_depletion flag crud_depfrac

`flag`	Boolean	Optional
Units: N/A		
Applicable Value(s): `true`, false		
Limitation(s): None		
Description: This input is used to enable or disable crud depletion		
Notes: None		

`crud_depfrac`	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: This input is used to specify the fraction of crud to be depleted		
Notes: None		

meshing_method meshing_method

meshing_method	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): useraxialmesh (axial_mesh input present), *or* matbound (axial_mesh input not present) (default), nonfuel, all		
Limitation(s): Must be set in conjunction with the axial_edit_bounds input in the EDIT block of the VERA input when the option is not useraxialmesh. These data are required to set up the axial mesh for every input option except the useraxialmesh, where it is separately specified		
Description: This input specifies the type of axial meshing to be used. If this input is not present, then the method will default to useraxialmesh if the axial_mesh input is present, or it will default to matbound if the axial_mesh input is not present. • useraxialmesh: requires the use of the axial mesh input, and no automeshing is performed in this instance. This option will not use the values specified by the automesh_bounds because it does not perform any automeshing • matbound: calculates the axial mesh just at the axial material boundaries of the problem and uses the axial_edit_bounds as the mesh within the fuel regions. No further meshing is performed. This option will not use the values specified by the automesh_bounds because it does not perform any automeshing • nonfuel: will take the material boundaries and automesh the regions below and above the fuel. The minimum and maximum bounds (or default values) specified by the automesh_bounds will be used to determine the sizing • all: will take the material boundaries and automesh all regions. The minimum and maximum bounds (or default values) specified by the automesh_bounds will be used to determine the sizing. When using the all option, fuel regions will not be homogenized with nonfuel regions. Homogenization will only occur within those regions		
Notes: When using the useraxialmesh option, it is possible to specify a mesh that does not conform or align with the problem's geometry. Warnings will be printed to the log file stating that the mesh does not match the geometry boundaries, and those regions will be homogenized		

automesh_bounds automesh_bounds

automesh_bounds	Array of Floating-Point Real Numbers, Length = 2	Optional
Units: cm (default)		
Applicable Value(s): 2.0 20.0 (when automeshing is enabled) (default), Positive real numbers greater than zero. The maximum value must be at least 1.0 greater than the minimum value		
Limitation(s): None		
Description: This input specifies the minimum and maximum desired axial mesh for the axial automeshing. Any geometry or mesh region larger than the specified value will be divided into smaller mesh regions that have heights between the maximum and minimum values. Any geometry or mesh region smaller than the specified value will be homogenized and added to a neighboring mesh region until the value is above the minimum and below the maximum		

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automesh_bounds, continued...

Notes: The region where these values are applied is specified by the meshing_method input. This input is ignored when the useraxialmesh and matbound method is specified. Note that specifying min and max values that are close together will most likely result in more axial homogenization than might be desired by the user. This would mean that most of the material interfaces will be homogenized to some degree. Also, this routine in no way optimizes the axial meshing for a given problem. It is primarily designed to reduce user burden from specifying a typically troublesome input parameter. It is best suited for problems with a large number of planes that vary in thickness. It is also useful for setting a problem up if the user is unsure about the axial discretization. Using this input will save time spent on recalculating values whenever the axial mesh needs to be adjusted

axial_mesh axial_mesh

axial_mesh	Array of Floating-Point Real Numbers, Length = User Specified	Optional
Units: cm (default)		
Applicable Value(s): N/A (default), Array of positive real numbers		
Limitation(s): The sum of the values specified within this input must be equal to the total geometric height of the problem		
Description: This input is used to specify the axial mesh used in the 2D/1D simulation. The input is the thickness of each axial section the user wishes to model. This input is optional if the meshing_method input specifies an option other than useraxialmesh. If the meshing_method is useraxialmesh, then it is required		
Notes: If the array of axial meshes sums to less than the problem height, the geometry at the top will be truncated. If it sums to more than the problem height, the top geometry will be extended all the way to the upper mesh height. Therefore, it is very important to make sure the axial mesh is specified in accordance with the geometry		

inter_assembly_gapmeshnum wide_gap_normal wide_gap_parallel narrow_gap_normal narrow_gap_parallel inner_gap

wide_gap_normal	Integer	Optional
Units: N/A		
Applicable Value(s): 3 (default), values must be on the interval [1,10]		
Limitation(s): Applicable only to BWR cores		
Description: This input defines the number of MOC fine source mesh regions in a pin cell in the wide gap along the direction normal to the channel box		
Notes: The inter_assembly_gapmeshnum input is optional, but this parameter is required on this input		

wide_gap_parallel	Integer	Optional
Units: N/A		
Applicable Value(s): 3 (default), values must be on the interval [1,10]		
Limitation(s): Applicable only to BWR cores		
Description: This input defines the number of MOC fine source mesh regions in a pin cell in the wide gap along the direction parallel to the channel box		
Notes: The inter_assembly_gapmeshnum input is optional, but this parameter is required on this input		

narrow_gap_normal	Integer	Optional
Units: N/A		
Applicable Value(s): 3 (default), values must be on the interval [1,10]		
Limitation(s): Applicable only to BWR cores		
Description: This input defines the number of MOC fine source mesh regions in a pin cell in the narrow gap along the direction normal to the channel box		
Notes: The inter_assembly_gapmeshnum input is optional, but this parameter is required on this input		

narrow_gap_parallel	Integer	Optional
Units: N/A		
Applicable Value(s): 3 (default), values must be on the interval [1,10]		
Limitation(s): Applicable only to BWR cores		
Description: This input defines the number of MOC fine source mesh regions in a pin cell in the narrow gap along the direction parallel to the channel box		
Notes: The inter_assembly_gapmeshnum input is optional, but this parameter is required on this input		

inner_gap	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), values must be on the interval [1,10]		
Limitation(s): Applicable only to BWR cores		
Description: This input defines the number of MOC fine source mesh regions in a pin cell in the inner gap of the channel box and fuel pins parallel to channel box		
Notes: The inter_assembly_gapmeshnum input is optional, but this parameter is required on this input. The number of inner gap and channel box mesh divisions normal to the channel box uses the corresponding values of the wide_gap_normal and narrow_gap_normal parameters		

control_blade_meshnum sheath_num CR_rodlet_num

sheath_num	Integer	Optional
Units: N/A		
Applicable Value(s): 3 (default), values must be on the interval [1,10]		
Limitation(s): Applicable only to BWR cores		

continued on next page...

sheath_num, continued...

Description: This input defines the number of MOC fine source regions along the length of the sheath of the control blade in a pin cell
Notes: The control_blade_meshnum input is optional, but this parameter is required

CR_rodlet_num	Integer	Optional
Units: N/A		
Applicable Value(s): 2 (default), values must be on the interval [1,10]		
Limitation(s): Applicable only to BWR cores		
Description: This input defines the number of MOC fine source radial mesh in the rodlets of the control blade		
Notes: The control_blade_meshnum input is optional, but this parameter is required		

detector_meshnum DT_gap_num DT_rodlet_num

DT_gap_num	Integer	Optional
Units: N/A		
Applicable Value(s): 2 (default), values must be on the interval [1,10]		
Limitation(s): Applicable only to detectors in BWR cores		
Description: This input defines the gap mesh number of the BWR detector region. This is the number of radial divisions in the water outside the detector, inside the detector cell		
Notes: The detector_meshnum input is optional, but this parameter is required if detector_meshnum is present		

DT_rodlet_num	Integer	Optional
Units: N/A		
Applicable Value(s): 2 (default), values must be on the interval [1,10]		
Limitation(s): Applicable only to detectors in BWR cores		
Description: This input defines the rodlet mesh number of the BWR detector. This is the number of radial divisions in the detector cell		
Notes: The detector_meshnum input is optional, but this parameter is required if detector_meshnum is present		

pin_cell_mod_mesh pin_cell_mod_mesh

pin_cell_mod_mesh	Array of mixed types Integer and String, Length = 2	Optional
Units: N/A		
Applicable Value(s): num_rings = 1 and pin_cell_type = fuel (default), > 0 nonfuel, > 0 both		
Limitation(s): This option does not work with explicit grid spacers. To use with grid spacers, set the grid_treatment option to homogenize		

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pin_cell_mod_mesh, continued...

Description: This input is used to specify the MOC flat source region mesh in the moderator outside the defined cylindrical geometry in specified pin cells. The radius of the outermost moderator ring is fixed at `0.95*sqrt(2)/2*pitch`. This gives more refined meshing in the pin cell corners, which improves the accuracy of calculations at room temperature • `num_rings`: positive integers. Practically less than 10 • `pin_cell_type`: `fuel, nonfuel, both`
Notes: When this input is not specified, the following value is used for the 1 default moderator radius: `max_radii = 0.75*(pitch*0.5 - r_last)+r_last`. When this input is specified, that value changes to `max_radii = 0.95*(0.5*pitch*sqrt(2))`, which is equal to 95% of the distance from the pin cell's center to the corner. The default moderator radius is also applied to pin cells which do not match the `pin_cell_type` when the input is used. So, for example, if `pin_cell_type` is set to `nonfuel`, then the fuel pins would still use the default moderator radius

rad_fuel_mesh rad_fuel_mesh

`rad_fuel_mesh`	Float	Optional
Units: N/A		
Applicable Value(s): > 0.0 or < 1.0		
Limitation(s): Size must match radial divisions specified for fuel on the `mesh fuel` input—not applicable to annular fuel		
Description: Fractional radii of MOC source regions in fuel		
Notes: None		

crud_mesh crud_mesh

`crud_mesh`	One Floating-Point Real and One Integer	Optional
Units: microns (default)		
Applicable Value(s): N/A (default)		
Limitation(s): None		
Description: This input is used to specify the radial mesh that is added for each cell to account for CRUD buildup on the surfaces of the fuel pins. The options are positive real numbers for `max_rad` and integers greater than 0 for `num_rad`. The `max_rad` is the maximum thickness of the outermost CRUD region in microns, and `num_rad` is the number of radial subdivisions in the CRUD region		
Notes: None		

quad_type quad_type

`quad_type`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): CHEBYSHEV-YAMAMOTO (default), CHEBYSHEV-CHEBYSHEV (Product), CHEBYSHEV-GAUSS (Product), CHEBYSHEV-BICKLEY (Product), QUADRUPLE-RANGE (Product), LEVEL-SYMMETRIC (Base)		
Limitation(s): None		

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quad_type, continued...

Description: This input is used to specify the name of the angular quadrature to use when determining the angles at which the rays are traced throughout the problem

Quadrature Name	Type	Azimuthal Order	Polar Order
CHEBYSHEV-CHEBYSHEV	Product	integers > 0	integers > 0
CHEBYSHEV-GAUSS	Product	integers > 0	integers > 0
CHEBYSHEV-BICKLEY	Product	integers > 0	1, 2, 3, or 4
CHEBYSHEV-YAMAMOTO	Product	integers > 0	1, 2, or 3
LEVEL-SYMMETRIC	General	even integers $\in [2, 16]$	N/A
QUADRUPLE-RANGE	Product	integers $\in [1, 37]$	integers $\in [1, 18]$

Notes: None

gamma_quad_type gamma_quad_type

gamma_quad_type	Fixed Character String	Optional

Units: N/A

Applicable Value(s): quad_type value (default), CHEBYSHEV-CHEBYSHEV (Product), CHEBYSHEV-GAUSS (Product), CHEBYSHEV-BICKLEY (Product), QUADRUPLE-RANGE (Product), LEVEL-SYMMETRIC (Base)

Limitation(s): None

Description: This input is used to specify the name of the angular quadrature to use when determining the angles at which the rays are traced throughout the problem for gamma transport

Quadrature Name	Type	Azimuthal Order	Polar Order
CHEBYSHEV-CHEBYSHEV	Product	integers > 0	integers > 0
CHEBYSHEV-GAUSS	Product	integers > 0	integers > 0
CHEBYSHEV-BICKLEY	Product	integers > 0	1, 2, 3, or 4
CHEBYSHEV-YAMAMOTO	Product	integers > 0	1, 2, or 3
LEVEL-SYMMETRIC	General	even integers $\in [2, 16]$	N/A
QUADRUPLE-RANGE	Product	integers $\in [1, 37]$	integers $\in [1, 18]$

Notes: None

shield_quad_type shield_quad_type

shield_quad_type	Fixed Character String	Optional

Units: N/A

Applicable Value(s): CHEBYSHEV-YAMAMOTO (default), CHEBYSHEV-CHEBYSHEV (Product), CHEBYSHEV-GAUSS (Product), CHEBYSHEV-BICKLEY (Product), QUADRUPLE-RANGE (Product), LEVEL-SYMMETRIC (Base)

Limitation(s): None

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shield_quad_type, continued...

Description: This input is used to specify the name of the angular quadrature to use when determining the angles at which the rays are traced throughout the problem for the shielding calculation

Quadrature Name	Type	Azimuthal Order	Polar Order
CHEBYSHEV-CHEBYSHEV	Product	integers > 0	integers > 0
CHEBYSHEV-GAUSS	Product	integers > 0	integers > 0
CHEBYSHEV-BICKLEY	Product	integers > 0	1, 2, 3, or 4
CHEBYSHEV-YAMAMOTO	Product	integers > 0	1, 2, or 3
LEVEL-SYMMETRIC	General	even integers $\in [2, 16]$	N/A
QUADRUPLE-RANGE	Product	integers $\in [1, 37]$	integers $\in [1, 18]$

Notes: None

azimuthals_octant azimuthals_octant

azimuthals_octant	Integer	Optional
Units: N/A		
Applicable Value(s): 16 (default), Column Order in the above table		
Limitation(s): None		
Description: This input is used to specify the number of azimuthal angles per octant and corresponds to the Order column in the table in quad_type input		
Notes: None		

gamma_azimuthals_octant gamma_azimuthals_octant

gamma_azimuthals_octant	Integer	Optional
Units: N/A		
Applicable Value(s): azimuthals_octant value (default), Column Order in the above table		
Limitation(s): None		
Description: This input is used to specify the number of azimuthal angles per octant for gamma transport and corresponds to the Order column in the table in quad_type input		
Notes: None		

polars_octant polars_octant

polars_octant	Integer	Optional
Units: N/A		
Applicable Value(s): 2 (default), Column Order Θ in the above table		
Limitation(s): None		
Description: This input is used to specify the number of polar angles per octant and corresponds to the Order Θ column in the quadrature table specified in quad_type input. Note that the number of polar angles might be limited by the quadrature type used. Also, any nonproduct quadrature types will not use this input (i.e., in the applicable only case LEVEL-SYMMETRIC)		
Notes: None		

gamma_polars_octant gamma_polars_octant

gamma_polars_octant	Integer	Optional
Units: N/A		
Applicable Value(s): polars_octant value (default), Column Order Θ in the above table		
Limitation(s): None		
Description: This input is used to specify the number of polar angles per octant for gamma transport and corresponds to the Order Θ column in the quadrature table specified in quad_type input. Note that the number of polar angles might be limited by the quadrature type used. Also, any nonproduct quadrature types will not use this input (i.e., in the applicable only case LEVEL-SYMMETRIC)		
Notes: None		

shield_azimuthals_octant shield_azimuthals_octant

shield_azimuthals_octant	Integer	Optional
Units: N/A		
Applicable Value(s): 8 (default), Column Order in the above table		
Limitation(s): None		
Description: This input is used to specify the number of azimuthal angles per octant for the shielding sweeper and corresponds to the Order column in the table in quad_type input		
Notes: None		

shield_polars_octant shield_polars_octant

shield_polars_octant	Integer	Optional
Units: N/A		
Applicable Value(s): polars_octant value (default), Column Order Θ in the above table		
Limitation(s): None		
Description: This input is used to specify the number of polar angles per octant for the shielding calculation and corresponds to the Order Θ column in the quadrature table specified in quad_type input. Note that the number of polar angles might be limited by the quadrature type used. Also, any nonproduct quadrature types will not use this input (i.e., in the only applicable case LEVEL-SYMMETRIC)		
Notes: None		

xs_type xs_type

xs_type	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): ORNL (default), HELIOS		
Limitation(s): None		
Description: This input is used to specify the type of cross section file to use		
Notes: None		

xs_filename xs_filename

xs_filename	Free-Form Character String, Max. Length = 200	Optional
Units: N/A		
Applicable Value(s): mpact51g_71_4.3m3_01222019.fmt (default), filename of a supported cross section library		
Limitation(s): None		
Description: This input is used to specify the name of the cross section file to use		
Notes: None		

ce_filename ce_filename

ce_filename	Free-Form Character String, Max. Length = 200	Optional
Units: N/A		
Applicable Value(s): No default value (default), filename of an indexing file for CE library		
Limitation(s): None		
Description: This input is used to specify the name of the indexing file of the continuous energy (CE) cross section library to be used when quasi_1D is toggled on		
Notes: None		

shield_method shield_method

shield_method	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): subgroup (default), essm, subgroup-cell, essm-cell, sdessm-cell		
Limitation(s): The xs_shielder input must be enabled (default) to enable this input; otherwise, unshielded cross section (infinite-dilute) will be used		
Description: This input is used to specify the method used to shield the cross sections. The values are described as follows: • subgroup: uses the whole-core subgroup self-shielding method to calculate equivalence cross sections • essm: uses the whole-core embedded self-shielding method (ESSM) to calculate equivalence cross sections • subgroup-cell: uses a cell-based subgroup self-shielding method to calculate equivalence cross sections • essm-cell: uses a cell-based ESSM to calculate equivalence cross sections • sdessm-cell: uses a cell-based spatially dependent ESSM to calculate equivalence cross sections		

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`shield_method`, continued...

Notes: The subgroup method has a few advantages over ESSM, such as a better representation of distributed self-shielding within the fuel and the resonance category treatment (resonance isotopes are grouped into categories). Therefore, the subgroup method is an option with better accuracy than in the current version. The cell-based shelf-shielding methods still use a one-group whole-core subgroup calculation to treat spacer grids, cladding, and other similar materials. The cell-based method is then applied to the fuel rods, control rods, and other important resonance materials that have multiple subgroup categories and levels

shield_nbatch shield_nbatch

`shield_nbatch`	Integer	Optional
Units: N/A		
Applicable Value(s): 5 (default)		
Limitation(s): None		
Description: This input is used to specify the number of batches used to divide the pseudogroups of the MG shielding sweeper		
Notes: None		

xs_shielder xs_shielder

`xs_shielder`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`, `t`, `f`		
Limitation(s): None		
Description: This input is used to specify whether to shield the cross sections or not: `true`–enabled, `false`–disabled		
Notes: If shielder is disabled, the infinite-dilute cross sections for the resonance energy groups are used		

spatial_essm spatial_essm

`spatial_essm`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`, `t`, `f`		
Limitation(s): None		
Description: This input is used to specify whether to perform the spatial embedded self-shielding method (ESSM) correction for self-shielding calculation. Currently, this option can only be toggled on with `essm`		
Notes: None		

quasi_1D quasi_1D

`quasi_1D`	Fixed Character String	Optional
Units: N/A		

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quasi_1D, continued...

