A DOE Energy Innovation Hub

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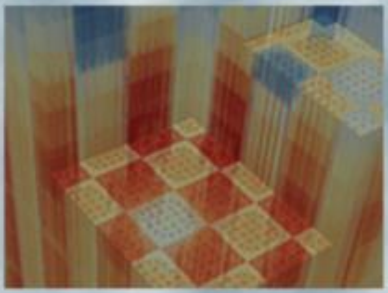
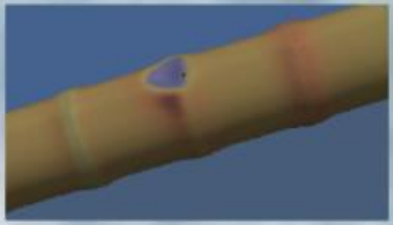
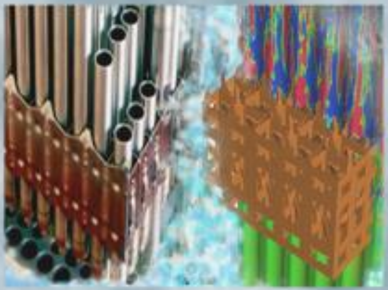




VERA Common Input User Manual



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U.S. DEPARTMENT OF ENERGY | Nuclear Energy

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VERA Common Input User Manual

Approvals:

Scott Palmtag Digitally signed by Scott Palmtag
Date: 2019.08.12 14:18:54 -04'00'

8/12/2019

Scott Palmtag, VERAIO Product Software Manager

Date

[illegible] Digitally signed by Brendan Kochunas
Date: 2019.08.12 14:08:02 -04'00'

08/12/2019

Brendan Kochunas, Independent Reviewer

Date

CONTENTS

FIGURES

ACRONYMS

CASL	Consortium for Advanced Simulation of Light Water Reactors
BOC	Beginning of Cycle
BWR	Boiling Water Reactor
CFD	Computational Fluid Dynamics
CILC	Crud-Induced Localized Corrosion
CIPS	Crud-Induced Power Shift (also called AOA)
CTF	COBRA-TF (Subchannel Code)
DNB	Departure from Nucleate Boiling
EFPD	Effective Full Power Days
EOC	End of Cycle
GWd/MT	Gigawatt-Days per Metric Ton Heavy Metal
HFP	Hot Full Power
HZP	Hot Zero Power
LWR	Light Water Reactor
MOC	Middle of Cycle
MWd/MT	Megawatt-Days per Metric Ton Heavy Metal
PCI	Pellet-Cladding Interaction
PCM	Percent Mille (10^{-5})
PPM	Parts per Million (usually boron)
PWR	Pressurized Water Reactor
QA	Quality Assurance
RIA	Reactivity Insertian Accident
VERA	Virtual Environment for Reactor Applications

1. INTRODUCTION

1.1. INTRODUCTION TO CASL

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

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

CASL's mission is to provide coupled, high-fidelity, usable modeling and simulation capabilities needed to address light water reactor 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 the current industry approach by incorporating coupled physics and science-based models, state-of-the-art numerical methods, modern computational science, integrated uncertainty quantification (UQ) and validation against data from operating pressurized water reactors (PWRs), single-effect experiments, and integral tests.

CASL will address, through new insights afforded by its ModSim technology, key nuclear energy industry challenges to furthering power uprates, higher fuel burnup, and lifetime extension while providing higher confidence in enhanced nuclear safety and this cleaner energy source.

The CASL Team is a consortium that consists of ten core partners and numerous contributing members. The CASL organization is led by Oak Ridge National Lab, and CASL's research and development is executed in six technical teams called Focus Areas (FA) and one integrating technical area. This ground-breaking partnership provides unparalleled collective institutional knowledge, nuclear science and engineering talent, computational science leadership, and a record of LWR design and regulatory accomplishments!

More information on CASL can be found at the website www.casl.gov.

1.2. VERA CORE SIMULATOR

One component of VERA is the VERA Core Simulator (VERA-CS). The core simulator is the specific collection of multi-physics computer codes used to model and deplete a 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 deplete the reactor core and provide data and boundary conditions to model CASL Challenge Problems such as CIPS, CILC, DNB, PCI, and 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 due to inconsistent geometries in different codes.

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

1.3. MANUAL ORGANIZATION

This manual is organized into three main parts.

The first part, which includes Chapters 2 through 4, is the "User's Manual", which describes how a user would set up a typical input. This part of the manual gives the most common input cards that a user would need and describes how to use them. This part of the manual does not include a complete list of cards or show every available option.

The second part of the manual, Chapter 5, is a "Reference Manual" and includes a complete listing of every available input card.

The third part of the manual, Chapter 6, 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, used to run VERA jobs, is given in Chapter 7.

Note that the VERA input processor (called 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

There is no required training for running 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 organization.

Optional user training is periodically available from the VERA Users Group. Please contact support (contact information given below) to inquire about training opportunities.

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

1.5. PURPOSE AND FUNCTIONAL REQUIREMENTS

The purpose and functional requirements of the VERA common input processor (VERAIn) are:

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 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:

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 parallel computing cluster.

1.6. CODE CAPABILITIES AND LIMITATIONS

The current code capabilities of VERAIn and VERARun are specified by the functional requirements listed above. 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 coolant that is not water.

Other VERA components may have limitations, and the user should refer to the documentation of the other VERA components for a listing.

1.7. 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.

1.8. 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 `casl-support@ornl.gov`.

Additional user information may also be found on the CASL website www.casl.gov.

2. USER MANUAL

The VERA common input is an ASCII file and is designed to be modular. The input is split 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, which includes 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 and rely on very little global information. The independent descriptions make quality assurance (QA) easier and allows objects to be defined in one cycle and be re-used in subsequent cycles without worrying about input conflicts. Another advantage of the module approach is that it makes it easier to shuffle fuel assemblies, and 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 also allows the same input to be used with multiple physics codes.

The VERA input blocks are:

CASEID This block contains an input title card.

CORE This block describes the core layout including 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 describes reactor core operating parameters (statepoint 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 statepoint.

ASSEMBLY These blocks contains 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 This block contains 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 on what edits the code should produce.

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

In addition to the blocks listed above, there are additional code-specific blocks that contain options specific to each physics code. Examples of code-specific blocks are **COBRATF**, **MPACT**, and **SHIFT**. Additional code-specific input blocks can be added as new physics codes are added to the core simulator.

The following sections in this chapter describe the most common concepts and features of each input block. This section does not provide a comprehensive list of each input card or option on each card. Refer to Chapter 5 for a detailed listing of all input and options.

2.1. INPUT SYNTAX

VERA input files are text files that contain standard printable ASCII characters. The data is organized in blocks with names and purpose 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 that there is no hierarchy in the block segments. A start of a new block also implies the end of the previous block. There can be multiple instances of [ASSEMBLY], [INSERT], and i[STATE] blocks. Other blocks, like [CORE] and the code-specific blocks, are unique, so that 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 input file, except for the [STATE] blocks, in which each statepoint must be entered in chronological order.

The blocks contain input cards 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, as the spaces usually imply delimiters in the card data. A value can be a single or list entry. Input card value entries can contain different data types, depending on the card format. The data types are real numbers, integers, characters, and character strings. String entries that include spaces should be enclosed in single or double quote pairs.

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

In this manual, the convention used is that all input examples are shown in `typewriter font`. When input cards are used in the text (not in the examples), they are listed in *italic font*. All block names are listed with square brackets around them.

The exclamation mark, !, is a special character that makes everything from it to the end of line ignored for processing and is used for adding comments in an 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 showing blocks, comments, and cards, is shown below.

```
! comments start with an exclamation point

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

  rodbank A 228      ! cards 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

$$< n..m\,\mathrm{x}\,i >$$

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, the step size is one. Examples of list generated list 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 webpage.

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 only include entries 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 both calculations run in either full-core or quarter-core symmetry. If a calculation is run in quarter-core symmetry, the code must know if the symmetry is mirror

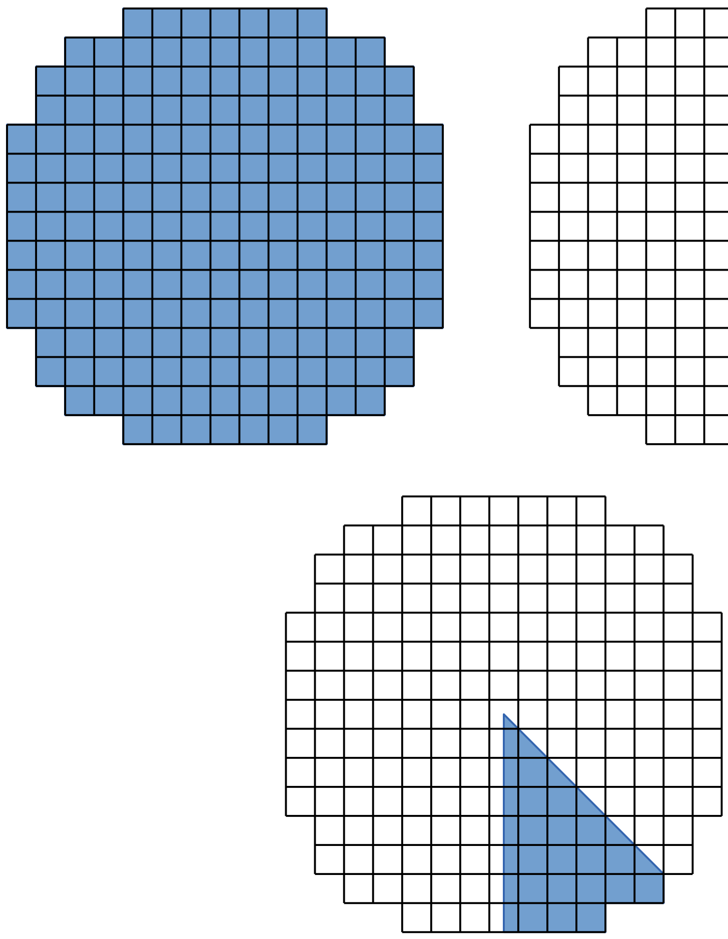

Figure 1. Full, quarter, and octant symmetry regions for a core map.

symmetric or rotationally symmetric. The type of quarter-core symmetry is defined with the *bc_sym* input card. 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, 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. 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 is expecting 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), enter a dash "-" for that location. The dash is significant and signifies an empty location in the core map. (The dash represents something is missing, but it is still a valid assembly location. The "0" in the *core_shape* represents an invalid assembly location.)

The *assm_map* shows where the assembly types are located within the core. In the example below, there are three assembly types which 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 qtr-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 with label "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 (sometimes called the 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* card. This card 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)
```

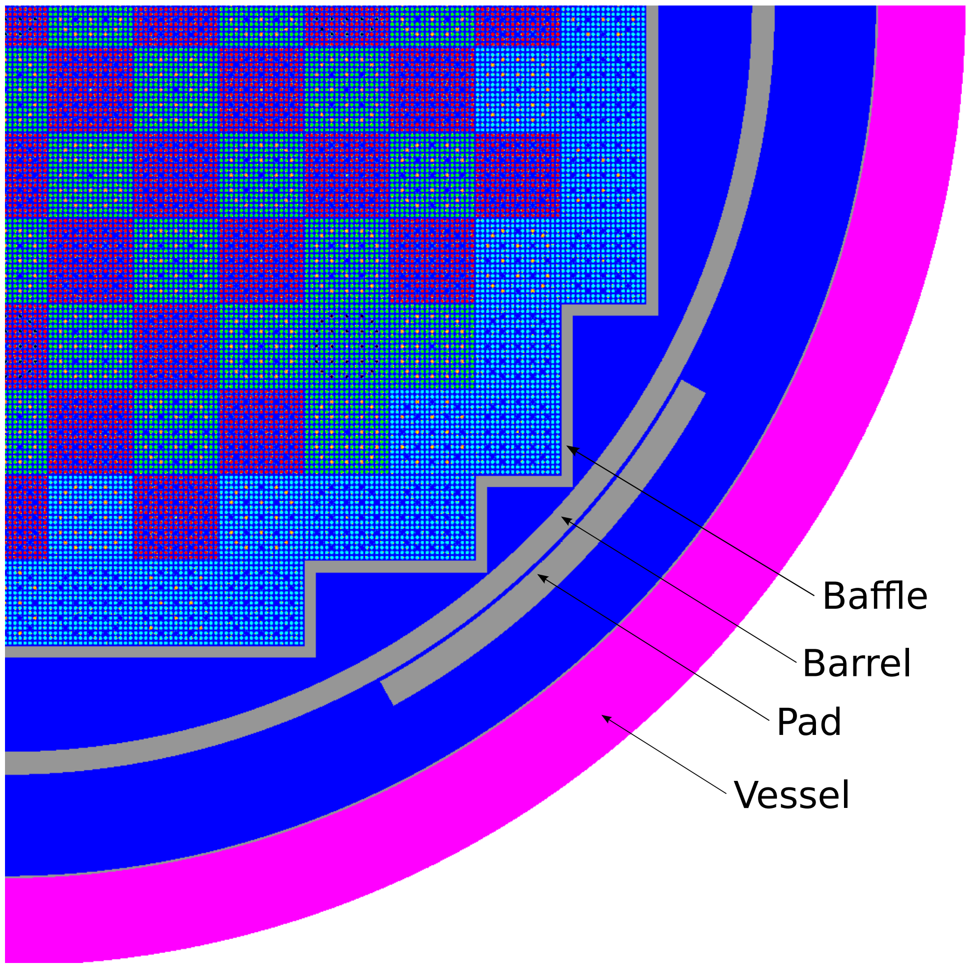

Figure 2. Core baffle and vessel (image courtesy of Andrew Godfrey).

There is currently 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
```

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, if the user only wants to run a single-assembly calculation, they 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
```

If the user wants to model a single fuel rod, they would define a core with one assembly and an assembly with one rod in it.