Applicable Value(s): `false` (default), `true`, `t`, `f`
Limitation(s): None
Description: This input is used to specify whether to perform the quasi-1D slowing-down correction for self-shielding calculation. Currently, this option can be toggled only on with `essm`
Notes: None

res_up_scatter res_up_scatter

`res_up_scatter`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: This input is used to specify whether to use the resonance data that incorporates the epithermal upscattering model. Currently, this option is only supported for the ORNL library from version 4 onward		
Notes: None		

subgr_temp_average subgr_temp_average

`subgr_temp_average`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `plane` (default), `pin`		
Limitation(s): None		
Description: This input is used to specify the fuel temperature averaging scheme for the subgroup temperature correction		
Notes: The averaged temperature is not directly used for cross section calculation. It is used to correct the nonuniform temperature effect in calculating the equivalence cross sections for subgroup method		

dep_filename dep_filename

`dep_filename`	Free-Form Character String, Max. Length = 200	Optional
Units: N/A		
Applicable Value(s): `origen_data_paths_casl2.2.txt` (default), `origen_data_paths_scale62.txt`, `MPACT.dpl`		
Limitation(s): None		
Description: This input is used to specify the depletion file to use, which provides all the data required, in addition to the data in the transport library for depletion calculation. The `MPACT.dpl` option must be used if `dep_kernel` is set to `internal`. The depletion libraries listed here are provided with VERA, but others can also be used if the user supplies them		
Notes: None		

mats_file mats_file

mats_file	Free-Form Character String, Max. Length = 200	Optional
Units: N/A		
Applicable Value(s): No default value (default), filename of a HDF5 material database file		
Limitation(s): None		
Description: This input is used to specify the name of the HDF5 material database file. This file is used to overwrite the isotopic and weight fraction values for default VERA material		
Notes: Marked for deprecation—do not use!		

mod_mat mod_mat

mod_mat	Free-Form Character String, Max. Length = 200	Optional
Units: N/A		
Applicable Value(s): mod (default), any user-defined name of the moderator material		
Limitation(s): None		
Description: This input is used to rename the moderator material		
Notes: None		

subgroup_set subgroup_set

subgroup_set	Integer	Optional
Units: N/A		
Applicable Value(s): 4 (default), integers 1 through 9		
Limitation(s): The shield_method must be set to subgroup or subgroup-cell. Other shielding options ignore this input		
Description: This input is used to specify the subgroup set		
Notes: In most cases, 4 (the default) should be used. This option provides a good balance of accuracy and computing time. In general, the numbering is from 1 to 9, with 1 being the simplest set (fast), and 9 being the most explicit set (slow)		

cat_onegroup cat_onegroup

cat_onegroup	Array of Integers, Length = User Specified	Optional
Units: N/A		
Applicable Value(s): 3(if subgroup_set = 4) (default), any integer number		
Limitation(s): The shield_method must be set to subgroup. ESSM ignores the cat_onegroup option		
Description: This input is used to specify the categories that use one-group subgroup		
Notes: The user can specify the categories that will use one-group subgroup treatment, which results in a fast, approximate subgroup calculation in that category. If subgroup_set = 4 (default), the default value of this option is 3 (clad category); otherwise, no default category will be assigned to one-group subgroup unless specified by the user. The user can also specify zero or a negative integer number to use the MG-subgroup for all categories		

shld_range shld_range

shld_range	Array of Integers, Length = 2	Optional
Units: N/A		
Applicable Value(s): 1,ng (default), between 1 and ng		
Limitation(s): Currently only simplified AMPX library supports this option		
Description: This input is used to specify the beginning and ending groups that resonance self-shielding calculation will be performed		
Notes: None		

k_tolerance k_tol

k_tol	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0E-6 (default), >0.0		
Limitation(s): None		
Description: This input is used to specify the global tolerance on convergence of the eigenvalue		
Notes: None		

flux_tolerance flux_tolerance

flux_tolerance	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 5.0E-5 (default), >0.0		
Limitation(s): None		
Description: This input is used to specify the tolerance on the convergence of the 2-norm of the fission source		
Notes: None		

gamma_flux_tolerance gamma_flux_tolerance

gamma_flux_tolerance	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0E-4 (default), >0.0		
Limitation(s): None		
Description: This input is used to specify the tolerance on the convergence of the 2-norm of the gamma flux		
Notes: None		

search_tolerance search_tol

search_tol	Floating-Point Real Number	Optional
Units: units will follow what is searched: ppm for boron, % for power and flow, and C for Tinlet, etc (default)		
Applicable Value(s): 1.0E-2 (default), >0.0		
Limitation(s): None		

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search_tol, continued...

Description: This input is used to specify the global tolerance for search variables including boron power, flow, and tinlet. There is no convergence criteria for critical rod search
Notes: None

num_outers num_outers

num_outers	Integer	Optional
Units: N/A		
Applicable Value(s): 500 (default), ≥1		
Limitation(s): None		
Description: This input is used to specify the maximum number of outer eigenvalue iterations. If the case is not converged to within the specified tolerances, this input value is compared with the current outer iteration value. If the current outer iteration value is equal to the input value, the program execution will exit with an error saying that the maximum number of iterations has been reached		
Notes: None		

num_inners num_inners

num_inners	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), ≥1		
Limitation(s): None		
Description: This input is used to specify the number of inner 1-group transport sweeps done during group sweeping every outer iteration		
Notes: For 2D/1D problems, it is usually optimal for num_inners to be set to 1. However, numerical instability is frequently an issue. The instability presents as an inability to converge to the desired tolerance. The solution will stagnate to within some tolerance and oscillate around that value until the maximum number of outers are reached. In this case, it is advised to use additional inner sweeps for stabilization. If so, num_inners=2 or 3 (with up_scatter=1) is a typical value		

gamma_num_inners gamma_num_inners

gamma_num_inners	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), ≥1		
Limitation(s): None		
Description: This input is used to specify the number of inner 1-group transport sweeps for gamma transport performed during group sweeping for every outer iteration		
Notes: None		

up_scatter up_scatter

up_scatter	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), ≥0		

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up_scatter, continued...

Limitation(s): None
Description: This input is used to specify the number of upscattering iterations that occur during group sweeping, (i.e., between fission source iterations)
Notes: Increasing up_scatter is one way to potentially remedy issues with numerical instability

gamma_up_scatter gamma_up_scatter

gamma_up_scatter	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), ≥0		
Limitation(s): None		
Description: This input is used to specify the number of upscattering iterations that occur during group sweeping for gamma transport, that is, between fission source iterations		
Notes: Increasing up_scatter is one way to potentially remedy issues with numerical instability		

num_extsrc_itrs num_extsrc_itrs

num_extsrc_itrs	Integer	Optional
Units: N/A		
Applicable Value(s): num_outers (default), ≥1		
Limitation(s): None		
Description: This input is used to specify the number of outer iterations an external source strength iteration will perform before increasing the source strength. If the current outer iteration value is equal to it, the source strengths will be increased by the strength multiplication factor, and outer iterations will be started again from count zero. This will repeat until the source is at full strength, wherein the full num_outers value will be used for the full strength iterations		
Notes: None		

scattering scattering

scattering	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): TCP0 (default), P0, P1, P2, P3, P4, P5, Pn0, LTCP0, FLTCP0		
Limitation(s): None		

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scattering, continued...

Description: This input is used to specify the scattering treatment to be used by the radial neutron transport calculations in MPACT. There are two primary categories: those that use the P0 sweeper and those that use the Pn sweeper. The P0 sweeper options are described as follows: • P0: performs transport calculations using isotropic scattering with no transport correction • TCP0: performs transport calculations using isotropic scattering with transport-corrected cross sections—this is the default • LTCP0: performs the same transport calculations as TCP0 except that for energies above 1 MeV the transport correction is limited to prevent negative self-scatter cross sections. This can hinder accuracy, but it can help stability in certain cases • FLTCP0: does the same thing as LTCP0 but for all energies The Pn sweeper options are described as follows: • Pn0: uses the same physics as TCP0, but with the Pn sweeper • P1: uses linearly anisotropic scattering for the transport calculations • P2: uses second-order anisotropic scattering for transport calculations • P3: uses third-order anisotropic scattering for transport calculations • P4: uses fourth-order anisotropic scattering for transport calculations • P5: uses fifth-order anisotropic scattering for transport calculations
Notes: None

gamma_scattering gamma_scattering

gamma_scattering	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): TCP0 (default), P0, LTCP0, FLTCP0		
Limitation(s): None		
Description: This input is used to specify the scattering treatment to be used by the radial gamma transport calculations in MPACT. The options for gamma transport are described as follows: • P0: performs transport calculations using isotropic scattering with no transport correction • TCP0: performs transport calculations using isotropic scattering with transport-corrected cross sections—this is the default • LTCP0: performs the same transport calculations as TCP0 except that for energies above 1 MeV the transport correction is limited to prevent negative self-scatter cross sections. This can hinder accuracy, but it can help stability in certain cases • FLTCP0: does the same thing as LTCP0 but for all energies		
Notes: None		

trim_Pn_moments trim_Pn_moments

trim_Pn_moments	Boolean	Optional
Units: N/A		
Applicable Value(s): true (default), false		
Limitation(s): None		
Description: This input is used to toggle the logic to trim unused scattering moments when using Pn scattering techniques		

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trim_Pn_moments, continued...

Notes: None

boundary_update boundary_update

boundary_update	String	Optional
Units: N/A		
Applicable Value(s): P0 (default), none, DP0, P1		
Limitation(s): None		
Description: This input is used to specify the CMFD boundary update method to accelerate convergence of problems using CMFD. The following options are available: • NONE: use no boundary update • P0: use CMFD scalar fluxes to scale transport angular fluxes (default) • DP0: use CMFD partial currents to scale transport angular fluxes • P1: use CMFD currents to scale transport angular fluxes		
Notes: The DP0 and P1 options are more complex and generally do not provide significant convergence improvement. The default option of P0 is recommended		

depl_time_method depl_time_method

depl_time_method	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): p-c(predictor-corrector) (default), semip-c(semi-predictor-corrector), postcorrector(semi-predictor-corrector-post-corrector), explicit		
Limitation(s): None		
Description: This input is used to specify the time-stepping method in depletion. The p-c method computes a predicted nuclide concentration based on the steady-state flux condition at the beginning of the time step, which is then averaged with the corrected nuclide concentration based on the steady-state flux condition at the end of the time step. Two steady-state eigenvalue calculations are performed for each depletion time step. The p-c method is a well-demonstrated method, and it can be used for large time steps. The semip-c method simplifies the p-c method by skipping the second steady-state eigenvalue calculation, and thus it becomes more efficient in small time- step depletion calculation. The postcorrector method is identical to the semip-c method except that the number densities used for the beginning of time step steady-state eigenvalue calculation are "postcorrected" so that they more closely represent the averaged number densities of the full p-c method. This allows for accuracy comparable with the full p-c method while still skipping the second steady-state eigenvalue calculation. The explicit method simply does one forward step in time using an explicit time step; this is not a recommended method because it will provide poor accuracy, but it can be useful for testing. The explicit option is what is used during transient calculations because the time steps are small enough for the explicit option to be accurate, and transient calculations are computationally expensive enough to warrant using the fastest possible depletion method		
Notes: The semip-c method can result in an inconsistency when restarting. However, the differences that arise from a semip-c restart are smaller in magnitude than the differences between semip-c and p-c. The inconsistency in the semip-c restart arises from an extra flux calculation that occurs on restart, so presumably the difference results in a more accurate solution		

gad_dep_method gad_dep_method

gad_dep_method	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): none (default), qgd2		
Limitation(s): None		
Description: This input is used to request a higher order treatment of gadolinium isotopes during burnup calculations. Currently, the only option is qgd2. When called with the qgd2 option, gadolinium isotopes are dealt with using the high-order methodology described in D. Lee, J. Rhodes, and K. Smith. "Quadratic Depletion Method for Gadolinium Isotopes in CASMO-5," *Nuclear Science and Engineering* 174 (2013), pp. 79–86. If the none option is used, then no special treatment of gadolinium isotopes will be considered		
Notes: None		

depl_origen_solver depl_origen_solver

depl_origen_solver	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): cram(CRAM solver) (default), matrex(MATREX solver)		
Limitation(s): None		
Description: This input is used to specify the solver method used by ORIGEN when performing depletion calculations. The cram method is the Chebyshev Rational Approximation Method (CRAM). The matrex method is a hybrid matrix exponential/linear chain method and is the legacy ORIGEN solution method		
Notes: Compared with the matrex solver, cram has similar run times but is more accurate and robust on a larger range of problems. Unlike matrex, the length of a step does not significantly affect the accuracy of cram in the absence of substep power renormalization. Thus, it is recommended that cram be used for ORIGEN depletion solves		

num_space num_space

num_space	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), Integer greater than 0 and less than the number of CPU cores		
Limitation(s): None		
Description: This input is used to specify the number of spatial decomposition regions used in a parallel execution step. This value can be 1. a subset of the number of planes in the model, 2. the total number of planes, or 3. a product of all of the planes and any number of radial regions comprised of groups of quarter assemblies for PWRs or groups of assemblies for BWRs. The ability to decompose a problem by planes can be used with the DEFAULT partition method. Any partition that decomposes the problem radially requires the EXPLICITFILE partition method		
Notes: See the description of input num_angle for explanation of using spatial and angular decomposition in conjunction		

num_angle num_angle

num_angle	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), Integer greater than 0 and less than the number of CPU cores		
Limitation(s): Specifying a value greater than 2*azimuthals_octant will cause an exception error		
Description: This input option specifies the number of parallel partitions used to decompose the problem based on the azimuthal angle (i.e., ray directions in the x-y plane). To get the 2D MOC solution for a single x-y plane, rays are traced through the domain in multiple azimuthal directions as specified by the user in the option azimuthals_octant. Note that the terms *octant* and *quadrant* are interchangeable in the context of azimuthal angles). The azimuthal angles are divided into num_angle groups, and each group is assigned to a parallel partition (i.e., process). If spatial decomposition is used in the same problem, then each spatial decomposition region is copied to num_angle partitions. Therefore, the total number of parallel partitions is num_angle*num_space		
Notes: The user is cautioned against using too many processes to decompose the problem. Because of the increase in interprocess communication with increased parallel decomposition, excessive parallelization will not yield speedup of the solution. The proper amount of parallelization must be determined on a case-by-case basis		

num_energy num_energy

num_energy	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default)		
Limitation(s): None		
Description: Energy decomposition is not yet supported. MPACT will run only with num_energy=1		
Notes: None		

num_threads num_threads

num_threads	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), Integer greater than 0 and less than the number of CPU cores		
Limitation(s): None		
Description: This input is used to specify the number of threads used in parallel execution. The number of threads specified are used only during the MOC transport sweep. For a given ray direction (i.e., angle), threads are used to sweep multiple rays in parallel		
Notes: It is recommended that num_angle*num_space*num_threads does not exceed the total number of physical CPU cores. MPACT will still run if the user exceeds this limit, but the parallel performance will be degraded		

par_method par_method

par_method	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): GRAPH (default), ASSEMBLY, EXPLICITFILE, EXPLICITRADIAL, PS, FULLCORE		

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par_method, continued...

Limitation(s): The EXPLICITFILE option can be used only if the user has created a partition file. For a description of the partition file, see the input option par_file
Description: This input is used to specify the method of parallel decomposition • GRAPH: spatially decomposes the core using graph partitioning methods. This method is automated, more flexible, and generally provides better load balance than the other options • [ASSEMBLY]: the parallelization scheme for decomposing a problem spatially. The problem will be decomposed radially first, and if there are more processors, it will then attempt to parallelize the problem axially. This process is done automatically, and the user is only required to specify the number of spatial processors available in the num_space input, described subsequently. Thie method is recommended for large problems. • EXPLICITFILE: for more advanced users who are running large problems, using the EXPLICITFILE option might enable the user to parallelize the problem more effectively. For a description of the EXPLICITFILE method, see the input option par_file • EXPLICITRADIAL: same as EXPLICITFILE, except that the decomposition is provided for a single plane and is applied to all planes • PS: same as ASSEMBLY • FULLCORE: assumes axial decomposition only; each 2D plane should be on the same process
Notes: None

par_file par_file

par_file	Free-Form Character String	Optional
Units: N/A		
Applicable Value(s): partition.txt (default)		
Limitation(s): No comments are allowed in the file		

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par_file, continued...

Description: This input is used to specify the parallel decomposition file if EXPLICITFILE is used. This is an advanced feature that is not recommended for most users. The MPACT domain is divided into a regular grid of ray trace modules; the partition file allows the user to specify the spatial decomposition of the domain by listing the ray trace modules in each spatial partition via their (x,y,z) indices (this is explained more in the following paragraphs). The partition file also allows the user to decompose the MPACT domain radially, which is not possible with the DEFAULT partition method The file structure itself has two header lines followed by the specification of the radial partition regions. The first line has three values: the first is the number of MPACT ray trace modules in the x direction, the second is the number of ray trace modules in the y direction, and the third is the number of axial planes in the model The second line also has three values. The first two pertain specifically to how MPACT partitions ray trace modules in space, and these values should always be 0 and 1, respectively. The third value should be the number of radial partitions being subsequently specified The following lines should describe all radial partition regions for the problem, including any regions that will be used with a jagged core. The input for each line is six integers. The first pair of integers is the starting and stopping module indices in the x direction, the second pair is the starting and stopping module indices in the y direction, and the last pair is for the z direction; however, these integers are ignored currently, and all radial partitions are assumed to be the same for each axial plane. The coordinate system point of origin when specifying the starting and stopping indices is the lower left (southwest) corner of the module. When specifying the starting and stopping indices, note that these are not necessarily the assembly positions. Typically, in the case of modeling a full reactor, the ray trace modules represent a quarter of an assembly. In this case, the number of ray trace modules in a given direction will be about twice the number of assemblies in that direction
Notes: If the core is jagged, additional attention is required to keep track of the actual number of processors being used by MPACT. Even though the nonexistent assemblies are "partitioned" in the explicit file, nothing there will be run. Therefore, the user cannot simply take the third value from the second line and multiply it by the third value from the first line to get the total number of spatial partitions for this case. In the following example, the third value in the second line must have the number of "jagged" partitions subtracted from it. In this case, the actual number of processors per plane becomes 49 - 8 = 41. That number can then be multiplied by the number of planes to get 2,378 processors, which should be input into the num_space input Also, it might be unclear to the user how many planes will be created in MPACT before the case is run. The output file has a summary of the axial mesh information, including the total number of planes. If the case crashes when using the partition file, the user should check that the number of planes specified matches the value in the output file

par_xdim par_xdim

par_xdim	Integer	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This input specifies the x dimension of the model when using the par_map option		
Notes: None		

par_ydim par_ydim

par_ydim	Integer	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This input specifies the y dimension of the model when using the par_map option		
Notes: None		

par_map par_map

par_map	2D Integer Map	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: If the EXPLICITRADIAL partition method is used and a file is not specified, then a par_map must be provided. This multiline map should contain the indexes containing each module. These domains must be contiguous (all modules in a domain must neighbor at least one other module in the domain) and must have no concave boundaries		
Notes: None		

graph_part_method graph_part_method

graph_part_method	Array of Fixed Character Strings	Optional
Units: N/A		
Applicable Value(s): 'REB' (default), 'RSB', 'RIB'		
Limitation(s): Applicable only if par_method is GRAPH		
Description: This input is used to read the decomposition/partition algorithms to be used for spatial decomposition		
Notes: None		

graph_refn_method graph_refn_method

graph_refn_method	Array of Fixed Character Strings	Optional
Units: N/A		
Applicable Value(s): 'KL', 'SKL', 'None'		
Limitation(s): Applicable only if par_method is GRAPH		
Description: This input is used to read the communication refinement algorithms to be used during spatial decomposition		
Notes: Should be of size 1 or same size as GRAPH_PART_METHOD		

graph_cond graph_cond

graph_cond	Array of Integers	Optional
Units: number of modules (default)		

continued on next page...

graph_cond, continued...