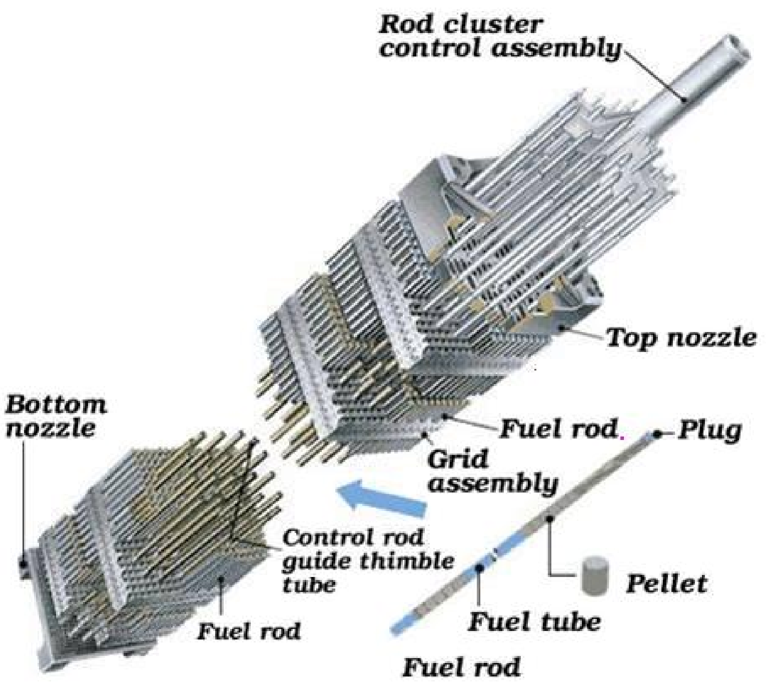

Figure 3. PWR Fuel Assembly (source: Public internet).

2.3. ASSEMBLY DESCRIPTION

The [ASSEMBLY] block contains the geometric description of a unique fuel assembly design (type). Multiple [ASSEMBLY] blocks are allowed 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* card 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. different vendors, different generations, etc.) 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 having to rely on global definitions.

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

A complete listing of all the input cards in the [ASSEMBLY] block is located in Chapter 5.

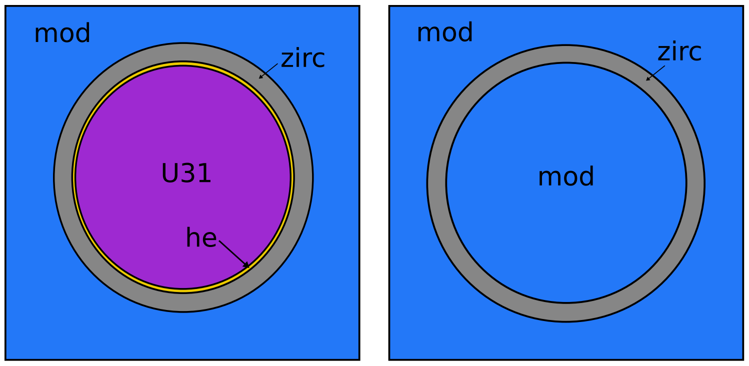

Figure 4. Pincell diagrams of a fuel rod and a guide tube.

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 card.

```
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 $[apitch - npin * ppitch]/2$

The fuel and structural materials are defined with the following cards. See Chapter 3 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 cards 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, as shown in Figure 4.

The first parameter on the *cell* card 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 compose each ring. The cell ID's 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* cards, respectively. (Refer to Chapter 3 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 T/H conditions and the soluble boron concentration, and cannot be specified by a user on a *mat* card.

In the example above, the guide tube (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* card.

```
! large CE 16x16 water rod
  ppitch  1.28524
  cell WR   cell WR    0.4096 0.418 0.475 / U31 he zirc
```

2.3.3 Lattice Descriptions

Once the cells are defined, they are placed into 2D "lattices" as shown below. Like the core maps, the lattice maps can be entered with either full-symmetry, qtr-symmetry, or octant-symmetry. The maps below are octant symmetric maps for 17x17 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, PCAP1, etc.), followed by a map of the *cell* ID's.

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* card as shown below.

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

The *axial* card 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* cards, 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 cards are used to define unique grid spacer types. The following example defines two grid types, “END” and “MID”.

```
grid END inc   3.866 1017  ! grid spacer material, height(cm), mass (g)
grid MID zirc4 3.810  875
```

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

```
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 is a very good approximation 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 card. If the user wants to use more than one material to define a nozzle, they can define a custom material that is a mixture of the materials and then use the custom material in the nozzle card.

Note that the *lower_nozzle* height should match the bottom elevation on the *axial* card. The *upper_nozzle* height + the top elevation on the *axial* card 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 similar same way as fuel assembly is defined. 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 guide tubes and the fuel assembly defines the guide tubes 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 example below, 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 rods 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* card in the [STATE] block.

Note that the locations of the control rod fingers must match the guide tube 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 guide tubes. The input parser does not currently perform a check to make sure the control rod finger descriptions are consistent with the guide tube 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 3 for details.

A complete listing of all the input cards in the [CONTROL] block is located in Chapter 5.

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* card.

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

The second value on the *stroke* card 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 used for typical Westinghouse PWR's.

```
  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* card shown above, the bottom of the AIC at the fully-inserted position is 15.46 cm. From the *stroke* card, 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

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

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

- 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

2.5. INSERT DESCRIPTION

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

The fuel assembly description should contain the guide tube descriptions and the insert description defines what is inserted in the guide tubes. Assembly inserts can be inserted and withdrawn during a core shuffle (by specifying a *insert_map* card in the [CORE] block), but 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 guide tube 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 guide tubes. The input parser does not currently perform a check to make sure the insert finger descriptions are consistent with the guide tube descriptions. This check should be performed in each of the individual physics codes.

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

A complete listing of all the input cards in the [INSERT] block is located in Chapter 5.

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 listing of all the input cards in the [DETECTOR] block is located in Chapter 5.

2.7. 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.

An example showing the most common input cards in the [STATE] block is shown below. A complete listing of all the input cards in the [STATE] block is located in Chapter 5.

```
[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 T/H 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* card tells the code to run the calculation in full-core or qtr-core symmetry. If the calculation is run in qtr-core symmetry, the symmetry is either set to qtr-core rotational or qtr-core mirror by the *bc_sym* card in the [CORE] block.

The *rodbank* card 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* card in the [CONTROL] block (see Section 2.4.1). For Westinghouse PWR's, a typical value of fully-withdrawn is 228 steps.

2.8. 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* card. The user may 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 input cards in the [EDITS] block is located in Chapter 5.

2.8.1 CTF Nodalization

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

When running CTF, there is a restriction that the grid boundaries must be explicitly included in the *axial_edit_bounds*. This 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* card and the elevations of the grid midpoints on the *grid_axial* card. 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 $75.0 \pm 1.25 = 73.75$ 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 because 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 the loss coefficients are calculated correctly.

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

2.9. 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 5 for a complete listing of all the cards 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 only used to define generic coupling parameters.

As an example, consider the following multi-physics 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 card *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 card *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 example shown above uses a Picard iteration to converge. Picard 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:

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

where x is the calculated parameter and ω is the relaxation factor. A relaxation factor of 1.0 signifies 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.

An example [COUPLING] input block is shown below.

```
[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 input cards in the [COUPLING] block is located in Chapter 5.

3. 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* card) and fuel materials (input with a *fuel* card).

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, they only have scope in the block they are defined. The reason for this is to maintain the modularity of the geometry objects.

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

Materials are used in many different input cards. 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* card or a *fuel* card (see notes on the material "mod" below).

3.1. STRUCTURAL MATERIALS

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

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 input cards such as *cell*, *grid*, *nozzle*, etc. (No default)
- *density* is the material density in g/cc (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. (Default=1.0 if there is only one library material in the user material).

There are two special user materials, "mod" 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" or "vacuum" on a *mat* card.

Some example material cards are shown below.

```
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
```

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

3.1.1 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, it will look in the [CORE] block

If materials are defined in the [CORE] block, they have global scope over the entire input. If materials are defined in other blocks, they only have scope 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 the "zirc" can have different compositions in each of the assemblies.

3.2. DEFAULT MATERIALS

There are many default files available to the users. The default materials and their compositions are defined on the initialization file CORE.ini. A list of default materials is given in Table 1.

3.3. FUEL MATERIALS

Fuel materials are defined with *fuel* cards. Fuel materials are heavy metal oxides which are usually UO_2 with different U-235 enrichments. Fuel materials may also include MOX fuel, which consists of mixtures of uranium, plutonium and other actinides. Fuel materials may 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 below.

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

Table 1. 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

Fuel materials are defined with the following input card:

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.
- *thden* is the percent of theoretical density in the pellet (%) (No default). The theoretical density is only used 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*.
- *U-235_enrichment* is the U-235 enrichment in the fuel in weight % (No default).
  - If U-234 and U-236 are not specified, they will automatically be added to the fuel by a pre-determined function (see below)
  - If the sum of the heavy metal (HM) enrichments does not equal 100%, the remainder of the HM composition will be assigned to U-238.
- *HM_material*$_i$ is the material name for HM isotope i (Pu-239, Pu-241, 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 gadolina (or other integral burnable absorber material) (optional). The gad material is usually a mixture defined on a separate *mat* card.
- *gad_fraction* is the weight percent of the gad material relative to the total fuel mass (optional)

Oxygen should not be included on the *fuel* card. 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

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

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

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

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

$$W_{236} = 0.0046 \cdot W_{235} \quad (5)$$

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

If a user specifically does NOT want U-234 or U-236, they should specify a U-234 and/or U-236 enrichment of zero.

Examples of typical *fuel* cards are shown below. The user only has to specify the U-235 enrichment and the code will automatically add U-234, U-236, U-238, 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* card with gadolinia burnable poison is shown next. In this example, the gadolinia oxide is first defined with a *mat* card 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=0.05 ! 1.8% enriched fuel with 5% gad
```

Some examples of MOX fuel cards are shown next. In these cards, the user specifies the U-235 enrichment (the U-235 enrichment is usually small in MOX fuel) and the plutonium isotope enrichments. The code will automatically add U-234, U-236, U-238, 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* card. Metallic fuel is not supported.

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

4. DEPLETION

This chapter describes depletion and working with restart files.

Depletion and restart files are only available with MPACT.

4.1. 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* card 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 card is the units used in the depletion and can be "EFPD" for Effective Full-Power Days, "GWDMT" for Giga-Watt-days per metric ton of initial heavy metal, or "hours". Following the unit is a list of depletion steps to take. Each depletion step is referred to as a "statepoint" calculation. The first depletion step must always be zero.

Listing multiple depletion steps on a single *deplete* card will deplete with all of the other values in the [STATE] block held constant. If the user wants to change a state parameter between depletion steps (power, flow, etc.), they can split the depletion over multiple [STATE] blocks. In the following example, the code depletes three statepoints at 50% power, changes the power to 100%, and depletes for four more statepoints. The depletion step at 10 EFPD 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* card with automatic list generation is

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

4.2. WRITING RESTART FILES

Often a user will 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 is useful if a calculation is long-running and needs to be split into multiple cases. Other times a user may want to save certain statepoints so they can go back and run perturbation or flux map calculations at the saved points.

The restart file includes **only** includes 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 statepoint by using a *restart_write* card,

```
  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 statepoints written to the same file. Examples of restart labels include "100EFPD", "HZP", "22.56", "100EFPD_ARO", etc. A restart file can include multiple statepoints as long as each one uses a different restart label.

If a *restart_label* card is used with a *deplete* card, 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 statepoints.

```
  [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 card
    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 will be discussed in a later section.) If writing a restart file at the EOC, the shutdown date should be included using the *op_date* card.

The reason for including the shutdown date is so the code will be able to calculate the isotopic decay during the outage. An example of the *op_date* card is shown in the last [STATE] block in the example above.

4.3. READING RESTART FILES

A restart file can be read by including a *restart_read* card 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* card 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 statepoint in quarter-symmetry, then read the restart back in full-symmetry, or vice-versa.

There is currently a restriction that a user should not include a *deplete* card in any [STATE] block where a restart is read. Instead, the user should split the restart read and depletion into separate blocks, like the following example shows:

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

4.4. 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 can be brought in from the fuel pool that were discharged in previous cycles. Fuel can even be added that was discharged from other units (cross-unit shuffle).

When performing a core shuffle, the user needs to specify the location where existing fuel assemblies were moved from, 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 include 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 "C3K-12" refers to location "K-12" of cycle "C3". If no cycle number is specified, the cycle label defaults to the previous cycle number (i.e. cycle N-1).

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

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 the previous assembly locations and new assembly fuel types.

The following example is the full-core loading pattern for cycle 2 of the BEAVRS 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 C2
  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
```

At this time, there is a restriction where the user must also include an *assm_map* card 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* card 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 and 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, the code will go to the second restart file, and so on.

The next section gives an example of a core shuffle.

4.4.1 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 only show the pertinant cards 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
```

4.4.2 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 build-up 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 the assembly data was written. The cycle start-up date is the *op_date* in the core shuffle deck.