Applicable Value(s): > 0
Limitation(s): Applicable only if par_method is GRAPH
Description: This input reads inputs for smallest graph size (modules) for each decomposition method. This input should not be used by typical users
Notes: Should be of size 1 less than GRAPH_PART_METHOD

coupling_method coupling_method

coupling_method	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): simplified (if not configured with CTF) *or* ctf (if configured with CTF) (default), ctf_external, user_defined, hybrid, none		
Limitation(s): The feedback input in the [STATE] block must be set to on for any of the TH coupling methods		
Description: This input is used to indicate which TH coupling method should be used. The simplified option uses MPACT's internal TH solver. The ctf option internally couples CTF to MPACT, and ctf_external couples MPACT and CTF through the lime interface. The user_defined option uses TH conditions defined in the HDF5 file specified by the user_defined_th_filename input in the [MPACT] block. The none option will use parameters from the [STATE] block: fuel temperatures will be constant and equal to tfuel, moderator temperatures will be constant and equal to tinlet, and moderator densities will be constant and equal to modden. The hybrid option will use the simplified option for the first several iterations to obtain an approximate solution before switching to ctf		
Notes: For either the ctf or ctf_external options, MPACT must be configured with CTF. The internal option can be used regardless of whether or not MPACT was configured with CTF		

friction_correlation friction_correlation

friction_correlation	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), 2, 3, 4, 5		
Limitation(s): None		
Description: Thermal hydraulics friction factor correlation. The following options are available: 1. Default Ben's Formulation—From previous BWRFluidFlow implementation. Pulled from Dave Kropaczek's ANTS code. Does not use roughness. Correlation is $f = 0.1892Re^{-0.2}$ 2. VUQ PIRT—Original CTF correlation, does not use roughness 3. McAdams Correlation—Does not use roughness 4. Ziagrang-Sylvester correlation—Used by RELAP5, uses roughness 5. Churchill Formulation—Uses roughness		
Notes: None		

shielder_th shielder_th

shielder_th	Integer, Floating-Point Real Number, Floating-Point Real Number	Optional
Units: {unitless, K, g/cm^3} (default)		
Applicable Value(s): 100, 5.0, 0.01 (default), > 0 > 0.0 and > 0.0		
Limitation(s): If the xs_shielder input is set to f or false, then this input does nothing since cross section shielding calculations will never be performed		
Description: This input is used to control the number of cross section shielding calculations performed when using TH feedback. It sets a maximum number of iterations with shielding calculations; it also sets parameters to stop the shielding calculations earlier if the TH feedback effects on temperature and moderator density are small enough. The first input is the maximum number of outer iterations for which MPACT will perform cross section shielding calculations following a TH update. The second input is the minimum change in temperature for which MPACT will perform cross section shielding calculations following a TH update. The third and final input is the minimum change in moderator density for which MPACT will perform cross section shielding calculations following a TH update		
Notes: If multiple state points are performed in the calculation, then the counter for the shield_max_outers input is reset for each state point If the xs_shielder input is not set to f or false, then shielding calculations will always be performed on the first iteration		

outers_per_TH outers_per_TH

outers_per_TH	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), ≥ 0		
Limitation(s): None		
Description: This input is used to indicate how many outer iterations MPACT should perform before performing an additional TH update		
Notes: None		

init_from_STH_outers init_from_STH_outers

init_from_STH_outers	Integer	Optional
Units: N/A		
Applicable Value(s): 5 (BWR), or 3 (Non-BWR) (default), ≥ 0		
Limitation(s): None		
Description: If coupling_method is set to hybrid, then this input is used to determine how many simplified TH solves will be performed before switching to CTF		
Notes: If coupling_method is not set to hybrid, this input does nothing. Additionally, if the solution converges before reaching the number of iterations specified in this option, then the code will switch to CTF immediately for the subsequent iteration; this ensures that CTF is run at least once before the solution is considered converged		

average_ftemp average_ftemp

average_ftemp	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: If true, this input applies a volume-averaged fuel temperature to each fuel pin. If false, it applies a radially dependent fuel temperature to each fuel pin		
Notes: None		

radial_power_ctf_coupling radial_power_ctf_coupling

radial_power_ctf_coupling	Boolean	Optional
Units: N/A		
Applicable Value(s): true (default), false		
Limitation(s): None		
Description: If true, this input calculates the radial power Zernike coefficients to pass to CTF. If false, no coefficients are calculated		
Notes: None		

radial_burnup_ctf_coupling radial_burnup_ctf_coupling

radial_burnup_ctf_coupling	Boolean	Optional
Units: N/A		
Applicable Value(s): true (default), false		
Limitation(s): None		
Description: If true, this input calculates the radial burnup Zernike coefficients to pass to CTF. If false, no coefficients are calculated		
Notes: None		

radial_temp_ctf_coupling radial_temp_ctf_coupling

radial_temp_ctf_coupling	Boolean	Optional
Units: N/A		
Applicable Value(s): true (default), false		
Limitation(s): None		
Description: If true, this input uses the radial fuel temperature Zernike coefficients from CTF to set the fuel temps in MPACT. If false, the coefficients are not used and the volume-averaged fuel temp is used in all fuel rings		
Notes: None		

ctf_basename ctf_basename

ctf_basename	Free-Form Character String, Max. Length = 200	Optional
Units: N/A		
Applicable Value(s): deck (when CTF is run in serial) *or* pdeck (when CTF is run in parallel) (default), Any filename base for valid CTF input decks		

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`ctf_basename`, continued...

Limitation(s): Filename must have `.inp` extension
Description: This input is used to indicate the `basename` of the CTF input files for CTF coupling. The `basename` is the section of the CTF input filename(s) without any extensions
Notes: Absolute or relative paths to the file are both acceptable

sth_hgap sth_hgap

`sth_hgap`	Floating-Point Real Number	Optional
Units: W/m^2· K (default)		
Applicable Value(s): 5678.3 (default), > 0.0		
Limitation(s): It is ignored if feedback is off or if coupling with CTF is being used		
Description: This input is used to set the gap conductance value for internal TH calculations		
Notes: Typical values range from 1,000 (very low) to 10,000 (very high)		

sth_channeltype sth_channeltype

`sth_channeltype`	Character String	Optional
Units: N/A		
Applicable Value(s): assem (default), node, chan		
Limitation(s): None		
Description: This input is used to set the size of the region over which average moderator conditions will be applied. Acceptable values are assembly, node (quarter assembly), or pin (flow channel between four fuel pins)		
Notes: None		

sth_avgpin sth_avgpin

`sth_avgpin`	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: This input is used to determine whether an average pin is used for each region or whether fuel conduction calculations are done uniquely for each pin. If true, a representative pin will be used. If `sth_channeltype` is set to pin, this input is ignored		
Notes: None		

sth_trfluid sth_trfluid

`sth_trfluid`	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: This input is used to determine whether the simplified TH solver uses the transient fluid convection model		
Notes: This input can be used for a long transient calculation such as load-follow		

sth_C0_mult sth_C0_mult

sth_C0_mult	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), > 0.0		
Limitation(s): This is used only for BWR STH runs		
Description: This input is used to set a multiplier on the void distribution parameter in the internal BWR fluid solver		
Notes: None		

sth_Vgj_mult sth_Vgj_mult

sth_Vgj_mult	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), > 0.0		
Limitation(s): This is used only for BWR STH runs		
Description: This input is used to set a multiplier on the void drift velocity in the internal BWR fluid solver		
Notes: None		

sth_hd_mult sth_hd_mult

sth_hd_mult	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), > 0.0		
Limitation(s): This is used only for BWR STH runs		
Description: This input is used to set a multiplier on the detachment enthalpy in the internal BWR fluid solver		
Notes: None		

sth_f2p_mult sth_f2p_mult

sth_f2p_mult	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), > 0.0		
Limitation(s): This is used only for BWR STH runs		
Description: This input is used to set a multiplier on the two phase friction factor in the internal BWR fluid solver		
Notes: None		

temptable_shape temptable_shape

temptable_shape	Boolean	Optional
Units: N/A		
Applicable Value(s): true (default), false		
Limitation(s): None		

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temptable_shape, continued...

Description: Logical to interpolate shape onto fuel temperature table value
Notes: None

temptable_boundary temptable_boundary

temptable_boundary	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): N/A (default), Boundary for applying the temperature tables		
Limitation(s): If the input is present, then temperature tables in the named file will be used to calculate fuel temperatures instead of the internal conduction solvers or CTF. If this input is not present, then internal or CTF solvers are used		
Description: This input is used to define the boundary from which the table was generated and which should be used to apply the table		
Notes: Temperature tables contain fuel temperature values as functions of power and burnup. When depleting, the thermal properties of the fuel change significantly. Internal TH and CTF do not know how these properties change when depleting, so temperature tables can be used to more accurately perform TH calculations during depletion simulations using tabulated data rather than fuel conduction solvers		

temptable_qprime temptable_qprime

temptable_qprime	Floating-Point Real Numbers	Optional
Units: N/A		
Applicable Value(s): N/A (default), Heat flux used to generate fuel temperatures		
Limitation(s): If the input is present, then temperature tables in the named file will be used to calculate fuel temperatures instead of the internal conduction solvers or CTF. If this input is not present, then internal or CTF solvers are used		
Description: This input is used to define the heat flux used to generate fuel temperature tables		
Notes: Temperature tables contain fuel temperature values as functions of power and burnup. When depleting, the thermal properties of the fuel change significantly. Internal TH and CTF do not know how these properties change when depleting, so temperature tables can be used to more accurately perform TH calculations during depletion simulations using tabulated data rather than fuel conduction solvers		

temptable_polynomial temptable_polynomial

temptable_polynomial	Floating-Point Real Numbers	Optional
Units: GWD/MT, K, K (default)		
Applicable Value(s): N/A (default), Fuel temperature table values		
Limitation(s): If the input is present, then temperature tables will be used to calculate fuel temperatures instead of the internal conduction solvers or CTF. If this input is not present, then internal or CTF solvers are used		
Description: This input is used to indicate the data for temperature tables		

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`temptable_polynomial`, continued...

Notes: Temperature tables contain fuel temperature values as functions of power and burnup. When depleting, the thermal properties of the fuel change significantly. Simplified TH and CTF do not know how these properties change when depleting, so temperature tables can be used to more accurately perform TH calculations during depletion simulations using tabulated data rather than fuel conduction solvers

user_defined_th_filename user_defined_th_filename

`user_defined_th_filename`	Free-Form Character String, Max. Length = 200	Optional
Units: N/A		
Applicable Value(s): N/A (default), Filename of any valid HDF5 file with user-defined TH conditions		
Limitation(s): If the input is present, TH conditions defined for each state and pin cell will be used to set the TH variables of each pin cell in the model instead of calculating the TH condition using the internal TH solver or CTF		
Description: This input is used to indicate the name of the file containing the pin-wise TH conditions for each state		
Notes: The format of the HDF5 file must follow the same format as the HDF5 output edits. The head dataset of the file must contain `[STATE]` datasets following the *STATE_**** nomenclature, which are populated with pin-wise data with the same names as their output edit counterparts. Currently supported dataset names are *pin_fuel_temp*, *pin_clad_temp*, *pin_mod_temp*, *pin_mod_dens*, *pin_gtube_temp*, and *pin_gtube_dens*. The TH datasets must have the same shapes as their corresponding output counterparts. Users are not required to provide the TH conditions for all states and TH variables, and those that are absent will be populated based on the global state variables such as `tinlet`		

user_defined_crud_filename user_defined_crud_filename

`user_defined_crud_filename`	Free-Form Character String, Max. Length = 200	Optional
Units: N/A		
Applicable Value(s): N/A (default), Filename of any valid HDF5 file with user defined CRUD conditions		
Limitation(s): If the input is present, CRUD conditions defined for each state and pin cell will be used to set the CRUD variables of each pin cell in the model instead of calculating the CRUD condition using MAMBA		
Description: This input is used to indicate the name of the file containing the pin-wise CRUD conditions for each state		
Notes: The format of the HDF5 file must follow the same format as the HDF5 output edits. The head dataset of the file must contain `[STATE]` datasets following the *STATE_**** nomenclature, which are populated with pin-wise data with the same names as their output edit counterparts. Currently supported dataset names are *pin_avg_crud_thickness*, *pin_avg_crud_massdensity*, and *pin_avg_crud_borondensity*. The CRUD datasets must have the same shapes as their corresponding output counterparts. Users are required to provide the CRUD conditions for all states and CRUD variables; otherwise, an error will be thrown		

dep_shielder_dt dep_shielder_dt

dep_shielder_dt	Floating-Point Real Number	Optional
Units: GWD/MTU (default)		
Applicable Value(s): 10.0 (default), > 0.0		
Limitation(s): If the xs_shielder input is set to f or false, this input does nothing since cross section shielding calculations will never be performed		
Description: This input is used to control how often cross section shielding calculations are performed when depleting. It sets the maximum time in GWD/MTU that can be simulated without running new shielding calculations		
Notes: None		

dep_substep dep_substep

dep_substep	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		
Description: This input is used to read the number of substeps for the depletion predictor and corrector step. The substep method is applied to perform multiple depletion calculations between transport calculations. Substeps should be set to 1 if using CRAM and no high-order depletion or substep renormalization. Because the depletion calculation typically takes less time than the transport calculation, using this input with high-order depletion or renormalization will often save computational time		
Notes: When not using the high-order depletion methodology or substep renormalization, one substep is recommended for CRAM, and three substeps are recommended for MATREX or internal BATEMAN. This input is also valid in OPTION block		

dep_substep_pred dep_substep_pred

dep_substep_pred	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		
Description: This input is used to read the number of substeps for the depletion predictor step. The substep method is applied to perform multiple depletion calculations between transport calculations. Substeps should be set to 1 if using CRAM and no high-order depletion or substep renormalization. Because the depletion calculation typically takes less time than the transport calculation, using this input with high-order depletion or renormalization will often save computational time		
Notes: When not using the high-order depletion methodology or substep renormalization, one substep is recommended for CRAM, and three substeps are recommended for MATREX or internal BATEMAN. This input is also valid in OPTION block		

dep_substep_corr dep_substep_corr

dep_substep_corr	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		

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dep_substep_corr, continued...

Description: This input is used to read the number of substeps for the depletion corrector step. The substep method is applied to perform multiple depletion calculations between transport calculations. Substeps should be set to 1 if using CRAM and no high-order depletion or substep renormalization. Because the depletion calculation typically takes less time than the transport calculation, using this input with high-order depletion or renormalization will often save computational time
Notes: When not using the high-order depletion methodology or substep renormalization, one substep is recommended for CRAM, and three substeps are recommended for MATREX or internal BATEMAN. This input is also valid in OPTION block

dep_kernel dep_kernel

dep_kernel	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): origen (default), internal		
Limitation(s): None		
Description: This input is used to specify the depletion kernel to use. The MPACT internal depletion kernel is based on the same methodology as origen but uses simplified depletion chains and runs faster than origen		
Notes: None		

include_depl_mats include_depl_mats

include_depl_mats	Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This input is used to list the names of materials the user wishes to deplete. The inputs for this input are a 1D array of strings. The default value is an empty array		
Notes: None		

exclude_depl_mats exclude_depl_mats

exclude_depl_mats	Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: This input is used to list the names of materials the user does not wish to deplete. The inputs for this input are a 1D array of strings. The default value is an empty array		
Notes: None		

cmfd cmfd

cmfd	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): odcmfd (default), scmfd, mlcmfd, msed, none (2D only)		

continued on next page...

cmfd, continued...

Limitation(s): None
Description: This input is used to specify which CMFD method will be used. The options are described as follows: • cmfd: default CMFD method (currently odcmfd) • odcmfd: optimally diffusive CMFD method • scmfd: standard CMFD method • mlcmfd: a multi-level cmfd method • msed: same as odcmfd, but the CMFD system is now solved via the MSED method • none: disables CMFD and can be used only in 2D problems
Notes: CMFD must be present for every 3D problem because it is the basis for the solution transfer between 2D and 1D

cmfd_num_groups cmfd_num_groups

cmfd_num_groups	Integer	Optional
Units: N/A		
Applicable Value(s): the number of transport energy groups (default), > 0, $\leq$ the number of transport energy groups		
Limitation(s): None		
Description: This input is used to define the number of CMFD energy groups		
Notes: The number of CMFD energy groups is identical to the number of transport energy groups by default. The few-group CMFD is used when cmfd_num_groups is smaller than the number of transport energy groups		

fgcmfd_type fgcmfd_type

fgcmfd_type	String	Optional
Units: N/A		
Applicable Value(s): dynamic (default), constant		
Limitation(s): None		
Description: This input is used to define the method to determine few-group structure of few-group CMFD. These are described as follows: • dynamic: the flux residual from the transport calculation is used as a weight factor to collapse the transport energy group structure to a few-group structure, resulting in each group of the few-group structure having similar residuals. The group structure can be dynamically changed during the calculation • constant: a few-group structure is determined such that each group of the few-group structure contains an approximately equal number of groups from the transport energy group structure. The structure does not change throughout the calculation		
Notes: This input does nothing unless cmfd_num_groups is also specified with a value less than the number of transport energy groups		

fgcmfd_ubound fgcmfd_ubound

fgcmfd_ubound	Array of Integers	Optional
Units: N/A		
Applicable Value(s): > 0, ≤ the number of transport energy groups		
Limitation(s): None		
Description: This input is used to define the CMFD upper boundary of transport energy group structure to be collapsed to few-group		
Notes: When this input is used, the cmfd_num_groups input is ignored and the group structure is set to match fgcmfd_ubound. The first element should be 1		

fgcmfd_fmr fgcmfd_fmr

fgcmfd_fmr	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Enables the fundamental mode rebalance to accelerate the flux on the transport energy group structure		
Notes: Use this input when the few-group CMFD takes significantly more outer iterations than the default multigroup CMFD. This input is more useful for smaller problems than for larger ones		

multilevel multilevel

multilevel	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): energy (default), space		
Limitation(s): None		
Description: This input is used to specify whether space, energy, or both space and energy multilevel CMFD is used		
Notes: Active only when mlcmfd is specified for the cmfd input		

max_v_cycles max_v_cycles

max_v_cycles	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), Any positive integer		
Limitation(s): None		
Description: The maximum number of multilevel CMFD V-cycles to be performed on each outer iteration		
Notes: Active only when mlcmfd is specified for the cmfd input		

mlcmfd_num_levels mlcmfd_num_levels

mlcmfd_num_levels	Integer	Optional
Units: N/A		
Applicable Value(s): 3 (default), Any positive integer		
Limitation(s): None		

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`mlcmfd_num_levels`, continued...

Description: The number of levels to use for multilevel CMFD
Notes: Active only when `mlcmfd` is specified for the `cmfd` input

prolongation prolongation

`prolongation`	Character String	Optional
Units: N/A		
Applicable Value(s): flat (default), linear		
Limitation(s): None		
Description: Flag to indicate whether flat or linear prolongation will be used for CMFD		
Notes: None		

cmfd_solver cmfd_solver

`cmfd_solver`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `mgnode` (default), `mggroup`, `1gsweep`, `1grbsor`, `mgrbsor`, `reducedmg`		
Limitation(s): None		
Description: This input is used to specify how the CMFD linear system is set up and solved. The options are described as follows: • `1gsweep`: sweeps through all of the energy groups one by one using Gauss-Seidel iteration in energy • `mgnode`: sets up a full multigroup CMFD matrix in node-major ordering (e.g., each node is a group-by-group block) • `mggroup`: sets up a full multigroup CMFD matrix in group-major ordering • `1grbsor`: sweeps through all of the energy groups one by one using Red-Black Successive Over-Relaxation iteration • `mgrbsor`: sets up a full multigroup CMFD matrix in node-major ordering (e.g., each node is a group-by-group block) and uses Red-Black Successive Over-Relaxation iteration • `reducedmg`: same as mgnode, except it solves the groups without an upscattering source one group at a time before forming a multigroup matrix with only the upscattering groups. DOES NOT WORK WITH WIELANDT SHIFT. k_shift (or lambda_shift) must be 0		
Notes: `1gsweep` requires less memory than the others, but it is generally slower to converge than mgnode		

cmfd_linear_solver cmfd_linear_solver

`cmfd_linear_solver`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): PETSC (default), TRILINOS or NATIVE		
Limitation(s): None		

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`cmfd_linear_solver`, continued...