4.4.3 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* card 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* card:

```
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 right chronological order because an assembly could theoretically go from U2:CYC3 to U1:CYC10 then back to U2:CYC6. Therefore, the restarts must be in the correct 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 the shutdown decay will be correctly calculated for each assembly. It doesn't matter what unit the assembly came from, the right shutdown dates will be used.

5. INPUT CARD DESCRIPTIONS

This chapter contains a complete listing of the available input cards.

The input for each block is given in separate subsections.

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

5.1. BLOCK CASEID

title case_name

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

5.2. BLOCK STATE

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: Operating date of this statepoint. 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): 1e-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): 1e-8 (default), >= 0		
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: 2-D array that must match the shape of assm_map in [CORE]. Gives a multiplier that will be applied to nominal inlet mass flow rate in each assembly.		
Notes: This map is not normally used.		

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: 2-D array that must match the shape of assm_map in [CORE]. Gives an adder that will be added to nominal outlet pressure in each assembly.		
Notes: This map is not normally used.		

bypass bypass_percent

`bypass_percent`	Float	Optional
Units: Percent (default)		
Applicable Value(s): 0 (default), >= 0		
Limitation(s): None		
Description: Bypass flow fraction applied to the acutal flow.		
Notes: None		

tinlet inlet_temperature units

`inlet_temperature`	Float	Optional
Units: N/A, F, K		

continued on next page...

`inlet_temperature`, continued...

Applicable Value(s): 326.85 C (default), > 0
Limitation(s): None
Description: Core inlet temperature
Notes: Required when couping to CTF. Examples of this card are `560 F` or `600 K`.

tinlet_dist inlet_temperature_adder

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

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.		

tfuel fuel_temperature units

`fuel_temperature`	Float	Optional
Units: N/A, F, C		
Applicable Value(s): 600 K (default), $> 0K$, $< 1600K$		
Limitation(s): None		
Description: Fixed fuel temperatures.		
Notes: Only used if feedback is turned OFF. Examples of this card 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: Only used 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 I-135 and Xe-135 number densities to zero. • `equil` — Sets I-135 and Xe-135 number densities to calculated equilibrium values. • `dep` — Treats I-135 and Xe-135 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		
Description: Samarium treatment option: • `zero` — Sets Pm-149 and Sm-149 number densities to zero. • `equil` — Sets Pm-149 and Sm-149 number densities to calculated equilibrium values. • `dep` — Treats Pm-149 and Sm-149 explicitly as other isotopes in transport calculation. • `peak` — Adds Pm-149 number density to Sm-149 number density and then sets Pm-149 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

continued on next page...

predictor_order, continued...

Units: N/A
Applicable Value(s): 0 (default), >= 0
Limitation(s): None
Description: This card 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 G. G. Davidson, et al., "Nuclide depletion capabilities in the Shift Monte Carlo code", Annals of Nuclear Energy, 114, pg 259-276 (2018). For any given timestep the code will attempt the highest polynomial order approximation, without exceeding the user specification, as is allowed by the thus far generated data. For example, if the user designates order 2, then on the first time step order 0 will be used since no previous time data is available. On the second step order 1 will be used since only one previous set of time data is available, and on the third and subsequent steps order 2 will be used since sufficient data from previous timesteps is 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 card 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 search or rod search		
Notes: None		

search search_option

`search_option`	Character String	Optional
Units: N/A		
Applicable Value(s): keff (default), boron, rod		
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		

continued on next page...

`outlet_pressure`, continued...

Notes: Required when coupling to CTF or when modeling a BWR reactor type. Must be set to 2250 psi when using internal or simplified T/H.

deplete deplete_units depletion_steps

`deplete`	Float	Optional
Units: GWDMT (default), MWDMT, EFPD, hours		
Applicable Value(s): , `depletion_steps` must be listed in ascending order		
Limitation(s): None		
Description: Specification of a single or multiple depletion steps.		
Notes: Recommended that depletion step sizes are less than 1 GWDMT, 1000 MWDMT, or 30 EFPD.		

edit state_edits

`state_edits`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: A list of state variables to be edited. By default, MPACT edits `pin_powers` and `pin_exposures`. Aditionally, individual isotopes can be edited using `pin_isotopes_` followed by the isotope in ZZ-AAA format. The edit flag `pin_isotopes_all` can be used to edit all isotopes in the problem.		
Notes: None		

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: List of control rod banks to position. 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		
Limitation(s): None		
Description: Flag to turn on and off T/H feedback.		
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: Perform thermal expansion.		

continued on next page...

`thermal_expansion_option`, continued...

Notes: Additional thermal expansion options are given on other input cards.		

thexp_tfuel fuel_thermal_expansion_temperature units

`fuel_thermal_expansion_temperature`	Float	Optional
Units: N/A, F, C		
Applicable Value(s): 293 K (default)		
Limitation(s): None		
Description: 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: N/A, F, C		
Applicable Value(s): 293 K (default)		
Limitation(s): None		
Description: 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: 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: 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.		

continued on next page...

3D_thermal_expansion_option, continued...

Notes: None

thexp_outfile thermal_expansion_outfile

thermal_expansion_outfile	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: 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): , $>= 0$, $< 50.0e - 6$		
Limitation(s): None		
Description: 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): , $>= 0$, $< 50.0e - 6$		
Limitation(s): None		

continued on next page...

`pin_pitch_expansion_coefficient`, continued...

Description: 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): , $>= 0$, $< 50.0e - 6$		
Limitation(s): None		
Description: Thermal expansion coefficient to be used when expanding the axial dimension of the problem. If not specified, the expansion coefficient will be calculated internally assuming UO2 thermal expansion coefficient and the fuel temperature. This is only done if 3-D expansion is enabled.		
Notes: None		

sym symmetry_option

`symmetry_option`	Character String	Optional
Units: N/A		
Applicable Value(s): full (default), qtr		
Limitation(s): None		
Description: 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 accross the whole geometry. The `qtr` option will only model the south-east quarter of the geometry. In quarter-symmetry, the boundary conditions along the symmetry boundary are determined by the `bc_sym` card.		
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`		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. Used to apply conservatism to transient calculations. Can be used in steady-state calculations to iterate to 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. Used to apply conservatism to transient calculations. Can be used in steady-state calculations to iterate to 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		

scram_type scram_type scram_rate scram_time

`scram_type`	Free Form Character String, Pairs of doubles	Optional
Units: false (default), true		
Applicable Value(s):		
Limitation(s): Can only be used for transient cases, and at least one "trip_" card 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") and the scram bank movement speed intervals. These are specified using rate/time pairs, where each rate is accociated with the following time interval. The units are RUs/second and seconds, respectively. At least one time/rate pair must be present.		
Notes: This card is only used in transient calculations.		

bank_wd bank_wd

bank_wd		
Units: N/A		
Applicable Value(s): , Any control rod bank label and real values > 0		
Limitation(s): Currently only works for one control rod bank and for transient cases.		
Description: This card is used to specify the position of a control rod bank at a specified time. There is no limit to the number of time and position pairs, and at least one pair must exist. • `bank_label` — The bank to be withdrawn. • `time_N` — The selected transient time that corresponds to the bank position. • `pos_N` — The number of steps withdrawn at a given time step.		
Notes: None		

scram_lock bank_label

bank_label	List of Free Form Character Strings	Optional
Units: N/A		
Applicable Value(s): , `true`		
Limitation(s): Requires scram_type card.		
Description: This option is used to specify the bank labels of the banks that will not participate in the scram. These banks will continue their normal movement. At least one bank label must be specified.		
Notes: This card is only used in transient calculations.		

trip_time trip_time

trip_time	double	Optional
Units: N/A		
Applicable Value(s): , `true`		
Limitation(s): Requires scram_type card.		
Description: This option is used to specify the simulation time at which a trip will occur (in seconds) for scram functionality.		
Notes: This card is only used in transient calculations.		

trip_power high_power low_power delay number_detectors

trip_power	double, double, double, integer	Optional
Units: N/A		
Applicable Value(s): , `true`		
Limitation(s): Requires scram_type card.		

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`trip_power`, continued...

Description: This option is used to specify the trip power conditions for scram functionality. The high and low power entries are in units of % fp. The delay entry is the specified time after delay before scram bank movement occurs (seconds). The last entry is the number of detectors required to meet these conditions before a trip occurs (currently, only the full core power can be assessed, with an option of 0).
Notes: This card is only used in transient calculations.

trip_rate upper_power_threshold lower_power_threshold delay number_detectors

`trip_rate`	double, double, double, integer	Optional
Units: N/A		
Applicable Value(s): , `true`		
Limitation(s): Requires scram_type card.		
Description: This option is used to specify the trip power rate change conditions for scram functionality. The first two entries are the upper and lower power rate change thresholds in units of % fp/second. The delay entry is the specified time after delay before scram bank movement occurs (seconds). The last entry is the number of detectors required to meet these conditions before a trip occurs (currently, only the full core power can be assessed, with an option of 0).		
Notes: This card is only used in transient calculations.		

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 card is used to specify sets of assembly isotopic data for assembly batches that do not have a full simulation history. These assemblies have an approximated history so that 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 assemblydata • `source_location` — core label coordinate for assembly positionwhen restart data was 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. They must be listed as a matching file-label pair.		
Notes: See Section 4.4 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. They must be listed as a matching file-label pair.		
Notes: See Section 4.4 for more information and examples.		

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. More information about this input card is included in user manual.		

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		
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: 2-D 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 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.		

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		
Description: Coolant chemistry concentrations to be used for crud formation: • h_conc — Dissolved hydrogen in coolant [ppm] • li_conc — Coolant Lithium Concentration [ppm] • ni_sol — Coolant Soluble Nickel Concentration [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: Only used 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 only used when using fuel temperature tables.		

5.3. BLOCK CORE

name core_name

`name`	Character String	Optinoal
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Name of the reactor core.		
Notes: None		

cycle cycle_num

`cycle`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Cycle number.		
Notes: None		

unit unit

`unit`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Reactor plant unit name. Only used for multi-unit sites with cross-unit shuffle.		
Notes: None		

op_date operation_date

`op_date`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): Limited to "MM/DD/YYYY" or "YYYY/MM/DD"		
Description: Start-up date of core reload.		
Notes: Only used 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: N/A, MW		
Applicable Value(s): , >= 0		
Limitation(s): None		
Description: Rated thermal power at 100% power.		
Notes: None		

`rated_flow`	Float	Required
Units: N/A, Mlbs/hr		
Applicable Value(s): , >= 0		
Limitation(s): None		
Description: Rated vessel flow at 100% flow		
Notes: None		

rcs_volume rcs_volume

`rcs_volume`	Float	Optional
Units: N/A, ft^3		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Volume of the Reactor Coolant System.		
Notes: Only used with B-10 depletion.		

apitch apitch

`apitch`	Float	Required
Units: N/A, cm		
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: None		

`baffle_gap`	Float	Optional
Units: N/A, cm		
Applicable Value(s): , >= 0		
Limitation(s): None		
Description: Gap between outside assembly (including assembly gap) and baffle.		
Notes: None		

`baffle_thick`	Float	Optional
Units: N/A, cm		
Applicable Value(s): , >= 0		
Limitation(s): None		
Description: Thickness of baffle.		
Notes: None		

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 card 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 card 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 card 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 card 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: Tis card defines the azimuthal angle location where each pad is located. 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)		

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`pad_nonuniform_arc`, continued...

Applicable Value(s):
Limitation(s): None
Description: This card is used to define the arc length for each corresponding neutron pad location defined in the `pad` card. Therefore, each pad can be of different arc lengths. If all pads are the same arc length, this card is not needed and the single `pad_arc` value from the `pad` card will suffice.
Notes: This card requires the `pad` card 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: N/A, cm		
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 card 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 card 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 card 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: 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: 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		

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 assembly rotations.		
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		

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`insert_rotate_map`, continued...

Description: Core map of 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: 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: 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: 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: 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.		

continued on next page...

crd_bank, 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: N/A, cm		
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: Lower core plate material volume fraction. Remainder of volume fraction will be filled with coolant.		
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: N/A, cm		
Applicable Value(s): , >= 0		
Limitation(s): None		
Description: Upper core plate thickness.		

continued on next page...

`upper_thick`, continued...

Notes: None

`upper_vfrac`	Float	Optional
Units: N/A		
Applicable Value(s): , >= 0,<= 1		
Limitation(s): None		
Description: Upper core plate material volume fraction. Remainder of volume fraction will be filled with coolant.		
Notes: None		

bc_sym bc_sym

`bc_sym`	Character String	Optional
Units: N/A		
Applicable Value(s): , rot, mir		
Limitation(s): None		
Description: Symmetry flag for the core when using qtr-symmetry. 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		
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: List of 2-character assembly position labels in x-direction. These values are used in the edit maps.		
Notes: See Section 4.4 and Section 6.1 for examples.		

ylabel ylabel

`ylabel`	Character Strings	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: List of 2-character assembly position labels in y-direction. These values are used in the edit maps.		
Notes: See Section 4.4 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: Format of label entries in shuffle_label card.		
Notes: None		

height height

`height`	Float	Required
Units: N/A, cm		
Applicable Value(s): , >= 0		
Limitation(s): None		

continued on next page...

height, continued...

Description: Total axial distance from bottom core plate to upper core plate. Distance does not include core plate thicknesses.
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 the User's Manual.		
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: N/A, cm		
Applicable Value(s): , >= 0		
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.		
Notes: None		

upper_ref upper_refl_mats upper_refl_thicks upper_refl_vfracs

upper_refl_mats	Character String	Optional
Units: N/A		

continued on next page...

`upper_refl_mats`, continued...

Applicable Value(s):
Limitation(s): None
Description: Upper reflector materials.
Notes: None

`upper_refl_thicks`	Float	Optional
Units: N/A, cm		
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.		
Notes: None		

reactor_type reactor_type

`reactor_type`	Character String	Optional
Units: N/A		
Applicable Value(s): PWR (default), BWR		
Limitation(s): None		
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: An integer id corresponding to the material of external source.		
Notes: None		

`iso_id`	Integer	Optional
Units: N/A		
Applicable Value(s):		

continued on next page...

iso_id, continued...

Limitation(s): None
Description: An integer value representing an isotope on whose absolute atom quantity the source strength will be scaled. Input should follow the formate 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: A positive real 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 which appears in a given FSR. Units are in neutrons per second per unit volume (cc) per number of isotope atoms. This value is only required if the user provides `iso_id(i)`.		
Notes: None		

spectrum	Float	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: 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 much 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: A real greater than 0.0 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		Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		

continued on next page...

`str_mult`, continued...

Description: A real 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: 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: Used in the chemistry source term calculation to determine amount of source term created.		

`sg_plug_frac`	Float	Optional
Units: none (default)		
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		

continued on next page...

`hot_leg_alloy`, continued...

Limitation(s): None		
Description: Hot leg piping stainless steel alloy number.		