Description: This input is used to specify which linear solver package will be used. The options are described as follows: • `PETSC`: uses PETSc for linear solver and SLEPc for eigenvalue problems • `TRILINOS`: uses Trilinos solvers Belos for linear solves and Anasazi for eigenvalue problems • `NATIVE`: uses native Futility code for linear solves and eigenvalue problems
Notes: CMFD must be present for every 3D problem because it is the basis for the solution transfer between 2D and 1D

petsc_linear_solver_method petsc_linear_solver_method

`petsc_linear_solver_method`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): gmres (default), bicgstab, or multigrid		
Limitation(s): None		
Description: This input is used to specify which linear solver from PETSc will be used. It does nothing if Trilinos is chosen as the linear solver		
Notes: None		

petsc_linear_solver_method_1G petsc_linear_solver_method_1G

`petsc_linear_solver_method_1G`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): gmres (default), bicgstab, or multigrid		
Limitation(s): None		
Description: This input is used to specify which linear solver from PETSc will be used in 1-group calculations. It does nothing if Trilinos is chosen as the linear solver		
Notes: None		

multigrid_cg_solver multigrid_cg_solver

`multigrid_cg_solver`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): gmres (default), sor, bjacobi, bicgstab, or lu		
Limitation(s): None		
Description: This input is used to control the solver used on the coarsest grid of multigrid. The options are as follows: • `gmres` – Standard GMRES solver in PETSc, with a preconditioner that is ILU-like locally and Jacobi-like between processors • `bicgstab` – Standard BiCGSTAB solver in PETSc, same preconditioner as GMRES • `lu` – Exact LU solver. In parallel, superLU package must be enabled to use this • Any of the options for the `multigrid_smoother` input		
Notes: Active only when `msed` is specified for the `cmfd` input		

multigrid_cg_solver_its multigrid_cg_solver_its

multigrid_cg_solver_its	Integer	Optional
Units: N/A		
Applicable Value(s): 15 (default), > 0		
Limitation(s): None		
Description: Number of cg_solver iterations to perform on coarsest grid of the multigrid solver		
Notes: Active only when msed is specified for the cmfd input		

multigrid_cg_tol multigrid_cg_tol

multigrid_cg_tol	Float	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Set the tolerance for the coarsest grid on the multigrid system		
Notes: Active only when msed is specified for the cmfd input		

multigrid_cg_solver_1G multigrid_cg_solver_1G

multigrid_cg_solver_1G	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): gmres (default), sor, bjacobi, bicgstab, or lu		
Limitation(s): None		
Description: This input is used to control the solver used on the coarsest grid of multigrid. The options are as follows: • gmres – Standard GMRES solver in PETSc, with a preconditioner that is ILU-like locally and Jacobi-like between processors • bicgstab – Standard BiCGSTAB solver in PETSc, same preconditioner as GMRES • lu – Exact LU solver. In parallel, superLU package must be enabled to use this • Any of the options for the multigrid_smoother input		
Notes: Active only when msed is specified for the cmfd input		

multigrid_cg_solver_its_1G multigrid_cg_solver_its_1G

multigrid_cg_solver_its_1G	Integer	Optional
Units: N/A		
Applicable Value(s): 15 (default), > 0		
Limitation(s): None		
Description: Number of cg_solver iterations to perform on coarsest grid of the multigrid solver		
Notes: Active only when msed is specified for the cmfd input		

multigrid_cg_tol_1G multigrid_cg_tol_1G

multigrid_cg_tol_1G	Float	Optional
Units: N/A		
Applicable Value(s): > 0		

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multigrid_cg_tol_1G, continued...

Limitation(s): None
Description: Set the tolerance for the coarsest grid on the 1G multigrid system
Notes: Active only when msed is specified for the cmfd input

multigrid_smoother multigrid_smoother

multigrid_smoother	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): sor (default), bjacobi		
Limitation(s): None		
Description: This input is used only when petsc_linear_solver_method is set to multigrid or if petsc_linear_solver_method_1G is set to multigrid and the corresponding 1G quantity is not available. The same is true of any input beginning with multigrid_. This input is used to control the smoother that is used on all but the coarsest grid in multigrid. The options are as follows: • sor – PCSOR from PETSc. It is not really SOR since it does not give it a relaxation parameter. It is Gauss-Seidel locally and Jacobi between processors • bjacobi – Block Jacobi preconditioner where each proc is a block in the global matrix. Each block is partially inverted by an ILU iteration (ILU locally, Jacobi globally)		
Notes: Active only when msed is specified for the cmfd input		

multigrid_num_smooth multigrid_num_smooth

multigrid_num_smooth	Integer	Optional
Units: N/A		
Applicable Value(s): 1/0 (default), > 0		
Limitation(s): None		
Description: This input is used to control the number of smoother iterations used on each level of the multigrid scheme except the the coarsest. If no value is given, it will do one smoother iteration on the way down and no smoother iterations on the way up. If a value is given, it will do that many iterations on the way up and on the way down. The only way to achieve the default behavior is to leave this entry blank		
Notes: Active only when msed is specified for the cmfd input		

multigrid_smoother_1G multigrid_smoother_1G

multigrid_smoother_1G	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): sor (default), bjacobi		
Limitation(s): None		

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multigrid_smoother_1G, continued...

Description: This input is used only when petsc_linear_solver_method_1G is set to multigrid. This input is used to control the smoother that is used on all but the coarsest grid in multigrid. The options are as follows: • sor – PCSOR from PETSc. It is not really SOR since it has no relaxation parameter. It is Gauss-Seidel locally and Jacobi between processors • bjacobi – Block Jacobi preconditioner where each proc is a block in the global matrix. Each block is partially inverted by an ILU iteration (ILU locally, Jacobi globally)
Notes: Active only when msed is specified for the cmfd input

multigrid_num_smooth_1G multigrid_num_smooth_1G

multigrid_num_smooth_1G	Integer	Optional
Units: N/A		
Applicable Value(s): 1/0 (default), > 0		
Limitation(s): None		
Description: This input is used to control the number of smoother iterations used on each level of the multigrid scheme except the coarsest. If no value is given, it will do one smoother iteration on the way down and no smoother iterations on the way up. If a value is given, it will do that many iterations on the way up and on the way down. The only way to achieve the default behavior is to leave this entry blank		
Notes: Active only when msed is specified for the cmfd input		

multigrid_log_flag multigrid_log_flag

multigrid_log_flag	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: This input must be set to true for PETSc to printout performance and logging information for the multigrid solver. However, setting this to true is not sufficient. The user must also provide MPACT with the command line option -pc_mg_log at run time		
Notes: Active only when msed is specified for the cmfd input		

multigrid_log_flag_1G multigrid_log_flag_1G

multigrid_log_flag_1G	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: This input must be set to true for PETSc to printout performance and logging information for the multigrid solver. However, setting this to true is not sufficient. The user must also provide MPACT with the command line option -pc_mg_log at run time		
Notes: Active only when msed is specified for the cmfd input		

multigrid_precond_flag multigrid_precond_flag

multigrid_precond_flag	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Setting this input to true makes the code use multigrid as a preconditioner to GMRES rather than as a standalone solver		
Notes: Active only when msed is specified for the cmfd input		

multigrid_precond_flag_1G multigrid_precond_flag_1G

multigrid_precond_flag_1G	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Setting this input to true makes the code use multigrid as a preconditioner to GMRES rather than as a standalone solver		
Notes: Active only when msed is specified for the cmfd input		

preconditioner preconditioner

preconditioner	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): default (default), ilu, bilu, bjacobi_ilu, mg, eisenstat, none		
Limitation(s): None		
Description: This input is used to specify which preconditioner should be used in the CMFD solver. The default preconditioner depends on the method used to solve the CMFD eigenvalue problem. The mg preconditioner in PETSC is a bit misleading. It is not actually a multigrid preconditioner since PETSc is never provided with any information regarding the grid or interpolation/restriction; it simply performs a smoothing step on the fine grid level using its default smoother		
Notes: None		

cmfd_eigen_solver cmfd_eigen_solver

cmfd_eigen_solver	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): power (default), jd, gd, arnoldi, slepc_power		
Limitation(s): None		
Description: This input is used to specify which eigenvalue solver will be used. The options are described as follows: • power: standard power iteration • JD: SLEPc Jacobi-Davidson Solver • GD: SLEPc or Anasazi Generalized Davidson Solver depends on cmfd_linear_solver • Arnoldi: SLEPc Arnoldi Solver • SLEPc_power: SLEPc power iteration for comparison		
Notes: CMFD must be present for every 3D problem because it is the basis for the solution transfer between 2D and 1D		

k_shift k_shift

k_shift	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.5 (default)		
Limitation(s): Can be used only with the mgnode CMFD solver. This input is irrelevant unless the constant option is used for the cmfd_shift_method input		
Description: This input is used to specify a shifted eigenvalue problem for the CMFD power iterations		
Notes: k_shift should be larger than the eigenvalue of the system. Even a value of 2 would provide some enhanced convergence properties over not using k_shift		

k_shift_1G k_shift_1G

k_shift_1G	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.5 (default)		
Limitation(s): Can be used only with the mgnode CMFD solver. This input is irrelevant unless the constant option is used for the cmfd_shift_method_1G input and the msed option is used for the cmfd input		
Description: This input is used to specify a shifted eigenvalue problem for the 1G CMFD power iterations		
Notes: k_shift_1G should be larger than the eigenvalue of the system. Even a value of 2 would provide some enhanced convergence properties over not using k_shift_1G		

cmfd_relaxation cmfd_relaxation

cmfd_relaxation	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0 (default)		
Limitation(s): None		
Description: This input is for specifying the relaxation parameter for the CMFD flux update. The default value (1.0) corresponds to no relaxation of the update. Values below 1.0 underrelax the CMFD flux update to provide stability for cases with T/H or other feedback. For standalone neutronics problems, no underrelaxation should be needed to achieve stability when using the odcmfd option, and any underrelaxation will probably degrade the convergence rate		
Notes: None		

cmfd_relax_negative cmfd_relax_negative

cmfd_relax_negative	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		

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cmfd_relax_negative, continued...

Description: This option is to underrelax the CMFD flux when negative CMFD flux is calculated. If a negative CMFD flux is calculated at the end of CMFD iteration, then the CMFD flux is underrelaxed by the group-dependent relaxation factor. The underrelaxation factor, f_g, is determined to satisfy the following inequality: $f_g\phi_g^{\text{new}} + (1 - f_g)\phi_g^{\text{old}} > 0$
Notes: This input can be used with cmfd_relaxation. This input changes the CMFD flux itself only if a negative CMFD flux is calculated. However, the cmfd_relaxation input changes the projection factor

cmfd_dhat_relaxation cmfd_dhat_relaxation

cmfd_dhat_relaxation	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0 (default)		
Limitation(s): None		
Description: This input is for specifying the relaxation parameter for the CMFD dHat update. The default value (1.0) corresponds to no relaxation of the update. Values below 1.0 underrelax the CMFD dHat update to provide stability for cases with very large flux gradients. For typical neutronics problems, no underrelaxation should be needed to achieve stability when using the CMFD option, and any underrelaxation will probably degrade the convergence rate. When running an external source-driven problem, underrelaxation might be necessary to obtain convergence. In the most extreme cases, underrelaxation can be set to 0.0, which effectively removes the dHat correction coefficient in the CMFD calculation and results in CMFD calculating a more traditional diffusion solution. When running with no dHat correction coefficient, the equivalence between CMFD and fine mesh transport solutions is no longer guaranteed		
Notes: None		

cmfd_shift_c0 cmfd_shift_c0

cmfd_shift_c0	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 0.02 (default), > 0.0		
Limitation(s): Can be used only with the mgnode CMFD solver. This input is irrelevant unless the adaptive, ileps, or ilaps shift is being used		
Description: This input is used to specify the c0 parameter used in the adaptive/ileps/ilaps shift. c0 is used to reduce the shift to ensure both a positive fission source and a subcritical diffusion operator (i.e., to prevent overshifting)		
Notes: None		

cmfd_shift_method cmfd_shift_method

cmfd_shift_method	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): constant (default), none, adaptive, sdws-ileps, sdws-ilaps, sdws-laps, adap-ratio		
Limitation(s): These methods can be used only with the mgnode CMFD solver or the mgrbsor solver		

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cmfd_shift_method, continued...

Description: This input is used to specify which Wielandt shift method will be used to accelerate the power iterations on the CMFD problem. The options are described as follows:

- `none`: does not apply a shift to the CMFD system
- `constant`: applies a constant, iteration-independent shift to the CMFD system. The constant is given by the reciprocal of the input to the `cmfd` input
- `adaptive`: uses a traditional Wielandt shift method. The shift parameter is an iteration-dependent, spatially constant quantity defined by:

$$\lambda_{adaptive}^{(n)} = \max\left\{\lambda^{(n)} - c_1\left|\lambda^{(n)} - \lambda^{(n-1)}\right| - c_0\,, \lambda_{min}\right\}\,.$$

  c_1, c_0, and λ_{min} have been hard-coded to 10, 0.02, and 0.3, respectively. Future implementations of the method might allow the user to specify these parameters
- `sdws-ileps`: uses a space- and iteration-dependent Wielandt shift based on the local infinite-medium eigenvalues, $\lambda_{adaptive}$, and the current guess of the eigenvalue:

$$\lambda_{IPS}^{(n)}(\mathbf{x}) = \max\left\{\lambda_{adaptive}^{(n)}\,, \min\left\{\lambda_{\infty}(\mathbf{x}), \lambda^{(n)} - 0.01\right\}\right\}\quad.$$

- `sdws-ilaps`: combines sdws-laps with the adaptive shift
- `sdws-laps`: uses a space- and iteration-dependent Wielandt shift based on the local absorption values. The shift is limited to ensure a nonnegative fission source
- `adap-ratio`: uses a traditional Wielandt shift method. The shift parameter is an iteration-dependent, spatially constant quantity defined by

$$\lambda_{adaptive}^{(n)} = \max\left\{r\lambda^{(n)} - c_1\left|\lambda^{(n)} - \lambda^{(n-1)}\right|\,, \lambda_{min}\right\}\,.$$

  r is defined by adap-ratio

Notes: None

cmfd_shift_method_1G cmfd_shift_method_1G

cmfd_shift_method_1G	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): constant (default), `none`, adaptive, sdws-ileps, sdws-ilaps, sdws-laps, adap-ratio		
Limitation(s): This input is used only if the CMFD input is set to `msed`		
Description: This input is used to specify which Wielandt shift method will be used to accelerate the power iterations on the 1G CMFD problem. See `cmfd_shift_method` input for description. This input is applicable only if a 1G CMFD system is being used to accelerate the MG CMFD system		
Notes: None		

cmfd_ktol cmfd_ktol

cmfd_ktol	Floating Point Number	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-6} (default), > 0.0		
Limitation(s): None		

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`cmfd_ktol`, continued...

Description: This input is used to specify the tolerance for the convergence of k in the overall CMFD eigenvalue problem
Notes: None

cmfd_rtol cmfd_rtol

`cmfd_rtol`	Floating Point Number	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-6} (default), > 0.0		
Limitation(s): None		
Description: This input is used to specify the tolerance for the relative residual reduction in a CMFD linear system solved each power iteration		
Notes: None		

cmfd_ktol_1G cmfd_ktol_1G

`cmfd_ktol_1G`	Floating Point Number	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-6} (default), > 0.0		
Limitation(s): None		
Description: This input is used to specify the tolerance for the convergence of k in the 1G CMFD eigenvalue problem in MSED		
Notes: None		

cmfd_flxtol_1G cmfd_flxtol_1G

`cmfd_flxtol_1G`	Floating Point Number	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-6} (default), > 0.0		
Limitation(s): None		
Description: This input is used to specify the tolerance for the convergence of the flux in the 1G CMFD eigenvalue problem in MSED		
Notes: None		

max_1G_eig_its max_1G_eig_its

`max_1G_eig_its`	Integer	Optional
Units: N/A		
Applicable Value(s): 20 (default), > 0		
Limitation(s): None		
Description: This input is used to specify the maximum number of power iterations allowed on the 1G CMFD system in MSED		
Notes: None		

cmfd_num_inners cmfd_num_inners

cmfd_num_inners	Integer	Optional
Units: N/A		
Applicable Value(s): 100 (default), > 0		
Limitation(s): None		
Description: This input is used to specify the maximum number of linear solver iterations per power iteration during a CMFD acceleration calculation		
Notes: None		

cmfd_num_inners_1G cmfd_num_inners_1G

cmfd_num_inners_1G	Integer	Optional
Units: N/A		
Applicable Value(s): 100 (default), ≥ 0		
Limitation(s): None		
Description: This input is used to specify the maximum number of linear solver iterations allowed per power iterations in the 1G CMFD system in MSED		
Notes: None		

linear_solver_tol linear_solver_tol

linear_solver_tol	Floating Point Number	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-10} (default), > 0.0		
Limitation(s): None		
Description: This input is used to specify the tolerance of linear solver used at each power iteration during a CMFD acceleration calculation		
Notes: None		

linear_solver_tol_1G linear_solver_tol_1G

linear_solver_tol_1G	Floating Point Number	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-10} (default), > 0.0		
Limitation(s): None		
Description: This input is used to specify the tolerance of linear solver used at each power iteration on the 1G system in MSED		
Notes: None		

cmfd_num_outers cmfd_num_outers

cmfd_num_outers	Integer	Optional
Units: N/A		
Applicable Value(s): 20 (default), > 0		
Limitation(s): None		
Description: This input is used to specify the number of outer eigenvalue power iterations to perform during a CMFD acceleration calculation		

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`cmfd_num_outers`, continued...

Notes: None

cmfd_up_scatter cmfd_up_scatter

`cmfd_up_scatter`	Integer	Optional
Units: N/A		
Applicable Value(s): 2 (default), ≥0		
Limitation(s): Applies only to `1gsweep` CMFD solver		
Description: This input is used to specify the number of upscatter iterations when doing `1gsweep` CMFD. This can help to converge the scattering source in thermal energy groups before updating the fission source. In general, this can be used to help optimize run time for a given problem		
Notes: None		

cmfd_num_outers_th cmfd_num_outers_th

`cmfd_num_outers_th`	Integer	Optional
Units: N/A		
Applicable Value(s): 5 (default), > 0		
Limitation(s): None		
Description: This input is used to specify the number of outer eigenvalue power iterations to perform during a CMFD acceleration calculation when near-optimal partial convergence CMFD is used		
Notes: None		

cmfd_shift_r cmfd_shift_r

`cmfd_shift_r`	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 0.667 (default), > 0.0		
Limitation(s): Can be used only with the mgnode CMFD solver. This input is irrelevant unless the adap-ratio is used		
Description: This input is used to specify the r parameter used in the adaptive-ratio shift. r is used to reduce the shift to ensure both a positive fission source and a subcritical diffusion operator (i.e., to prevent overshifting)		
Notes: None		

cmfd_shift_r_1G cmfd_shift_r_1G

`cmfd_shift_r_1G`	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 0.667 (default), > 0.0		
Limitation(s): Can be used only with the MSED solver. This input is irrelevant unless the adap-ratio is used		
Description: This input is used to specify the r parameter used in the adaptive-ratio shift. r is used to reduce the shift to ensure both a positive fission source and a subcritical diffusion operator (i.e., to prevent overshifting)		

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`cmfd_shift_r_1G`, continued...