Notes: 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: 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: 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: 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)		
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		

continued on next page...

`material_perturbation_file`, continued...

Applicable Value(s):
Limitation(s): None
Description: Name of the file to read in that contains material perturbation information in h5 format.
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: Defined detector types for automatic generation of an Omnibus excore input. Requires bioshield card.		
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: Defined detector locations for automatic generation of an Omnibus excore input. Requires bioshield and det cards.		
Notes: Materials must be defined in the Omnibus template input		

5.4. BLOCK ASSEMBLY

title title

`title`	Character String	Optional

continued on next page...

title, continued...

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: N/A, cm		
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 the User's Manual.		
Notes: See Section 2.3.2 for examples.		

lattice lattice

lattice	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: 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: 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: Label for this assembly. 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: List of axial labels for this assembly description. Correspond to labels in lattice maps.		
Notes: See Section 2.3.4 for examples.		

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

modden label material mass height

`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.		

`mass`	Float	Optional
Units: N/A, g		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Grid mass for this grid type.		
Notes: See Section 2.3.5 for examples.		

`height`	Float	Optional
Units: N/A, cm		
Applicable Value(s):		
Limitation(s): None		
Description: Grid height for this grid type.		
Notes: See Section 2.3.5 for examples.		

grid_axial grid_map grid_elev

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

`grid_elev`	Float	Optional
Units: N/A, cm		

continued on next page...

`grid_elev`, continued...

Applicable Value(s):
Limitation(s): None
Description: 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

`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: N/A, cm		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Lower nozzle height.		
Notes: None		

`lower_nozzle_mass`	Float	Optional
Units: N/A, g		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Lower nozzle mass. Code will calculate the volume of the nozzle given the nozzle mass, and use coolant for remaining volume.		
Notes: None		

upper_nozzle upper_nozzle_comp upper_nozzle_height upper_nozzle_mass

`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: N/A, cm		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Upper nozzle height.		
Notes: None		

upper_nozzle_mass	Float	Optional
Units: N/A, g		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Upper nozzle mass. Code will calculate the volume of the nozzle given the nozzle mass, and use coolant for remaining volume.		
Notes: None		

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 the User's Manual and in Section 3.3 of this document.		
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 the User's Manual and in Section 3.1 of this document.		
Notes: None		

gap gapw gapn

gapw	Float	Optional
Units: N/A, cm		
Applicable Value(s): , >= 0		
Limitation(s): None		
Description: Wide-gap width		
Notes: BWR only.		

`gapn`	Float	Optional
Units: N/A, cm		
Applicable Value(s): , >= 0		
Limitation(s): None		
Description: Narrow-gap width		
Notes: BWR only.		

channel_box chanmat chanth chanrad cornerth cornerlen

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

`chanth`	Float	Optional
Units: N/A, cm		
Applicable Value(s): , >= 0		
Limitation(s): None		
Description: Channel box thickness.		
Notes: None		

`chanrad`	Float	Optional
Units: N/A, cm		
Applicable Value(s): , >= 0		
Limitation(s): None		
Description: Channel box inside corner radius.		
Notes: None		

`cornerth`	Float	Optional
Units: N/A, cm		
Applicable Value(s): , >= 0		
Limitation(s): None		
Description: Thickness of channel box corner.		
Notes: Not yet functional.		

`cornerlen`	Float	Optional
Units: N/A, cm		
Applicable Value(s): , >= 0		
Limitation(s): None		

continued on next page...

`cornerlen`, continued...

Description: Length of thick corners measured from the channel corner.
Notes: Not yet functional.

temptable table_tag

`temptable`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): requires a temperature table file to be included below		
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.		
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 below 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		

5.5. 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: N/A, cm		
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 the User's Manual.		
Notes: See Section 2.4 for examples.		

lattice lattice

`lattice`	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: 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: 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: Label for this control rod description. Label 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. Correspond to labels in rod maps.		
Notes: See Section 2.4 for examples.		

`axial_elevations`	Float	Required
Units: N/A, cm		
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		
Description: Refer to the detailed materials description given in the User's Manual and in Section 3.1 of this document.		
Notes: None		

blade ntube tubecell bladespan bladeth bladerad bladesheath bladewing blademat

`ntube`	Integer	Optional
Units: N/A		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Number of rodlets in control blade wing.		
Notes: None		

`tubecell`	Character String	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Cell ID for rodlet.		
Notes: None		

`bladespan`	Float	Optional
Units: N/A, cm		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Control blade span from center to wing tip.		
Notes: None		

`bladeth`	Float	Optional
Units: N/A, cm		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Control blade wing thickness.		
Notes: None		

`bladerad`	Float	Optional
Units: N/A, cm		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Radius of control blade tip.		
Notes: None		

`bladesheath`	Float	Optional
Units: N/A, cm		
Applicable Value(s): , > 0		

continued on next page...

`bladesheath`, continued...

Limitation(s): None		
Description: Control blade sheath thickness.		
Notes: None		

`bladewing`	Float	Optional
Units: N/A, cm		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Blade central structure wing length.		
Notes: None		

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

5.6. 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 the User's Manual.		
Notes: See Section 2.5 for examples.		

lattice lattice

`lattice`	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: 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: 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: Label for this assembly insert description. Label 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: List of axial labels for this assembly insert description. Correspond to labels in rod maps.		
Notes: See Section 2.5 for examples.		

`axial_elevations`	Float	Required
Units: N/A, cm		
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 the User's Manual and in Section 3.1 of this document.		
Notes: None		

5.7. BLOCK DETECTOR

title title

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

type detector_type

`detector_type`	Character String	Optional
Units: N/A		
Applicable Value(s): , u235, v, rh		

continued on next page...

`detector_type`, continued...

Limitation(s): None
Description: Flag used to specify the type of detector to be modeled.
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 the User's Manual.		
Notes: See Section 2.6 for examples.		

lattice lattice

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

axial control_label axial_labels axial_elevations

`control_label`	Character String	Required
Units: N/A		
Applicable Value(s):		
Limitation(s): None		
Description: Label for this detector description. Label 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: List of axial labels for this detector description. Correspond to labels in rod maps.		
Notes: See Section 2.6 for examples.		

`axial_elevations`	Float	Required
Units: N/A, cm		
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 the User's Manual and in Section 3.1 of this document.		
Notes: None		

5.8. BLOCK EDITS

axial_edit_bounds axial_edit_bounds

`axial_edit_bounds`	Float	Required
Units: N/A, cm		
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: N/A, cm		
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: N/A, cm		
Applicable Value(s):		
Limitation(s): None		
Description: 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: N/A, cm(CART), degrees(RTHETA)		
Applicable Value(s):		
Limitation(s): None		

continued on next page...

points_dim2, continued...

Description: 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: N/A, cm		
Applicable Value(s):		
Limitation(s): None		
Description: 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: A list of edits that can be turned on or off as a group using the edit card in the [STATE] block.		
Notes: None		

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): , This card 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.		

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edit_scrape, continued...

Limitation(s): None
Description: Crud scrape edit info
Notes: This is only needed for specifying crud scrape locations.

5.9. BLOCK SHIFT

num_threads num_threads

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

seed seed

seed	integer	
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 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-CS		
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		

broaden_xs broaden_xs

`broaden_xs`	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
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`	bool	Optional
Units: N/A		
Applicable Value(s): true (default)		
Limitation(s): None		

continued on next page...

union_energy, continued...

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		