Notes: None

subplane_target subplane_target

`subplane_target`	Floating-Point Real Number	Optional
Units: cm (default)		
Applicable Value(s): N/A (default), > 0.0		
Limitation(s): None		
Description: This input is used to designate the target thickness of axial meshes in the CMFD system		
Notes: None		

subplane_max subplane_max

`subplane_max`	Floating-Point Real Number	Optional
Units: cm (default)		
Applicable Value(s): N/A (default), > 0.0		
Limitation(s): None		
Description: This input is used to designate the maximum thickness of axial meshes in the CMFD system. All MOC planes with thicknesses greater than this will be subdivided in the CMFD system using the `subplane_target` value		
Notes: None		

subgrid_spacers subgrid_spacers

`subgrid_spacers`	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: This input is used to designate whether or not spacer grids are used in subgrid solver setup		
Notes: None		

subgrid_reflector subgrid_reflector

`subgrid_reflector`	Logical	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: This input is used to designate whether or not axial reflectors are used in subgrid solver setup		
Notes: None		

subgrid_feedback subgrid_feedback

subgrid_feedback	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: This input is used to designate whether or not feedback logic is used in subgrid solver setup		
Notes: None		

num_subplanes num_subplanes

num_subplanes	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		
Description: This input is used to designate the number of subplanes used for each MOC plane in the CMFD system. Every MOC plane will be divided into `num_subplanes` subplanes. This input overrides both the `subplane_target` and `subplane_max` inputs. Any of these inputs can be used to control the subplane meshing, but this input is recommended since the other two result in parallel imbalance		
Notes: None		

cmfd_angle_decomp cmfd_angle_decomp

cmfd_angle_decomp	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): If angle decomposition or CMFD is not used, this input has no effect		
Description: This input is used to specify whether or not the angular decomposition processors for MOC are to be used during the CMFD setup/solve. The default for this treatment is `true` and is recommended for better parallel efficiency		
Notes: None		

split_TL split_TL

split_TL	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): Applies only to 3D models run with 2D/1D		
Description: This input is used to specify whether transverse leakage splitting will be enabled for a calculation using a 2D/1D method In the 2D/1D method, the axial transverse leakage is subtracted from the total fission and scattering sources, so in regions with relatively large axial streaming sources, the total source could become negative. To avoid negative total sources, the transverse leakage is split between the right-hand side and the left-hand side of the 2D transport equation, thus ensuring positivity of the total source and neutron balance		
Notes: None		

split_TL_tol split_TL_tol

`split_TL_tol`	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): ≥0.0		
Limitation(s): None		
Description: This input is used to specify the flux tolerance used in the transverse leakage splitting or MOC source splitting. If scalar flux is less than the flux tolerance, the transverse leakage splitting or MOC source splitting will not be performed		
Notes: This input should be used with `split_TL true` or `moc_source_splitting full`		

split_RTL split_RTL

`split_RTL`	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): Applies only to 3D models run with 2D/1D		
Description: This input is used to specify whether radial leakage splitting will be enabled for a calculation using a 2D/1D method In the 2D/1D method, the radial transverse leakage is subtracted from the total fission and scattering sources, so in regions with relatively large radial streaming sources, the total source could become negative. To avoid negative total sources, the radial leakage is divided between the right-hand side and left-hand side of the 1D transport equation, thus ensuring positivity of the total source and neutron balance		
Notes: None		

TL_treatment TL_treatment

`TL_treatment`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): lflat (default), flat		
Limitation(s): None		
Description: This input is used to specify the type of spatial shape of the axial transverse leakage applied to the 2D problem. `flat` means it is constant over a pin cell. This is used primarily to ensure stability of the iteration. These options are described as follows: • `lflat`: checks the total/transport cross section. If the value is below the threshold, then leakage will not be put into that region. This process is usually to avoid leakage in the fuel-clad gap. The leakage will then be redistributed to the other regions in that pin • `flat`: does not perform leakage threshold checks		
Notes: None		

moc_source_splitting moc_source_splitting

moc_source_splitting	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): none (default), full, linear		
Limitation(s): None		
Description: This input is used to describe the type of source splitting that is done before the MOC calculation to improve the stability of the calculation. These options are described as follows: • none: no source splitting is performed in MOC • full: if the source is negative before the MOC sweep, then all of the source is moved from the right to left side of the equation by modifying the transport cross section • linear: if the linear source is negative before the MOC sweep, then the gradient of the linear source and the quantity of source splitting are adjusted to ensure the nonnegativity of the linear source		
Notes: Minor changes in the converged solution will occur when source splitting is enabled. Source splitting is never implemented for gamma transport because of the detrimental effects on accuracy for highly anisotropic calculations. This input has no impact on the splitting of the axial transverse leakage source; the splitting controlled by this input is performed after the axial leakage splitting and after adding in the self-scatter source for the radial transport sweep		

nodal_method nodal_method

nodal_method	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): sp3 (default), nem, senm, sn-0, sn-1, sn-2, sn-3, p1, p3, p5, hyp3, fhp1, fhp3, senmp1, senmp3, senmp5, none		
Limitation(s): Applies only to 3D models run with 2D/1D		

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nodal_method, continued...

Description: This input is used to specify the type of nodal axial solver that will be used to solve the 1D portion of the 2D/1D solution Described as follows:	
Input Option	Full Name
NEM	Two-Node Source Expansion Nodal Method
SENM	Nodal Expansion Method
NEM-MG	Multigroup Nodal Expansion Method
SN-0	Discrete Ordinates with 0th Spatial Moment
SN-1	Discrete Ordinates with 1st Spatial Moment
SN-2	Discrete Ordinates with 2nd Spatial Moment
SN-3	Discrete Ordinates with 3rd Spatial Moment
P1	Pn 1st Order with One-Node NEM
P2	Pn 3rd Order with One-Node NEM
P3	Pn 5th Order with One-Node NEM
HYP3	Hybrid Pn 3rd Order with NEM
FHP1	1st Order with Full Height NEM
FHP3	3rd Order with Full Height NEM
SENMP1	Pn 1st Order with One-Node SENM
SENMP3	Pn 3rd Order with One-Node SENM
SENMP5	Pn 5th Order with One-Node SENM
NONE	Finite-Difference Method
Notes: The Sn methods are the most computationally intensive. SP3 is recommended as the best balance of accuracy and speed. If convergence/stability issues are encountered with SP3, then try running with NEM	

gamma_nodal_method gamma_nodal_method

gamma_nodal_method	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): sp3 (default), nem, senm, sn-0, sn-1, sn-2, sn-3, p1, p3, p5, hyp3, fhp1, fhp3, senmp1, senmp3, senmp5, none		
Limitation(s): Applies only to 3D models run with 2D/1D		

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gamma_nodal_method, continued...

Description: This input is used to specify the type of nodal axial solver that will be used to solve the 1D portion of the 2D/1D solution for gamma transport Described as follows: Input Option — Full Name NEM — Two-Node Source Expansion Nodal Method SENM — Nodal Expansion Method NEM-MG — Multigroup Nodal Expansion Method SN-0 — Discrete Ordinates with 0th Spatial Moment SN-1 — Discrete Ordinates with 1st Spatial Moment SN-2 — Discrete Ordinates with 2nd Spatial Moment SN-3 — Discrete Ordinates with 3rd Spatial Moment P1 — Pn 1st Order with One-Node NEM P2 — Pn 3rd Order with One-Node NEM P3 — Pn 5th Order with One-Node NEM HYP3 — Hybrid Pn 3rd Order with NEM FHP1 — 1st Order with Full Height NEM FHP3 — 3rd Order with Full Height NEM SENMP1 — Pn 1st Order with One-Node SENM SENMP3 — Pn 3rd Order with One-Node SENM SENMP5 — Pn 5th Order with One-Node SENM NONE — Finite-Difference Method
Notes: The Sn methods are the most computationally intensive. SP3 is recommended as the best balance of accuracy and speed. If convergence/stability issues are encountered with SP3, then try running with NEM

nodal_inners nodal_inners

nodal_inners	Integer	Optional
Units: N/A		
Applicable Value(s): varies depending on nodal method (default), ≥1		
Limitation(s): None		
Description: This input is used to specify the number of inner 1-group nodal sweeps performed during group sweeping for every outer iteration		
Notes: None		

nodal_group_loop nodal_group_loop

nodal_group_loop	Integer	Optional
Units: N/A		
Applicable Value(s): varies depending on nodal method (default), ≥1		
Limitation(s): None		
Description: This input is used to specify the number of iterations over energy groups performed during the nodal solve for every outer iteration		
Notes: None		

nodal_leakage_order nodal_leakage_order

`nodal_leakage_order`	Integer	Optional
Units: N/A		
Applicable Value(s): 2 (default), 0, 1		
Limitation(s): None		
Description: This input is used to specify the interpolation order for radial transverse leakage for nodal solves		
Notes: None		

nodal_group_start nodal_group_start

`nodal_group_start`	Integer	Optional
Units: N/A		
Applicable Value(s): >0		
Limitation(s): None		
Description: This input is used to specify the starting group index of nodal group iterations when `nodal_group_loop` is larger than 1		
Notes: If this input is not specified, then the starting group index is determined according to the range of upscattering		

nodal_inner_tol nodal_inner_tol

`nodal_inner_tol`	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): >0.0		
Limitation(s): None		
Description: This input is used to specify the tolerance on the convergence of the 2-norm of the nodal flux residual during within group nodal inner iterations		
Notes: None		

nodal_group_tol nodal_group_tol

`nodal_group_tol`	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): >0.0		
Limitation(s): None		
Description: This input is used to specify the tolerance on the convergence of the 2-norm of the nodal flux residual during nodal group iterations		
Notes: None		

nodal_relax_negative nodal_relax_negative

`nodal_relax_negative`	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		

continued on next page...

`nodal_relax_negative`, continued...

Limitation(s): None
Description: This option is used to underrelax the nodal flux when the negative nodal flux is calculated. The group-dependent underrelaxation factor, f_g, is determined to satisfy the following inequality: $f_g\phi_g^{\text{new}} + (1 - f_g)\phi_g^{\text{old}} > 0$
Notes: None

gamma_nodal_inners gamma_nodal_inners

`gamma_nodal_inners`	Integer	Optional
Units: N/A		
Applicable Value(s): varies depending on nodal method (default), ≥1		
Limitation(s): None		
Description: This input is used to specify the number of inner 1-group nodal sweeps performed during gamma group sweeping for every outer iteration		
Notes: None		

gamma_nodal_group_loop gamma_nodal_group_loop

`gamma_nodal_group_loop`	Integer	Optional
Units: N/A		
Applicable Value(s): varies depending on nodal method (default), ≥1		
Limitation(s): None		
Description: This input is used to specify the number of iterations over energy groups performed during the gamma nodal solve for every outer iteration		
Notes: None		

gamma_nodal_leakage_order gamma_nodal_leakage_order

`gamma_nodal_leakage_order`	Integer	Optional
Units: N/A		
Applicable Value(s): 2 (default), 0, 1		
Limitation(s): None		
Description: This input is used to specify the interpolation order for radial transverse leakage for gamma nodal solves		
Notes: None		

sntype sntype

`sntype`	Character String	Optional
Units: N/A		
Applicable Value(s): isotropic, aziint, explicit, moment, p3-moment, `none`		
Limitation(s): Applies only to 3D models run with 2D/1D		
Description: This input is used to specify the type of axial sn sweeper that will be used to solve the 1D portion of the 2D/1D solution		
Notes: None		

rtltype rtltype

rtltype	Character String	Optional
Units: N/A		
Applicable Value(s): isotropic, aziint, explicit, moment, p3-moment, p3-quad, p3-quadratic, p3-even, sym, none		
Limitation(s): None		
Description: The type of radial transverse leakage to use		
Notes: None		

atltype atltype

atltype	Character String	Optional
Units: N/A		
Applicable Value(s): isotropic, aziint, explicit, moment, azi, exp, mom, sym, none		
Limitation(s): None		
Description: The type of angular transverse leakage treatment to be used		
Notes: None		

rtlmom rtlmom

rtlmom	Integer	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The number of azimuthal Fourier moments to be used in the radial transverse leakage construction		
Notes: None		

homtype homtype

homtype	Character String	Optional
Units: N/A		
Applicable Value(s): isotropic (default), polar, moment, explicit, symmetric, none		
Limitation(s): None		
Description: The homtype option specifies the type of homogenization to use for the 1D solver. ANGLE_POL is polar-dependent homogenization. This can be used with the P3-MOMENT, MOMENT-MOMNET, or P3-EVENODD radial TL options. ANGLE_MOM is not recommended because it is much slower. ANGLE_EXP can be used with EXPLICIT-EXPLICIT radial TL. With all explicit options, the 2D/1D method uses exact angular TL and exact homogenized anisotropic XS, which are the most accurate (but expensive)		
Notes: None		

under_relax under_relax

under_relax	Float	Optional
Units: N/A		
Applicable Value(s): > 0, < 2		
Limitation(s): None		
Description: The underrelaxation factor to use when doing 2D/1D		
Notes: None		

mesh mesh

mesh	Fixed Character String Followed by Two Arrays of Integers Separated by a '/'	Optional
Units: N/A		
Applicable Value(s): num_rad = 3, 1 and num_azi = 1, 8, 8, 8, 12 (default), For num_rad, positive integers greater than zero. For num_azi, 1, 4, 8, 12, or 16. The length for num_rad is the number of geometric radii, and the length for num_azi is the sum of the subdivided radii		
Limitation(s): None		
Description: This input is used to specify the radial and azimuthal mesh for each cell. Currently, three cell types are used: fuel, gtube, and gad. Cells containing fuel materials are flagged to use the fuel mesh, and all other cells use the gtube meshing. For the inputs, num_rad is the number of radial subdivisions in each ring specified in the cell, and num_azi is the number of azimuthal regions in each subdivided radial ring. The last azimuthal value applies to the region outside the pin This input can also be used to mesh specific cells, specific assemblies, or specific cells inside specific assemblies. To do so, use the cell and axial labels from the [ASSEMBLY]. For a particular cell in any assembly, use mesh cell_<cell label>. For all cells in a particular assembly, use mesh assem_<axial label>. For particular cells in just one particular assembly, use mesh assem_<axial label>_cell_<cell label>. The radial and azimuthal divisions are then specified the same way as for the predefined cell types		
Notes: Currently insert, control, and detector rods have predefined mesh that cannot be overwritten In both cases, the last entry will be used for any remaining unspecified regions. For example, if a given fuel pin has three radial and material regions, and the fuel mesh had a num_rad of 3,1 and num_azi of 1,4,8, then the third ring in the fuel pin would have one radial subdivision, and the fourth subdivided radius to the end of the pin cell would have eight azimuthal subdivisions, including the region outside the pin cell If the mesh is specified too finely—or rather, finer than the value for ray spacing—instabilities can occur in which a ray is NOT traced through a flat source region, and no flux is calculated for that region. The code will automatically adjust the azimuthal discretization if the given ray spacing value is too coarse (or because the azimuthal mesh is too fine). Another way to cause the aforementioned instability would be to specify a very large number of radial subdivisions for the first num_rad value. That large number being the area of the first radius divided by the first num_rad value would have to yield a radius that is smaller than the ray spacing. For a typical PWR fuel pin radius, the first num_rad value must be well over 100 for this problem to arise, and this number is impractical given the memory it will consume		

delayenergy delayenergy

`delayenergy`	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: This option is used to specify whether to use explicit delayed energy kernel during the transient calculation. The default is false. The equilibrium delayed energy (about 7% of total fission energy including delayed beta and gamma) is assumed as default		
Notes: None		

kinetics_data kinetics_data

`kinetics_data`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): library (default), scale, keepin, tuttle, jeff3, santamarina, spert70f, spert250f, spert500f		
Limitation(s): None		
Description: This input is used to specify the set of kinetics data used in the transient calculation. This input is applied only to the MPACT cross section library for now. By default, MPACT uses the 6-group transient data provided in the MPACT MG cross section library. These data are described as follows: 1. `scale`: the 6-group transient data from SCALE 2. `keepin`: the 6-group transient data from G. R. Keepin's paper 3. `tuttle`: the 6-group transient data from R. J. Tuttle's paper 4. `jeff3`: the 8-group transient data from JEFF3 with uniform lambda 5. `santamarina`: the 8-group transient data suggested by A. Santamarina (a slight modification of JEFF3) 6. `library`: the 6-group transient data in the MPACT cross section library from ENDF 7. `spert70f,spert250f,spert500f`: the 6-group transient data measured in spert experiments		
Notes: None		

kinetics_lambda kinetics_lambda

`kinetics_lambda`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): fissweight (default), isotopic, precursorconsv		
Limitation(s): None		
Description: This input controls the calculation of decay constants for each fissile region. The isotopic lambda is the exact approach but can use a lot more memory. In general, it is recommended to use the precursor conservation option rather than fission source weighting. These options are described as follows: 1. `isotopic`: use exact isotope-dependent lambdas 2. `fissweight`: collapse isotopic lambdas by fission rate 3. `precursorconsv`: collapse isotopic lambdas by preserving the initial precursors		
Notes: None		

kinetics_otfbeta kinetics_otfbeta

kinetics_otfbeta	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: This option specifies whether to compute the problem-dependent nu-bar for on-the-fly calculation of beta. By default, the problem-independent beta computed from a typical PWR spectrum is used		
Notes: None		

rx_components rx_components

rx_components	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): Can be used only when acceleration is enabled		
Description: This option is used to specify whether to calculate component reactivity values. The default is `false`. This option is ignored for steady-state calculations		
Notes: None		

sep_flux_comp sep_flux_comp

sep_flux_comp	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: When `rx_components` is set to `true`, this input is used for separating flux shape reactivity		
Notes: None		

tml tml

tml	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: Flag to enable the transient multilevel (TML) method		
Notes: None		

tmllevel nCMFD nEPKE n1GCMFD

nCMFD	Integer	Optional
Units: N/A		
Applicable Value(s): 5 (default), > 0		
Limitation(s): None		
Description: The number of CMFD acceleration steps taken for every transport time step		

continued on next page...

nCMFD, continued...

Notes: Used only when tml is set to true

nEPKE	Integer	Optional
Units: N/A		
Applicable Value(s): 10 (default), > 0		
Limitation(s): None		
Description: The number of EPKE calculation steps taken for every transport time step		
Notes: Used only when tml is set to true		

n1GCMFD	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), > 0		
Limitation(s): None		
Description: The number of 1G CMFD acceleration steps taken for every transport time step		
Notes: Used only when tml is set to true		

1gacceltr 1gacceltr

1gacceltr	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Flag for coupled 1GCMFD/MGCMFD acceleration of the transient problem		
Notes: None		

1gaccel 1gaccel

1gaccel	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Flag for 1GCMFD acceleration of transient simulations		
Notes: None		

tml1gmg tml1gmg

tml1gmg	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): none (default), sweep, hybrid		
Limitation(s): None		

continued on next page...

tml1gmg, continued...

Description: The tml1gmg option specifies how to use 1GCMFD level for new TML. These are described as follows: 1. none: is to use the 1GCMFD to update the flux 2. sweep: is to use 1GCMFD for fission source and MGCMFD for flux 3. hybrid: is to not use 1GCMFD level when there is external reactivity and 1GCMFD for flux when there is no external reactivity
Notes: None

transmethod transmethod

transmethod	Fixed Character Array, Positive Real Number or Integer. Length 1	Optional
Units: N/A		
Applicable Value(s): {theta 0.5},{BDF 2} (default), {theta 0.0-1.0},{BDF 1-6}		
Limitation(s): None		
Description: The first option is used to specify the time discretization method; theta refers to the theta method, and BDF refers to the BDF method The <value> defines the option for the theta method [0.0,1.0] or the BDF method. For the BDF method, the value is an integer that ranges from 1 to 6. If only BDF is specified, then the default order is 2		
Notes: None		

checkpoint_read checkpoint_read_file checkpoint_read_label

checkpoint_read_file	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): When used, must have an associated checkpoint_read_label		
Description: The name of the file that should be read when restarting a transient from a previously created checkpoint		
Notes: None		

checkpoint_read_label	Float	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): Can be used only in conjunction with checkpoint_read_file		
Description: The perturbation completed before the checkpoint file was written		
Notes: None		

checkpoint_write checkpoint_write_file checkpoint_write_label

checkpoint_write_file	Character String	Optional
Units: N/A		

continued on next page...

checkpoint_write_file, continued...

Applicable Value(s):
Limitation(s): When used must have an associated checkpoint_write_label
Description: The name of the file to be created when a checkpoint of a transient case is desired
Notes: None

checkpoint_write_label	Float	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): Can be used only in conjunction with checkpoint_write_file		
Description: The perturbation to be completed prior to writing the checkpoint file		
Notes: None		

mat_emit_src mat_emit_src

mat_emit_src	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): Should only be used for subcritical systems; otherwise, no steady-state solution will ever be achieved		
Description: When just mat_emit_src is input without true|false, the option is set to false. This option is used to specify whether or not neutron emission sources from the decay of model materials will be treated. The default is set to false		
Notes: None		

7.14 BLOCK TRANSIENT

scram_type scram_type scram_rate scram_time

scram_type	Free Form Character String	Optional
Units: N/A		
Applicable Value(s): trip		
Limitation(s): Can be used only for transient cases, and at least one trip_ input must be present to specify trip conditions		
Description: This option is used to specify the scram type (of which the only current option is trip)		
Notes: This input is used only in transient calculations		

scram_rate	Double	Optional
Units: RU/s (default)		
Applicable Value(s): > 0.0		
Limitation(s): Can be used only for transient cases, and at least one trip_ input must be present to specify trip conditions		
Description: The scram bank movement speed intervals. These are specified in pairs where each rate is associated with the following time interval. At least one rate/time pair must be present		
Notes: This input is used only in transient calculations		

scram_time	Double	Optional
Units: seconds (default)		
Applicable Value(s): ≥ 0.0		
Limitation(s): Can be used only for transient cases, and at least one trip_ input must be present to specify trip conditions		
Description: The scram bank movement speed intervals. These are specified in pairs where each rate is associated with the following time interval. At least one rate/time pair must be present		
Notes: This input is used only in transient calculations		

scram_lock bank_label

bank_label	List of Free Form Character Strings	Optional
Units: N/A		
Applicable Value(s): At least one valid bank label		
Limitation(s): Requires scram_type input		
Description: This option is used to specify the bank labels of the banks that will ignore a scram signal. These banks will either continue with their specified linear_rod_ramp or remain at their current position if no such ramp exists. At least one bank label must be specified		
Notes: This input is used only in transient calculations		

trip_time trip_time

trip_time	Double	Optional
Units: seconds (default)		
Applicable Value(s): > 0		
Limitation(s): Requires scram_type input		
Description: This option is used to specify the simulation time when a trip will occur (in seconds) for scram functionality		
Notes: This input is used only in transient calculations		

trip_absolute trip_variable high low delay number_detectors

trip_variable	String	optional
Units: N/A		
Applicable Value(s): power		
Limitation(s): Requires scram_type input		
Description: This option specifies an absolute magnitude trip for the specified state variable		
Notes: This input is used only in transient calculations		

high	Double	optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): Requires scram_type input		
Description: This option specifies the high set point for the given variable		

continued on next page...

`high`, continued...

Notes: This input is used only in transient calculations

`low`	Double	optional
Units: percent full power (default)		
Applicable Value(s): ≥ 0		
Limitation(s): Requires `scram_type input`		
Description: This option specifies the low set point for the given variable		
Notes: This input is used only in transient calculations		

`delay`	Double	optional
Units: seconds (default)		
Applicable Value(s): ≥ 0		
Limitation(s): Requires `scram_type input`		
Description: The delay entry specifies the delay before scram bank movement occurs (seconds)		
Notes: This input is used only in transient calculations		

`number_detectors`	Integer	optional
Units: N/A		
Applicable Value(s): ≥ 0		
Limitation(s): Requires `scram_type input`		
Description: The last entry is the number of detectors required to meet these conditions before a trip occurs. Currently only 0 is supported, which signifies that no detector modeling occurs		
Notes: This input is used only in transient calculations		

trip_rate trip_variable high low delay number_detectors

`trip_variable`	String	optional
Units: N/A		
Applicable Value(s): power		
Limitation(s): Requires `scram_type input`		
Description: This options specifies a rate of changes trip for the specified state variable		
Notes: This input is used only in transient calculations		

`high`	Double	optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): Requires `scram_type input`		
Description: This options specifies the high set point for the given variable		
Notes: This input is used only in transient calculations		

low	Double	optional
Units: N/A		
Applicable Value(s):		
Limitation(s): Requires scram_type input		
Description: This option specifies the low set point for the given variable		
Notes: This input is used only in transient calculations		

delay	Double	optional
Units: seconds (default)		
Applicable Value(s): ≥ 0		
Limitation(s): Requires scram_type input		
Description: The delay entry specifies the delay before scram bank movement occurs (seconds)		
Notes: This input is used only in transient calculations		

number_detectors	Integer	optional
Units: N/A		
Applicable Value(s): ≥ 0		
Limitation(s): Requires scram_type input		
Description: The last entry is the number of detectors required to meet these conditions before a trip occurs. Currently only 0 is supported, which signifies that no detector modeling occurs		
Notes: This input is used only in transient calculations		

end_time end_time_value

end_time_value	Float	Optional
Units: seconds (default)		
Applicable Value(s): >0.0		
Limitation(s): None		
Description: The time at which the last transient step will be solved		
Notes: None		

timestep timestep_dt timestep_tf

timestep_dt	Float	Optional
Units: seconds (default)		
Applicable Value(s): >0.0		
Limitation(s): None		
Description: The time step that will be used between the specified time points		
Notes: Time 0.0 is assumed to be the beginning of the transient. So the first time step is applied between 0.0 and the first timestep_tf		

timestep_tf	Float	Optional
Units: seconds (default)		

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`timestep_tf`, continued...

Applicable Value(s): >0.0
Limitation(s): None
Description: The list of ending times for each specified `timestep_dt`
Notes: If the last `timestep_tf` is less than `end_time`, then the last specified `timestep_dt` will be used until `end_time`

linear_ramp state_variable linear_ramp_value linear_ramp_time

`state_variable`	Character String	Optional
Units: N/A		
Applicable Value(s): `'power','flow','bypass','tinlet','subcool','void','tfuel','modden','boron','pressure'`		
Limitation(s): None		
Description: The state variable that this linear ramp will change		
Notes: None		

`linear_ramp_value`	Float	Optional
Units: N/A		
Applicable Value(s): >0.0		
Limitation(s): None		
Description: The value that the state variable should have at the end of the ramp		
Notes: Excepting `tfuel`, which must be in Kelvin, state variables that have units associated with them in the `[STATE]` block assume the same units in the `[TRANSIENT]` block as in the `[STATE]` block		

`linear_ramp_time`	Float	Optional
Units: seconds (default)		
Applicable Value(s): >0.0		
Limitation(s): None		
Description: The time during the transient that the ramp should end		
Notes: The first ramp is assumed to start at time 0.0		

linear_rod_ramp bank_name linear_rod_ramp_value linear_rod_ramp_time

`bank_name`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		

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bank_name, continued...

Description: The name of the rod bank to move through this ramp. For PWRs, this corresponds to the bank name given in the crd_bank input map. For BWRs, blades can be defined two different ways. The first is to use the crd_map, crd_bank, and rodbank inputs. In this case, the meaning of bank_name for linear_rod_ramp is the same as for PWRs. The other method of defining BWR blades is to use the blade_map and blade_pos options. In this case, bank_name should refer to the x-y location of the BWR blade in blade_map that the user wishes to move. For example, for a small 4 × 4 core: A11 A12 A13 A14 A21 A22 A23 A24 A31 A32 A33 A34 A41 A42 A43 A44 The blade_map could be defined as follows, using four unique blade definitions: B11 B12 B21 B22 With this blade map, assigning a value of 1-2 to bank_name would move blade B12. Similarly, a value of 2-1 would move Bank B21. The x location must also come first, followed by the y location. The x numbering proceeds from left to right, and the y numbering proceeds from top to bottom. If the blade_map is in quarter symmetry, the numbering scheme used for bank_name is still based on the unfolded version of the map to allow for moving a single blade in any region of the core without requiring the unfolded maps to be specified by the user. If the length or height of the blade map is greater than 9, then leading 0s should not be used for lower numbers. The user should use 12-7, not 12-07 to move a blade at x = 12 and y = 7 in blade_map
Notes: None

linear_rod_ramp_value	Float	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The rod position at the end of the ramp		
Notes: None		

linear_rod_ramp_time	Float	Optional
Units: seconds (default)		
Applicable Value(s): >0.0		
Limitation(s): None		
Description: The time during the transient that the ramp should end		
Notes: The first ramp is assumed to start at time 0.0		

linear_mat_ramp mat_name linear_mat_ramp_value linear_mat_ramp_time

mat_name	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The name of the material to move through this ramp		
Notes: None		

linear_mat_ramp_value	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The material specification at the end of the ramp		
Notes: None		

linear_mat_ramp_time	Float	Optional
Units: seconds (default)		
Applicable Value(s): >0.0		
Limitation(s): None		
Description: The time during the transient that the ramp should end		
Notes: The first ramp is assumed to start at time 0.0		

edit_schedule edit_schedule_dt edit_schedule_tf

edit_schedule_dt	Float	Optional
Units: seconds (default)		
Applicable Value(s): >0.0		
Limitation(s): None		
Description: The time interval that should elapse between edits. The first edit_schedule_dt is applied between 0.0 and the first edit_schedule_tf		
Notes: Time 0.0 is assumed to be the beginning of the transient. So the first edit_schedule_dt is applied between 0.0 and the first edit_schedule_tf		

edit_schedule_tf	Float	Optional
Units: seconds (default)		
Applicable Value(s): >0.0		
Limitation(s): None		
Description: The list of ending times for each specified edit_schedule_dt		
Notes: If the last edit_schedule_tf is less than end_time, then the last specified edit_schedule_dt will be used until end_time		

xenon xenon_option

xenon_option	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: This is an option to enable transient xenon calculations. If disabled, the xenon will be calculated by the depletion solver. If enabled, a more precise numerical solver will be used to calculate the xenon		
Notes: None		

7.15 BLOCK MAMBA

A_NiFe2O4_out surface_prefactor

surface_prefactor	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Prefactor for $NiFe_2O_4$ surface growth		
Notes: None		

E_NiFe2O4_out surface_activation_energy

surface_activation_energy	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Activation energy for $NiFe_2O_4$ surface growth		
Notes: None		

A_NiFe2O4_in nucleation_prefactor

nucleation_prefactor	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Prefactor for $NiFe_2O_4$ nucleation		
Notes: None		

E_NiFe2O4_in nucleation_activation_energy

nucleation_activation_energy	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Activation energy for $NiFe_2O_4$ nucleation		
Notes: None		

ksnb_Fe2O4 boiling_growth_rate

`boiling_growth_rate`	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Boiling enhanced surface growth rate		
Notes: None		

D_mult diffusion_coefficient_prefactor

`diffusion_coefficient_prefactor`	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Diffusion coefficient prefactor for all species		
Notes: None		

D_Ni diffusion_coefficient

`diffusion_coefficient`	Floating-point Real Number	Optional
Units: cm^2/s (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Diffusion coefficient for nickel		
Notes: None		

D_Fe diffusion_coefficient

`diffusion_coefficient`	Floating-point Real Number	Optional
Units: cm^2/s (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Diffusion coefficient for iron		
Notes: None		

D_BOH3 diffusion_coefficient

`diffusion_coefficient`	Floating-point Real Number	Optional
Units: cm^2/s (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Diffusion coefficient for boric acid		
Notes: None		

D_Li diffusion_coefficient

`diffusion_coefficient`	Floating-point Real Number	Optional
Units: cm^2/s (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Diffusion coefficient for lithium		
Notes: None		

D_H2 diffusion_coefficient

`diffusion_coefficient`	Floating-point Real Number	Optional
Units: cm^2/s (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Diffusion coefficient for H_2		
Notes: None		

CRUD_porosity porosity

`porosity`	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): 0.7 (default), > 0		
Limitation(s): None		
Description: Initial porosity of CRUD layer		
Notes: None		

CRUD_solid_dens density

`density`	Floating-point Real Number	Optional
Units: g/cm^3 (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Density of solid $NiFe_2O_4$		
Notes: None		

CRUD_dep_frac fraction

`fraction`	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): 0.25 (default), ≥ 0		
Limitation(s): None		
Description: Fraction of the ^{10}B reaction rate applied to depletion		
Notes: None		

LTB_dissolve_scale LTB_dissolve_scale

LTB_dissolve_scale	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): 0.0 (default), $\geq 0, \leq 1$		
Limitation(s): None		
Description: Lithium tetraborate (LTB) dissolution parameter		
Notes: 0 to disable dissolution. 0.5 recommended for LTB dissolution		

chimney_gamma_l_c chimney_gamma_l_c

chimney_gamma_l_c	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Species chimney liquid carryover fraction		
Notes: None		

chimney_gamma_v_mult chimney_gamma_v_mult

chimney_gamma_v_mult	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Crud chimney vapor fraction multiplier		
Notes: None		

chimney_htc_model chimney_htc_model

chimney_htc_model	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), 2		
Limitation(s): None		
Description: Boiling heat transfer model inside a chimney. A value of 1 uses a chimney boiling htc model of the form $h_{boil,chimney} = h + T_{sup} h_{lin}$, where h is the chimney htc given by the input **chimney_htc** with units of W/cm^2K, h_{lin} is the chimney htc given by the input **chimney_htc_lin** with units of W/cm^2K^2, and T_{sup} is the local superheat inside the crud layer in Kelvin. A value of 2 uses a conduction limited boiling heat transfer coefficient model of the form $h_{boil,chimney} = hf(k, c_n)$, where $f(k, c_n)$ is a function of the crud thermal conductivity, k, and c_n is the chimney surface density		
Notes: None		

chimney_htc htc

htc	Floating-point Real Number	Optional
Units: W/cm^2-K (default)		
Applicable Value(s): > 0		
Limitation(s): None		

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htc, continued...

Description: Heat transfer coefficient inside a chimney
Notes: None

chimney_htc_lin htc_lin

htc_lin	Floating-point Real Number	Optional
Units: W/cm^2-K^2 (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Linear-in-T heat transfer coefficient inside a chimney		
Notes: None		

chimney_dens dens

dens	Floating-point Real Number	Optional
Units: num/cm^2 (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Surface density of chimney		
Notes: None		

chimney_rad radius

radius	Floating-point Real Number	Optional
Units: cm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Radius of average chimney		
Notes: None		

chimney_vf void_fraction

void_fraction	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): > 0, < 1		
Limitation(s): None		
Description: Void fraction of steam exiting chimney		
Notes: None		

CRUD_therm_cond k_crud

k_crud	Floating-point Real Number	Optional
Units: W/cm-K (default)		
Applicable Value(s): > 0		

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k_crud, continued...

Limitation(s): None
Description: Thermal conductivity of precipitate in CRUD
Notes: None

CRUD_heat_capacity Cp

Cp	Floating-point Real Number	Optional
Units: J/g-K (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Heat capacity for the CRUD skeleton		
Notes: Currently Cp is unused		

tke_scale factor

factor	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0E-12 (default), > 0		
Limitation(s): None		
Description: Scaling factor to convert from TKE to erosion		
Notes: None		

src_mult_A multiplier

multiplier	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), > 0		
Limitation(s): None		
Description: Multiplier for prefactor for source term model		
Notes: None		

src_mult_E multiplier

multiplier	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), > 0		
Limitation(s): None		
Description: Multiplier for activation energy for source term model		
Notes: None		

steam_generator_age age

age	Floating-point Real Number	Optional
Units: years (default)		

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age, continued...

Applicable Value(s): 0.0 (default), ≥ 0
Limitation(s): None
Description: Initial age of the steam generator
Notes: This is only needed for the first cycle simulated or for a steam generator replacement; default behavior is to retrieve these data from the restart file

sg_mass sg_mass

sg_mass	Floating-point Real Number	Optional
Units: kg (default)		
Applicable Value(s): 0.0 (default), ≥ 0		
Limitation(s): None		
Description: Initial surface particulate mass on steam generator		
Notes: This is ignored in case of restart		

sg_mult multiplier

multiplier	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), ≥ 0		
Limitation(s): None		
Description: Multiplier on steam generator source term		
Notes: This is required to scale the source term model to smaller reactor geometries (i.e., single assem)		

mass_mult multiplier

multiplier	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), ≥ 0		
Limitation(s): None		
Description: Multiplier on crud deposition mass term in the mass balance		
Notes: This is required to scale the source term model to smaller reactor geometries (i.e., single assem)		

piping_age age

age	Floating-point Real Number	Optional
Units: years (default)		
Applicable Value(s): 0.0 (default), ≥ 0		
Limitation(s): None		
Description: Initial age of the hot and cold leg		
Notes: This is only needed for the first cycle simulated; default behavior is to retrieve these data from the restart file		

chem_mass_bal chem_mass_bal

chem_mass_bal	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1		
Limitation(s): None		
Description: Option to select the mass balance model. The options are as follows: 1. 0: no mass balance enabled (user must specify particulate $NiFe_2O_4$ concentration) 2. 1: mass balance will be calculated by MAMBA		
Notes: None		

model_erosion model_erosion

model_erosion	Integer	Optional
Units: N/A		
Applicable Value(s): 2 (default), 0,1		
Limitation(s): None		
Description: Option to select the erosion model. The options are as follows: 1. 0: no crud erosion model 2. 1: calculate from shear so that average TKE is 0.1 J/kg 3. 2: use the Bradshaw model to calculate TKE from shear		
Notes: None		

nrmax nrmax

nrmax	Integer	Optional
Units: N/A		
Applicable Value(s): 200 (default), ≥ 1		
Limitation(s): None		
Description: Option to set maximum number of radial crud nodes		
Notes: None		

min_substeps min_substeps

min_substeps	Integer	Optional
Units: N/A		
Applicable Value(s): 4 (default), ≥ 1		
Limitation(s): None		
Description: Option to set minimum number of crud substeps per outer MAMBA step call		
Notes: None		

coupled_t_ltb_solve coupled_t_ltb_solve

coupled_t_ltb_solve	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), ≥ 0		

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coupled_t_ltb_solve, continued...

Limitation(s): None
Description: Option to set coupled temperature and LTB solver in MAMBA. Set to 0 for fast uncoupled solve. The uncoupled solve is the default. The uncoupled solve is appropriate for cases in which down-powers are not explicitly modeled but instead are modeled using the crud_replenish_b10 input. Set to 1 for fully coupled solve. The fully coupled solve is more accurate for resolving fast crud transients that might occur in simulation of down-power events with a small time step size between VERA state points
Notes: None

deltar deltar

deltar	Floating-point Real Number	Optional
Units: cm (default)		
Applicable Value(s): 0.0001 (default), ≥ 0		
Limitation(s): None		
Description: Radial mesh spacing in MAMBA		
Notes: None		

maxthick maxthick

maxthick	Floating-point Real Number	Optional
Units: cm (default)		
Applicable Value(s): 0.02 (default), ≥ 0		
Limitation(s): None		
Description: Max allowed crud thickness in MAMBA		
Notes: None		

li_table boron lithium

lithium	List of Two Floating-point Real Numbers	Optional
Units: ppm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Table of boron then lithium concentrations to define the lithium concentration based on boron concentration		
Notes: None		

7.16 BLOCK BISON

fuel_grain_radius_initial fuel_grain_radius_initial

fuel_grain_radius_initial	Float	Optional
Units: m (default)		
Applicable Value(s): 2.5×10^{-6} (default), > 0		
Limitation(s): None		

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`fuel_grain_radius_initial`, continued...

Description: The initial grain radius of the fuel
Notes: Defines the initial_condition parameter for the grain_radius object in the BISON AuxVariables block

mechanical_contact_penalty mechanical_contact_penalty

`mechanical_contact_penalty`	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^7 (default), ≥ 0		
Limitation(s): None		
Description: The penalty applied within the fuel-cladding mechanical contact solver		
Notes: Defines the penalty parameter for the pellet_clad_mechanical object in the BISON Contact block		

thermal_contact_tol thermal_contact_tol

`thermal_contact_tol`	Float	Optional
Units: m (default)		
Applicable Value(s): 1.0×10^{-6} (default), ≥ 0		
Limitation(s): None		
Description: The tangential distance to extend the edges of contact surfaces within the fuel-cladding thermal contact solver		
Notes: Defines the tangential_tolerance parameter for the thermal_contact object in the BISON ThermalContact block		

fuel_densification fuel_densification

`fuel_densification`	Float	Optional
Units: N/A		
Applicable Value(s): 0.005 (default), ≥ 0, ≤ 1		
Limitation(s): None		
Description: The fuel densification that will occur given as a fraction of its theoretical density		
Notes: Defines the total_densification parameter for the fuel_swelling object in the BISON Materials block		

temp_max_increment temp_max_increment

`temp_max_increment`	Float	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The maximum Newton increment when solving for the temperature of the fuel and cladding		
Notes: Defines the max_increment parameter for the limitT object in the BISON Dampers block		

linear_tol linear_tol

linear_tol	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-5} (default), > 0		
Limitation(s): None		
Description: The convergence tolerance applied to linear iterations		
Notes: Defines l_tol in the BISON Executioner block		

nonlinear_max_its nonlinear_max_its

nonlinear_max_its	Integer	Optional
Units: N/A		
Applicable Value(s): 25 (default), > 0		
Limitation(s): None		
Description: The maximum number of nonlinear iterations		
Notes: Defines nl_max_its in the BISON Executioner block		

nonlinear_rel_tol nonlinear_rel_tol

nonlinear_rel_tol	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-3} (default), > 0		
Limitation(s): None		
Description: The relative convergence tolerance applied to nonlinear iterations		
Notes: Defines nl_rel_tol in the BISON Executioner block		

nonlinear_abs_tol nonlinear_abs_tol

nonlinear_abs_tol	Float	Optional
Units: N/A		
Applicable Value(s): 1.0×10^{-10} (default), > 0		
Limitation(s): None		
Description: The absolute convergence tolerance applied to nonlinear iterations		
Notes: Defines nl_abs_tol in the BISON Executioner block		

lhr_axial_peaking_data_file lhr_axial_peaking_data_file

lhr_axial_peaking_data_file	Fixed Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The external axial peaking factors data file to be used for the BISON simulation		
Notes: Defines the data_file parameter for the axial_peaking_factors object in the BISON Functions block. Typically, the VERA power file is used, but this allows users to input a file if desired		

bc_temp_data_file bc_temp_data_file

bc_temp_data_file	Fixed Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The external boundary condition temperature data file to be used for the BISON simulation		
Notes: Defines the data_file parameter for the bc_temperature object in the BISON Functions block. Typically, VERA temperatures are used, but this allows users to input a file if desired		

bcs_plenumpressure_plenumpressure_initial_pressure rod_initial_pressure

rod_initial_pressure	Float	Optional
Units: Pascals (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Initial plenum pressure of (non-IFBA) fuel rods		
Notes: None		

bcs_plenumpressure_plenumpressure_initial_pressure_ifba rod_initial_pressure

rod_initial_pressure	Float	Optional
Units: Pascals (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Initial plenum pressure of IFBA-bearing fuel rods		
Notes: None		

bcs_plenumpressure_plenumpressure_startup_time startup_time

startup_time	Float	Optional
Units: seconds (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Time over which the simulation builds in the plenum pressure		
Notes: For numerical stability (if necessary)		

burnup_burnup_num_radial num_radial

num_radial	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 1		
Limitation(s): None		
Description: Number of radial mesh points in the burnup mesh		
Notes: None		

burnup_burnup_num_axial num_axial

num_axial	Float	Optional
Units: N/A		
Applicable Value(s): ≥ 1		
Limitation(s): None		
Description: Number of axial mesh points in the burnup mesh		
Notes: None		

executioner_start_time start_time

start_time	Float	Optional
Units: seconds (default)		
Applicable Value(s): Any float (+/-)		
Limitation(s): None		
Description: Starting time for the simulation		
Notes: Most standalone BISON cases use 0, but VERAOneWay typically uses -100 seconds		

executioner_dt dt

dt	Float	Optional
Units: seconds (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Initial time step of the simulation		
Notes: Adaptive time stepping immediately takes over from this		

executioner_dtmin dtmin

dtmin	Float	Optional
Units: seconds (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The minimum time step at which the adaptive time stepping will terminate the simulation		
Notes: None		

executioner_dtmax dtmax

dtmax	Float	Optional
Units: seconds (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The maximum time step at which the adaptive time stepping will terminate the simulation		
Notes: None		

executioner_end_time end_time

end_time	Float	Optional
Units: seconds (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The end time of the simulation		
Notes: None		

globalparams_a_lower a_lower

a_lower	Float	Optional
Units: m (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The lower bound of the active fuel		
Notes: None		

globalparams_a_upper a_upper

a_upper	Float	Optional
Units: m (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The upper bound of the active fuel		
Notes: None		

globalparams_energy_per_fission energy_per_fission

energy_per_fission	Float	Optional
Units: Joules/fission (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The energy per fission		
Notes: None		

mesh_file meshfilename

meshfilename	Fixed Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The external mesh file for the simulation		
Notes: Typically, the internal mesh generator is used, but this allows the user to input a file if desired		

avg_lhr_data_file avg_lhr_data_file

avg_lhr_data_file	Fixed Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The external linear heat rate profile data file to be used for the BISON simulation		
Notes: Defines the data_file parameter for the linear_heat_rate_profile object in the BISON Functions block. Typically, the VERA power file is used, but this allows users to input a file if desired		

mesh_nx_p nradial_pellet

nradial_pellet	Float	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The number of radial elements in the fuel pellet		
Notes: None		

mesh_ny_p naxial_pellet

naxial_pellet	Integer	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The number of axial elements in the fuel pellet		
Notes: None		

mesh_nx_c nradial_clad

nradial_clad	Integer	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The number of radial elements in the cladding		
Notes: None		

mesh_ny_c naxial_clad

naxial_clad	Integer	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The number of axial elements in the cladding		
Notes: None		

mesh_bx_p radial_bias

radial_bias	Integer	Optional
Units: N/A		
Applicable Value(s): > 0,< 2		
Limitation(s): None		
Description: The biasing parameter for the fuel radial mesh		
Notes: This is used to enforce a nonuniform radial mesh to enhance accuracy		

mesh_clad_bot_gap_height bot_gap_height

bot_gap_height	Float	Optional
Units: m (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The distance between the bottom of the fuel stack and the top of the lower clad region		
Notes: None		

outputs_file_base output_filename

output_filename	Fixed Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The filename of the output file for the simulation		
Notes: None		

fuel_pin_input_file_template fuel_inp_filename

fuel_inp_filenamee	Fixed Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The filename of the template for fuel rods		
Notes: None		

non_fuel_pin_input_file_template nonfuel_inp_filename

nonfuel_inp_filename	Fixed Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The filename of the template for nonfuel rods		
Notes: None		

power_file power_filenames

power_filenames	List of Free Form Character Strings	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The filenames of the VERA-generated HDF5 files with power and temperature data		
Notes: None		

cycle_xml cycle_xml_filenames

cycle_xml_filenames	List of Free Form Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The filenames of the corresponding VERA cycle depletion XML files		
Notes: None		

shuffle_xml shuffle_xml_filenames

shuffle_xml_filenames	List of Free Form Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The filenames of the corresponding VERA shuffle XML files		
Notes: None		

only_cycle only_cycle

only_cycle	Integer	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The cycle index for which to generate BISON input files		
Notes: Otherwise, all cycles of files will be generated		

only_assemblies assembly_locations

assembly_locations	List of Free Form Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The list of assembly locations for which to generate BISON input files		
Notes: Otherwise, all assemblies will be generated		

mesh_type mesh_type

mesh_type	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): smeared_pellet (default), unit_test		
Limitation(s): None		
Description: The mesh type		
Notes: Used for VERAOneWay testing		

output_average_axial_values output_average_axial_values

output_average_axial_values	Boolean	Optional
Units: N/A		
Applicable Value(s): true, false		
Limitation(s): None		
Description: Logical governing whether or not to output average axial values		
Notes: None		

solve_type solve_type

solve_type	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): standalone, temp_table		
Limitation(s): None		
Description: The solver scheme for the simulation		
Notes: Some options in the template are different, depending on the solve type		

bc_type bc_type

bc_type	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): bulk_cool (default), clad_outer		
Limitation(s): None		
Description: The boundary condition type used for the simulation		
Notes: Standalone BISON can use clad outer surface and bulk coolant temperature as the boundary condition		

axial_shape axial_shape

axial_shape	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): midpoint (default), constant		
Limitation(s): None		
Description: Governs the axial shaping of the power and temperature variables input from VERA		
Notes: Some options in the template are different depending on the solve type		

fast_flux fast_flux

`fast_flux`	Boolean	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		
Description: Logical governing whether or not to use pin clad fast flux from VERA		
Notes: None		

materials_fuel_relocation_relocation_activation1 activation_threshold

`activation_threshold`	Float	Optional
Units: W/m (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Threshold for the first level of relocation activation		
Notes: None		

auxkernels_fast_neutron_flux_factor flux_factor

`flux_factor`	Float	Optional
Units: n/m2-s per W/m (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Fast flux factor for approximating fast neutron flux from local power		
Notes: None		

materials_fuel_mech_model_creep model_creep

`model_creep`	Boolean	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: Enables the fuel mechanics creep model		
Notes: None		

materials_fuel_relocation_burnup_relocation_stop relocation_stop

`relocation_stop`	Boolean	Optional
Units: fissions per initial metal atom (fima) (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Burnup at which the relocation model turns off		
Notes: None		

thermalcontact_roughness_fuel roughness_fuel

roughness_fuel	Boolean	Optional
Units: μm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Fuel roughness value		
Notes: None		

thermalcontact_roughness_clad roughness_clad

roughness_clad	Boolean	Optional
Units: μm (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Clad roughness value		
Notes: None		

power_ramp_times power_ramp_times

power_ramp_times	Float	Optional
Units: seconds (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Power ramp times before and after each cycle input file. These should be input as lists of numbers in pairs, with the first number corresponding to the beginning of a cycle, and the second corresponding to the end of a cycle		
Notes: None		

temp_ramp_times temp_ramp_times

temp_ramp_times	Float	Optional
Units: seconds (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Temperature ramp times before and after each cycle input file. These should be input as a list of numbers in pairs, with the first number corresponding to the beginning of a cycle, and the second corresponding to the end of a cycle		
Notes: None		

functions_coolant_pressure_ramp_x pressure_ramp_time_values **functions_coolant_pressure_ramp_x** pressure_ramp_time_values

pressure_ramp_time_values	Fixed Character String	Optional
Units: seconds (default)		
Applicable Value(s):		
Limitation(s): None		

continued on next page...

pressure_ramp_time_values, continued...

Description: Time values for coolant/system pressure ramp
Notes: None

functions_coolant_pressure_ramp_y pressure_ramp_pressure_values

pressure_ramp_pressure_values	Fixed Character String	Optional
Units: Pascals (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Pressure values for coolant/system pressure ramp		
Notes: None		

7.17 BLOCK FAST

initial_plenum_pressure rod_initial_pressure

rod_initial_pressure	Float	Optional
Units: Pascals (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Initial plenum pressure of (non-IFBA) fuel rods		
Notes: None		

initial_plenum_pressure_ifba rod_initial_pressure_ifba

rod_initial_pressure_ifba	Float	Optional
Units: Pascals (default)		
Applicable Value(s): ≥ 0		
Limitation(s): None		
Description: Initial plenum pressure of IFBA-bearing fuel rods		
Notes: None		

flux_to_power_ratio flux_to_power_ratio

flux_to_power_ratio	Float	Optional
Units: neutrons/m2/s per W/g of fuel (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The flux to power ratio		
Notes: None		

mesh_nr nradial_pellet

nradial_pellet	Float	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The number of fuel radial nodes		
Notes: None		

mesh_na naxial_cells

naxial_cells	Integer	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: This is the number of fuel axial nodes. FAST will automatically create a uniformly sized mesh		
Notes: None		

mesh_max_deltaz mesh_max_deltaz

mesh_max_deltaz	Float	Optional
Units: m (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: This is the maximum axial mesh size. This will refine the VERA axial grid so that all the axial cells are less than or equal to mesh_max_deltaz		
Notes: None		

mesh_nc nradial_clad

nradial_clad	Integer	Optional
Units: N/A		
Applicable Value(s): > 0		
Limitation(s): None		
Description: The number of clad radial nodes		
Notes: None		

max_deltat max_deltat

max_deltat	Float	Optional
Units: seconds (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: This is the maximum size for time steps. Otherwise, the default time step will be the time between states		
Notes: None		

fuel_pin_input_file_template fuel_inp_filename

fuel_inp_filenamee	Fixed Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The filename of the template for fuel rods		
Notes: None		

power_file power_filenames

power_filenames	List of Free Form Character Strings	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The filenames of the VERA-generated HDF5 files with power and temperature data listed in sequential order		
Notes: None		

cycle_xml cycle_xml_filenames

cycle_xml_filenames	List of Free Form Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The filenames of the corresponding VERA cycle depletion XML files in sequential order		
Notes: None		

shuffle_xml shuffle_xml_filenames

shuffle_xml_filenames	List of Free Form Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: These are the filenames of the corresponding VERA shuffle XML files. There should be a shuffle file for the beginning of each cycle after the first		
Notes: None		

only_cycle only_cycle

only_cycle	Integer	Optional
Units: N/A		
Applicable Value(s): > 0		

continued on next page...

`only_cycle`, continued...

Limitation(s): None
Description: The cycle index for which to generate FAST input files
Notes: Otherwise, all cycles of files will be generated

only_assemblies assembly_locations

`assembly_locations`	List of Free Form Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: The list of assembly locations for which to generate FAST input files		
Notes: Otherwise, all assemblies will be generated		

solve_type solve_type

`solve_type`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): standalone		
Limitation(s): None		
Description: The solver scheme for the simulation		
Notes: None		

bc_type bc_type

`bc_type`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): bulk_cool (default), clad_outer		
Limitation(s): None		
Description: The boundary condition type used for the simulation		
Notes: Standalone FAST can use clad outer surface and bulk coolant temperature as the boundary condition		

thermalcontact_roughness_fuel roughness_fuel

`roughness_fuel`	Float	Optional
Units: m (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Fuel roughness value		
Notes: None		

thermalcontact_roughness_clad roughness_clad

roughness_clad	Float	Optional
Units: m (default)		
Applicable Value(s): > 0		
Limitation(s): None		
Description: Clad roughness value		
Notes: None		

7.18 BLOCK RUN

email list_of_emails

email	Character String	Optional
Units: N/A		
Applicable Value(s): Default email is the user's system email (default)		
Limitation(s): None		
Description: This is the email address used to inform the user of job status. A list of emails can be input by comma separating the email addresses		
Notes: None		

exe_mode exe_mode

exe_mode	Character String	Optional
Units: N/A		
Applicable Value(s): th		
Limitation(s): None		
Description: If given an input of th, then VERARun will execute multistate_cobra instead of MPACT.exe		
Notes: None		

pmem memory per processor

pmem	Floating-point Number	Optional
Units: GB (default)		
Applicable Value(s): System memory per processor (default), > 0.0		
Limitation(s): None		
Description: Memory per processor		
Notes: None		

ppn processors per node

ppn	Integer	Optional
Units: N/A		
Applicable Value(s): System processors per node (default), > 0		
Limitation(s): None		
Description: Number of processors that will be used per node		
Notes: None		

nprocs number of processors

`nprocs`	Integer	Optional
Units: N/A		
Applicable Value(s): Total number of system processors (default), > 0		
Limitation(s): None		
Description: Total number of processors that will be used		
Notes: None		

walltime maximum expected run time

`walltime`	Floating-point Number	Optional
Units: hours (default)		
Applicable Value(s): 24 hours (default), > 0.0		
Limitation(s): None		
Description: The wall time that is used for pbs submission		
Notes: None		

8. EXAMPLES

This chapter includes several input examples. Additional examples can be found in the VERAIn Git repository.

8.1 EXAMPLE 1—FULL CORE

The first example is a complete input for a full-core problem. This problem is Problem 7 of the VERA Core Physics Benchmark Progression Problem Specifications and is based on the publicly available description of the Watts Bar reactors.

More information on the CASL Progression Benchmark Problems can be found in the following CASL report:

- A. Godfrey, "VERA Core Physics Benchmark Progression Problem Specifications," CASL Technical Report: CASL-U-2012-0131-004, August 2014.

More details on Problem 7 can be found in the following CASL report:

- "Demonstration and Neutronics Coupled to Thermal-Hydraulics for a Full-Core Problem using VERA," CASL Technical Report: CASL-U-2013-0196-000, December 2013.

```
!
!  Sample Test case for Problem 7 (Full-Core HFP)
!
[CASEID]
  title 'CASL Progression Problem 7 - Watts Bar Unit 1 Cycle 1 - Public'

[STATE]
  power  100.0          ! % of rated power
  flow   100.0          ! % of rated flow
  pressure 2250.0       ! pressure (psia)
  feedback on

  tinlet 565.0 K        ! inlet temperature
  tfuel  900.0 K        ! typical HFP value
  boron  1285           ! ppmB
  modden 0.743          ! g/cc
  sym qtr

  rodbank SA 230
          SB 230
          SC 230
          SD 230
           A 230
           B 230
           C 230
           D 167

[CORE]
  size 15               ! assemblies across core
  rated 3411 131.68     ! rated power and flow - MW, Mlbs/hr
  apitch 21.5           ! assembly pitch (cm)
  height 406.337        ! assembly height (cm)

  core_shape
    0 0 0 0 1 1 1 1 1 1 1 0 0 0 0
    0 0 1 1 1 1 1 1 1 1 1 1 1 0 0
    0 1 1 1 1 1 1 1 1 1 1 1 1 1 0
    0 1 1 1 1 1 1 1 1 1 1 1 1 1 0
    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
    0 1 1 1 1 1 1 1 1 1 1 1 1 1 0
    0 1 1 1 1 1 1 1 1 1 1 1 1 1 0
    0 0 1 1 1 1 1 1 1 1 1 1 1 0 0
    0 0 0 0 1 1 1 1 1 1 1 0 0 0 0

  assm_map
    1
    2 1
    1 2 1
```

```
  2 1 2 1
  1 2 1 2 2
  2 1 2 1 2 3
  1 3 1 3 3 3
  3 3 3 3

insert_map
   -
  20  -
   - 24  -
  20  - 20  -
   - 20  - 20  -
  20  - 16  - 24 12
   - 24  - 16  -  -
  12  -  8  -

crd_map
  1
  - -
  1 - 1
  - - - 1
  1 - - - 1
  - 1 - 1 - -
  1 - 1 - 1 -
  - - - -

crd_bank
  D  -  A  -  D  -  C  -
  -  -  -  -  - SB  -  -
  A  -  C  -  -  -  B  -
  -  -  -  A  - SC  -  -
  D  -  -  -  D  - SA
  - SB  - SD  -  -  -
  C  -  B  - SA  -
  -  -  -  -

det_map
          1 - - 1 - - -
      1 - - - 1 - - 1 - 1 -
    - 1 - 1 - - 1 - - - - - 1
    - - - - 1 - - 1 - - 1 - -
  1 - - - 1 - - 1 - - 1 - - - 1
  - - - - 1 - 1 - - - - 1 - - -
  - 1 - - - - - - 1 - 1 - - - 1
  1 - 1 - 1 - 1 - - 1 - 1 1 1 -
  - - - 1 - - 1 - - 1 - - 1 - -
  1 - 1 - - 1 - 1 - - - - - 1 -
  - - - - 1 - - - 1 - 1 - 1 - -
    1 1 - - - - 1 - - - - - -
    - - - - - - 1 - 1 - 1 - 1
      1 - - 1 - 1 - - - - -
          - - 1 - - 1 -

baffle ss 0.19 2.85       ! baffle material, gap, and thickness (cm)
```

```
  vessel mod 219.71 cs 241.70

  lower_plate ss  5.0 0.5   ! mat, thickness, vol frac
  upper_plate ss  7.6 0.5   ! mat, thickness, vol frac

  lower_ref  mod 20.0 1.0   ! mat, thickness, vol frac
  upper_ref  mod 20.0 1.0   ! mat, thickness, vol frac

  xlabel  R P N M L K J H G  F  E  D  C  B  A
  ylabel  1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

  mat he     0.0001786
  mat inc    8.19
  mat ss     8.0
  mat zirc   6.56 zirc4

[ASSEMBLY]
  title "Westinghouse 17x17 Assembly"
  npin 17                ! number of pins across assembly
  ppitch 1.260           ! pin pitch (cm)

  fuel U21 10.257 94.5 / 2.110
  fuel U26 10.257 94.5 / 2.619
  fuel U31 10.257 94.5 / 3.100

  cell 1     0.4096 0.418 0.475 / U21 he zirc
  cell 2     0.4096 0.418 0.475 / U26 he zirc
  cell 3     0.4096 0.418 0.475 / U31 he zirc
  cell 4            0.561 0.602 / mod    zirc       ! guide/instrument tube
  cell 5            0.418 0.475 /     he zirc       ! plenum

  rodmap LAT21
       4
       1 1
       1 1 1
       4 1 1 4
       1 1 1 1 1
       1 1 1 1 1 4
       4 1 1 4 1 1 1
       1 1 1 1 1 1 1 1
       1 1 1 1 1 1 1 1 1

  rodmap LAT26
       4
       2 2
       2 2 2
       4 2 2 4
       2 2 2 2 2
       2 2 2 2 2 4
       4 2 2 4 2 2 2
       2 2 2 2 2 2 2 2
       2 2 2 2 2 2 2 2 2

  rodmap LAT31
```

```
          4
          3 3
          3 3 3
          4 3 3 4
          3 3 3 3 3
          3 3 3 3 3 4
          4 3 3 4 3 3 3
          3 3 3 3 3 3 3 3
          3 3 3 3 3 3 3 3 3

    rodmap PLEN
          4
          5 5
          5 5 5
          4 5 5 4
          5 5 5 5 5
          5 5 5 5 5 4
          4 5 5 4 5 5 5
          5 5 5 5 5 5 5 5
          5 5 5 5 5 5 5 5 5

! define three assemblies with labels 1, 2, 3

    axial  1  11.951 LAT21 377.711 PLEN 393.711
    axial  2  11.951 LAT26 377.711 PLEN 393.711
    axial  3  11.951 LAT31 377.711 PLEN 393.711

    grid END inc  1017 3.866   ! grid mass (g) and thickness (cm)
    grid MID zirc  875 3.810

    grid_axial                 ! axial grid positions - midpoints (cm)
        END  13.884
        MID  75.2
        MID 127.4
        MID 179.6
        MID 231.8
        MID 284.0
        MID 336.2
        END 388.2

    lower_nozzle  ss 6.053 6250.0  ! mat, height, mass (g)
    upper_nozzle  ss 8.827 6250.0  ! mat, height, mass (g)

  [INSERT]
    title "Pyrex"
    npin 17

    mat pyrx1 2.25 pyrex-vera

    cell 1  0.214 0.231 0.241 0.427 0.437 0.484 / he ss he pyrx1 he ss

    rodmap  PY8
       -
       - -
```

```
      - - -
      1 - - -
      - - - - -
      - - - - - 1
      - - - - - - - -
      - - - - - - - - -
      - - - - - - - - - -

   rodmap  PY12
      -
      - -
      - - -
      1 - - -
      - - - - -
      - - - - - -
      - - - 1 - - -
      - - - - - - - - -
      - - - - - - - - - -

   rodmap  PY16
      -
      - -
      - - -
      1 - - -
      - - - - -
      - - - - - 1
      - - - 1 - - -
      - - - - - - - - -
      - - - - - - - - - -

   rodmap  PY20
      -
      - -
      - - -
      1 - - -
      - - - - -
      - - - - - 1
      1 - - 1 - - -
      - - - - - - - - -
      - - - - - - - - - -

   rodmap  PY24
      -
      - -
      - - -
      1 - - 1
      - - - - -
      - - - - - 1
      1 - - 1 - - -
      - - - - - - - - -
      - - - - - - - - - -

! define 5 insert types with labels 8, 12, 16, 20, and 24
```

```
  axial   8  15.761 PY8  376.441
  axial  12  15.761 PY12 376.441
  axial  16  15.761 PY16 376.441
  axial  20  15.761 PY20 376.441
  axial  24  15.761 PY24 376.441

[CONTROL]
  title "B4C with AIC tips"
  npin 17
  stroke  365.125 230     ! approx for 1.5875 step sizes and 230 max stroke

  mat aic 10.2
  mat b4c 1.76

  cell 1  0.382 0.386 0.484 / aic he ss
  cell 2  0.373 0.386 0.484 / b4c he ss

  rodmap AIC
     -
     - -
     - - -
     1 - - 1
     - - - - -
     - - - - - 1
     1 - - 1 - - -
     - - - - - - - -
     - - - - - - - - -

  rodmap B4C
     -
     - -
     - - -
     2 - - 2
     - - - - -
     - - - - - 2
     2 - - 2 - - -
     - - - - - - - -
     - - - - - - - - -

  axial  1    17.031
         AIC 118.631
         B4C 377.711

[DETECTOR]
  title "Incore instrument thimble"
  npin 17

  mat he 0.0001786
  mat ss 8.0

  cell 1  0.258 0.382 / he ss

  rodmap  LAT
     1
```

```
      - -
      - - -
      - - - -
      - - - - -
      - - - - - -
      - - - - - - -
      - - - - - - - -
      - - - - - - - - -

  axial 1  0.0 LAT 406.337

[EDITS]
  axial_edit_bounds
       11.951   15.817   24.028   32.239   40.45
       48.662   56.873   65.084   73.295   77.105
       85.17    93.235  101.3    109.365  117.43
      125.495  129.305  137.37   145.435  153.5
      161.565  169.63   177.695  181.505  189.57
      197.635  205.7    213.765  221.83   229.895
      233.705  241.77   249.835  257.9    265.965
      274.03   282.095  285.905  293.97   302.035
      310.1    318.165  326.23   334.295  338.105
      346.0262 353.9474 361.8686 369.7898 377.711

[COBRATF]

[COUPLING]
```

8.2 EXAMPLE 2—SINGLE ASSEMBLY

The second example is a partial input for a single-assembly with T/H feedback. This problem is Problem 6 of the VERA Core Physics Benchmark Progression Problem Specifications [1].

A single assembly is defined by creating a core with one assembly in it, as described in the small-core geometry discussion in Section 2.2.5.

This input is also used to demonstrate the modular structure of the input. The [ASSEMBLY], [EDITS], [COBRATF], and [COUPLING] blocks are identical to Example 1, and they show how blocks can be re-used in different input decks. These blocks are not included here, but they can be copied directly from the first example problem if the user wishes to run this problem.

```
[CASEID]
  title 'CASL Benchmark Progression Problem 6'
!=====================================================================
!  Sample input for Problem 6 (Single-assembly with T/H feedback)
!=====================================================================

[STATE]
  power  100.0         ! %
  tinlet 559.0 F       !
  boron  1300          ! ppmB
  pressure 2250        ! psia

  feedback on
  sym full

[CORE]
  size 1               ! 1x1 single-assembly

 ! The rated power and flow are scaled down for a single-assembly
  rated 17.67   0.6824  ! rated power and flow (MW, Mlbs/hr)

  apitch 21.5          ! assembly pitch (cm)
  height 406.328       ! core height (cm)

  core_shape
    1                  ! core map with a single assembly

  assm_map
    A1                 ! name of assembly

  lower_plate ss 5.0 0.5    ! material, thickness (cm), vol frac
  upper_plate ss 7.6 0.5    ! material, thickness (cm), vol frac
  lower_ref   mod 26.0 1.0  ! material, thickness (cm), vol frac
  upper_ref   mod 25.0 1.0  ! material, thickness (cm), vol frac

  bc_rad reflecting         ! radial boundary condition

! Materials defined in the [CORE] block are global and can be accessed
! from any assembly, insert, etc.

  mat he     0.0001786
  mat inc    8.19
  mat ss     8.0
  mat zirc   6.56 zirc4

include  assembly.inc   ! Include [ASSEMBLY] block from Example 1
include  edits.inc      ! Include [EDITS]    block from Example 1
include  cobratf.inc    ! Include [COBRATF]  block from Example 1
```

8.3 EXAMPLE 3—2D LATTICE GEOMETRY

The third example is a complete input for a 2D lattice. This problem is Problem 2A of the VERA Core Physics Benchmark Progression Problem Specifications [1].

A single assembly is defined by creating a core with one assembly in it, as described in the small-core geometry description in Section 2.2.5.

The 2D lattice is defined by specifying an *axial* input with one level and defining reflective boundary conditions on the top and bottom of the core with the *bc_top* and *bc_bot* inputs.

This example problem also shows how multiple assembly, insert, and control types can be defined by using multiple *axial* inputs in a single input block.

```
[CASEID]
  title 'CASL AMA Benchmark Problem 2A - Fuel Lattice - Public'

[STATE]
  power 0.0                ! %
  tinlet 557.33 F          !
  tfuel  565 K             !
  modden 0.743             ! g/cc
  boron 1300               ! ppm
  rodbank A 1              ! rod fully withdrawn
  sym qtr

[CORE]
  size 1
  apitch 21.50
  height 1.0
  rated 0.01 0.01

  core_shape
    1

  assm_map
    ASSY

  insert_map
    -

  crd_map
    AIC

  crd_bank
    A

  bc_rad reflecting
  bc_top reflecting   ! specify top reflective boundary conditions
  bc_bot reflecting   ! specify bottom reflective boundary conditions

[ASSEMBLY]
  npin 17
  ppitch 1.26

! material definitions in an ASSEMBLY block only have scope in this block

  fuel U31 10.257 94.5 / 3.1
  mat he   0.000176
  mat zirc 6.56 zirc4

  cell 1 0.4096 0.418 0.475 / U31 he zirc
  cell 2        0.561 0.602 / mod zirc

  lattice LAT
    2
    1 1
```

```
      1 1 1
      2 1 1 2
      1 1 1 1 1
      1 1 1 1 1 2
      2 1 1 2 1 1 1
      1 1 1 1 1 1 1 1
      1 1 1 1 1 1 1 1 1

    axial ASSY 0.0 LAT 1.0

  [INSERT]
    title "Pyrex"
    npin 17

  ! material definitions in an INSERT block only have scope in this block

    mat he     0.0001786
    mat pyrx1  2.25 pyrex-vera
    mat ss     8.0

    cell 1  0.214 0.231 0.241 0.427 0.437 0.484 / he ss he pyrx1 he ss

! define multiple inserts corresponding to 8, 12, 16, 20, and 24 fingers

    lattice  LAT8
       -
       - -
       - - -
       1 - - -
       - - - - -
       - - - - - 1
       - - - - - - -
       - - - - - - - -
       - - - - - - - - -

    lattice  LAT12
       -
       - -
       - - -
       1 - - -
       - - - - -
       - - - - - -
       - - - 1 - - -
       - - - - - - - -
       - - - - - - - - -

    lattice  LAT16
       -
       - -
       - - -
       1 - - -
       - - - - -
       - - - - - 1
       - - - 1 - - -
```

```
    - - - - - - - -
    - - - - - - - - -

  lattice  LAT20
    -
    - -
    - - -
    1 - - -
    - - - - -
    - - - - - 1
    1 - - 1 - - -
    - - - - - - - -
    - - - - - - - - -

  lattice  LAT24
    -
    - -
    - - -
    1 - - 1
    - - - - -
    - - - - - 1
    1 - - 1 - - -
    - - - - - - - -
    - - - - - - - - -

! multiple INSERT types can be defined by defining separate axial inputs

  axial PY8   0.0 LAT8  1.0
  axial PY12  0.0 LAT12 1.0
  axial PY16  0.0 LAT16 1.0
  axial PY20  0.0 LAT20 1.0
  axial PY24  0.0 LAT24 1.0

[CONTROL]
  title "B4C and AIC RCCAs"
  npin 17
  stroke  1.0 1           ! 1 step for in/out

! material definitions in a CONTROL block only have scope in this block

  mat he     0.0001786
  mat ss     8.0
  mat aic   10.2
  mat b4c    1.76

  cell 1  0.382 0.386 0.484 / aic he ss
  cell 2  0.373 0.386 0.484 / b4c he ss

  lattice LAT_AIC
    -
    - -
    - - -
    1 - - 1
    - - - - -
```

```
    - - - - - 1
    1 - - 1 - - -
    - - - - - - - -
    - - - - - - - - -

  lattice LAT_B4C
    -
    - -
    - - -
    2 - - 2
    - - - - -
    - - - - - 2
    2 - - 2 - - -
    - - - - - - - -
    - - - - - - - - -

  axial AIC  0.0 LAT_AIC 1.0
  axial B4C  0.0 LAT_B4C 1.0

[MPACT]

  ! include SHIFT and/or MPACT block here
```

9. VERARUN

This chapter describes running cases with the VERARun script. VERARun is the driver script that runs the input processor and corresponding VERA component codes. VERARun also submits the job to the parallel job queue.

9.1 RUNNING A CASE

VERARun is run by specifying `verarun` on the command line, followed by the name of the input file. Additional command line options are shown subsequently.

```
--> verarun <input file>
```

For example, if your input deck is called `2a.inp`, you would enter

```
--> verarun 2a
```

To see what versions of VERA are available, use the -l option:

```
--> verarun -l
Available VERA versions (newest to oldest, * for default):
  VERA_4.1
  VERA_4.2 *
```

To use a different VERA version, use the -v option:

```
--> verarun -v VERA_4.2 file.inp
```

To use a development version of VERA (not usually recommended), use the –devs option:

```
--> verarun --devs -v VERA_4.3RC2 file.inp
```

To see additional VERARun command line options, just execute VERARun with no other command line input. To see detailed help and customizable environment variables use the -h option. Doing so will return the following:

```
usage: verarun [--devs] [-x] [--schema] [-e email_addr] [-h] [-c config_file]
               [-N job_name] [-l] [-n nprocs] [-O] [-M] [--ppn cpus_per_node]
               [-m mem_per_process] [-p project] [-q queue] [-s subdir]
               [-d vera_install_dir] [-v vera_version] [--verbose] [-W]
               [-w job_id] [-t walltime] [--chain] [--debug] [--hostname host]
               [-r {overwrite,readwrite}]
               [--vera-installs-dir vera_installs_dir]
               [input_path [input_path ...]]
```

```
Creates and optionally submits machine-specific VERA jobs.

positional arguments:
  input_path            path to VERA input (.inp) or XML (.xml) files

optional arguments:
  --devs, --allow-devs  override VERA_PROD_VERSIONS and allow development VERA
                        versions, implies -l
  -x, --dry-run         dry run only, create but don't execute the PBS script
  --schema              schema from react2xml.pl
  -e email_addr, --email-addrs email_addr
                        comma-delimited list of email addresses to notify of
                        job completion, defaults to ${USER}@$(hostname)
  -h, --help            print detailed help
  -c config_file, --host-config-file config_file
                        override host configuration file, supercedes
                        --hostname and --vera-installs-dir
  -N job_name, --job-name job_name
                        name for the PBS job
  -l, --list-vera-versions
                        list available VERA versions
  -n nprocs, --np nprocs, --nprocs nprocs, --num-procs nprocs
                        total number of processors need for the MPACT run
                        (mpiexec -np param), defaults to value computed from
                        input
  -O, --output-job-name
                        print the job id to stdout
  -M, --messages        print messages as process is run
  --ppn cpus_per_node, --pnode cpus_per_node
                        specify processors per node, by default this is
                        calculated
  -m mem_per_process, --pmem mem_per_process, --proc-memory mem_per_process
                        specify memory required per processor in GB, defaults
                        to undefined
  -p project, --project project
                        optional project or account to specify for the job,
                        overriding any default, where a value of "none" omits
                        a project
  -q queue, --partition queue, --queue queue
                        Torque queue or Slurm partition
  -s subdir, --subdir subdir
                        create subdir, a value of "." specifies automatically
                        generated subdir name
  -d vera_install_dir, --vera-dir vera_install_dir
                        path to VERA installation, superceding --vera-
                        installs-dir, --vera-version, and the host
                        configuration
  -v vera_version, --vera-version vera_version
                        name of VERA version to use
  --verbose             turn on verbose messaging
  -W                    wait on job last submitted via verarun, overrides -w
  -w job_id, --wait-job-id job_id
                        ID of job which must complete before starting this job
  -t walltime, --wall-time walltime
```

```
                        wallclock execution time in floating point hours,
                        defaults to 24.0

advanced arguments:
  --chain, --chain-jobs
                        each job depends on its predecessor
  --debug               debug mode
  --hostname host       force the hostname
  -r {overwrite,readwrite}, --restart {overwrite,readwrite}
                        optional restart mode
  --vera-installs-dir vera_installs_dir
                        path to vera_installs directory containing VERA
                        versions

Version 1.12
```

VERARun uses machine-specific characteristics to determine batch system directives applied to a job script template. Additional template parameters, such as which models and utilities to execute, are determined from the VERA input file (.inp). Configurations are provided for machines commonly in the VERA program. In order to port `verarun` to another environment it will be necessary to create a machine spec file.

9.2 EXECUTION

There are two verarun usage modes:

- If the `-l` command-line argument is specified, available VERA installations are listed. If `-verbose` is also specified, required files that are missing in each `vera_installs_dir` subdir are listed.
- If one or more VERA input files (.inp) are specified, a job script is created based on each input file. Note pre-processed VERA input XML (.xml) may be also be specified. If no file extension is given `.inp` is assumed.

By default the current directory will be used for all processing. Alternatively, you may specify that a subdirectory in the current directory be created and used as the working directory via the `-s` command-line argument. Specifying a directory value of `.` will tell `verarun` to create a subdirectory with name `{input_name}_{datetime}`, where `{input_name}` is the name of the input file without the `.inp` or `.xml` extension, and `{datetime}` is the ISO 8601 extended date format: `yyyy-mm-ddThh:mm:ss`.

A job script named with a `.pbs` extension is created in the working directory. If the `-x` argument is not specified, the job is also submitted. Output from the job will be in a file with extension `.stdout` in the working directory.

9.3 MACHINE SPECIFICATIONS

Machine specifications are stored in JSON (`.json`) files under the `verarun` Python package installation directory:

`../lib/python2.7/site-packages/verarun-<version>-py2.7.egg/verarun/config/`

It is also possible to specify a configuration file with the `-c` command-line argument.

9.4 JOB SCRIPT TEMPLATE

The Job template is a Bash script named `vera.pbs` stored under the `verarun` installation directory:

`../lib/python2.7/site-packages/verarun-<version>-py2.7.egg/verarun/job/`

Parameter values are substituted by name for curly-brace expressions in the template (.e.g., `{job_name}`).

9.5 ENVIRONMENT VARIABLES

There are environment variables which can be set to override behavior.

- `PBS_EMAIL`: sets the email address to be used for PBS notifications, overridden by the `-e` parameter (or `email-addrs`).
- `PBS_PROJECT`: sets the project for the job, overriding any default set in the host configuration but overridden by the `-p` (or `-project`) parameter.
- `VERA_BUILDS`: path to the directory containing VERA builds or installs. May also be specified as `VERA_BUILDS_DIR` or `VERA_INSTALLS_DIR`. Overrides the `$(hostname).json` file but is overridden by the `-vera-installs-dir` parameter.
- `VERA_BUILDS_DIR`: alternative name for `VERA_BUILDS`, where `VERA_BUILDS` has priority.
- `VERA_DEFAULT_VERSION`: names the default version of VERA to use, overriding what is specified in the host configuration file but overridden by the `-v` (or `-vera-version`) parameter.
- `VERA_INSTALLS_DIR`: alternative name for `VERA_BUILDS` or `VERA_BUILDS_DIR`, priority order being `VERA_BUILDS`, `VERA_BUILDS_DIR`, then `VERA_INSTALLS_DIR`
- `VERA_PROD_VERSIONS`: comma-delimited list of allowed production VERA versions.
- `VERA_QSUB`: custom `qsub` command to execute for hosts running Torque or PBS Pro.
- `VERA_SBATCH`: custom `sbatch` command to execute for hosts running SLURM.
- `VERA_SUMMARY_EMAIL`: if set and not blank, the `case.sum` file is emailed to the user when MPACT completes.
- `VERARUN_HOST_CONFIG_FILE`: path to a host configuration file to use, overriding the distributed `$(hostname).json` file but overridden by the `-c` parameter.

Note that VERARun will create a `.pbs` file that can also be modified and submitted manually using `qsub`. After job submittal, the job is managed by the typical queueing system commands (`qdel`, `qhold`, `qrls`, etc.).

With VERARun 1.11 and beyond, you can receive emails summarizing your job when it completes successfully. Depending on the font of your email client, this summary can be more or less readable. In Outlook, you can force plain text emails to use a certain font (such as Courier New) by going to `Options -> Mail -> Stationary and Fonts -> Composing and reading plain test messages...`.

To get information on past jobs submitted with VERARun, use the `verastat` command. This will provide a listing of job ID, date/time, and file location. To get info on a specific job, use

```
--> verastat job_id
```

For additional questions or support, please contact vera-support@ornl.gov.

9.6 VERARUN OUTPUT

Upon completion of a VERA job, several output files might be created depending on the code options used. Some typical outputs include the following:

- VERAIn XML file. This file is written upon successful completion of VERAIn.

- VERA HDF5 output file. This is a binary file with results that can be visualized in VERAView or be postprocessed with user utility codes.
- MPACT output file. This file is written upon the successful completion of MPACT (if applicable).
- MPACT log file. This file is written upon the successful completion of MPACT (if applicable).
- MPACT summary file. This file is written upon the successful completion of MPACT (if applicable).
- Standard output file. This file is a log of all output written to the standard output.
- Standard error file. This file is a log of all output written to the standard error file.

9.7 INPUT ERRORS

If the `verarun` command does not work, the user should make sure that it is in the path. The user might need to consult with the system administrator for the correct path.

The next step when looking for an error is to look at the standard error file. If the job ran successfully, the size of this file will be zero.

If there were any errors in VERAIn, the errors will be written to the standard error file. Common errors from the input processor include the following:

1. Invalid keywords
2. Invalid map sizes
3. Invalid input options

If the input processor works correctly, an error still might occur in one of the VERA component codes. The user should look at the error message and consult the user manual for the component code.

10. ACKNOWLEDGMENTS

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REFERENCES

[1] Andrew Godfrey, Greg Davidson, Ben Collins, and Scott Palmtag. VERAOut – VERA HDF5 Output Specification. Technical Report CASL-U-2014-0043-001, Oak Ridge National Laboratory, 2014.

[2] D. Lee, J. Rhodes, and K. Smith. Quadratice Depletion Method for Gadolinium Isotopes in CASMO-5. *Nuclear Science and Engineering*, 174:79–86, 2013.