dbrc dbrc

dbrc	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
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_micro_tally do_micro_tally

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

do_transport do_transport

`do_transport`	bool	Optional
Units: N/A		
Applicable Value(s): true (default)		
Limitation(s): None		
Description: Perform MC transport		
Notes: None		

do_output do_output

`do_output`	bool	Optional
Units: N/A		
Applicable Value(s): true (default)		
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	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
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	
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	
Units: N/A		
Applicable Value(s): 10 (default), > 0		
Limitation(s): None		

continued on next page...

`num_inactive_cycles`, continued...

Description: Number of inactive eigenvalue cycles
Notes: None

Np Np

`Np`	double	
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		
Limitation(s): None		
Description: Run mode		
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	bool	Optional
Units: N/A		
Applicable Value(s): true (default)		
Limitation(s): None		
Description: Output HDF5 files of raytraced geometry (initial) and compositions (each state)		
Notes: None		

output_fission_source output_fission_source

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

output_external_source output_external_source

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

output_micro_tally output_micro_tally

output_micro_tally	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
Limitation(s): None		
Description: Output micro reaction tallies		
Notes: None		

output_ww output_ww

output_ww	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
Limitation(s): None		
Description: Output the weight windows, if used		
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`	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
Limitation(s): None		

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vera_pressure_vessel, continued...

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		

use_pole_data use_pole_data

use_pole_data	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
Limitation(s): None		
Description: Use the pole data for on-the-fly doppler broadening		
Notes: None		

use_fission_source use_fission_source

use_fission_source	bool	Optional
Units: N/A		
Applicable Value(s): true (default)		
Limitation(s): None		
Description: Use the fission source provided by MPACT		
Notes: None		

use_external_source use_external_source

use_external_source	bool	Optional
Units: N/A		
Applicable Value(s): true (default)		
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 sammples 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		

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src_disc_max_samples, continued...

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, separable		
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		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	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
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 to homogenize within and have explicit pins outside of		
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 2 doubles	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Boundary mesh x-axis limits		
Notes: None		

y_bnd_mesh y_bnd_mesh

y_bnd_mesh	array of 2 doubles	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		
Description: Boundary mesh y-axis limits		
Notes: None		

z_bnd_mesh z_bnd_mesh

z_bnd_mesh	array of 2 doubles	Optional
Units: cm (default)		
Applicable Value(s):		
Limitation(s): None		

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`z_bnd_mesh`, continued...

Description: Boundary mesh z-axis limits
Notes: None

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		

create_unique_pins create_unique_pins

`create_unique_pins`	bool	Optional
Units: N/A		
Applicable Value(s): true (default)		
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), short, 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 MG data library file		
Notes: Applicable to hybrid simulations		

mesh mesh

`mesh`	integer	
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	
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	
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`	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
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`	bool	Optional
Units: N/A		
Applicable Value(s): true (default)		
Limitation(s): None		
Description: Perform adjoint solve		

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`adjoint`, continued...

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`	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
Limitation(s): None		
Description: Partition energy over upscatter groups only		
Notes: Applicable to hybrid simulations		

store_fulcrum_string store_fulcrum_string

`store_fulcrum_string`	string	Optional
Units: N/A		
Applicable Value(s): true if using 35 nodes or fewer (default)		
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		

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upscatter_solver, continued...

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), gmres		
Limitation(s): None		
Description: Which within group solver to use		
Notes: Applicable to hybrid simulations		

iterate_downscatter iterate_downscatter

iterate_downscatter	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
Limitation(s): None		
Description: Iterate over downscatter groups		
Notes: Applicable to hybrid simulations		

downscatter downscatter

downscatter	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
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): 100 if eq_set is spn_fv, 30 otherwise (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, spn_fv		
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		

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`quad_type`, continued...

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`	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
Limitation(s): None		
Description: Homogenize material in cells		
Notes: None		

Pn_correction Pn_correction

`Pn_correction`	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
Limitation(s): None		
Description: Use outscatter-corrected diffusion coefficient to reduce memory in solve		
Notes: None		

pin_partitioning pin_partitioning

`pin_partitioning`	bool	Optional
Units: N/A		
Applicable Value(s): false (default)		
Limitation(s): None		
Description: Partition mesh over pincells		
Notes: None		

5.10. BLOCK COBRATF

nfuel nfuel

`nfuel`	int	Optional
Units: N/A		
Applicable Value(s): 10 (default), > 0		

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nfuel, continued...

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	int	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	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0, 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

nfuel	int	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0, 1, 2, 3		
Limitation(s): None		
Description: 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, (3) Conduction in the radial, azimuthal and axial directions.		
Notes: None		

chf chf

chf	int	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0, 1, 2		
Limitation(s): None		

continued on next page...

chf, continued...

Description: CHF model option. Options are: 0 - No CHF check during transient (post-sim check using W-3) 1 - Check CHF during transient using W-3 2 - No CHF check during or after simulation (set CHF to infinity) 3 - No CHF check during transient (post-sim check using Groeneveld lookup tables)
Notes: None

debug debug

`debug`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0, 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 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 may be used to observe coupled convergence behavior.		
Notes: None		

disable_xml2ctf disable_xml2ctf

`disable_xml2ctf`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0, 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 a CTF input file called "deck.inp" is present in the simulation directory and that that model is consistent with the MPACT model. This option is provided so that a user may customize the CTF input file with options not provided through xml2ctf.		
Notes: None		

irfc irfc

`irfc`	int	Optional
Units: N/A		
Applicable Value(s): 2 (default), 1, 2, 3, 4		
Limitation(s): None		
Description: Friction model: 1 - original CTF model 2 - new CTF model 3 - Colebrook 4 - Sylvester		
Notes: None		

dhfrac dhfrac

dhfrac	float	Optional
Units: N/A		
Applicable Value(s): 0.026 (default), ≥ 0.0		
Limitation(s): None		
Description: Percentage of rod heat directly deposited into fluid (gamma heating)		
Notes: None		

guide_tube_coefficient guide_tube_coefficient

guide_tube_coefficient	float	Optional
Units: N/A		
Applicable Value(s): 0.0 (default), $0.0 \leq$ guide_tube_coefficient ≤ 1.0		
Limitation(s): None		
Description: Used to determine the temperature rise in guide tubes using the following: T_guide_tube(z) = (T_fluid(z)-T_inlet)*guide_tube_coefficient+T_inlet 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 T_inlet 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: The boiling heat transfer coefficient under-relaxation coefficient. Because of the semi-implicit coupling of the fluid and energy equations in the CTF numerical solution, it is necessary to under-relax the heat transfer coefficient in time for numerical stability. For some boiling cases, it may be necessary to increase the under-relaxation.		
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: The under-relaxation coefficient used when calculating rod surface temperatures on the rod surface coupling mesh set up by CTF for coupling to MAMBA. It may be necessary to reduce this value if many iterations are failing during the temperature reconstruction process when using the ROTHCON grid files. notes		

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`rothcon_temp_beta`, continued...

Notes: NONE SPECIFIED

hgap hgap

`hgap`	float	Optional
Units: W/m**2/K (default)		
Applicable Value(s): 5678.3 (default), > 0.0		
Limitation(s): None		
Description: Sets the gap conductance in the fuel rod gap (only applicable when using a constant gap conductance fuel rod model).		
Notes: None		

clad_material clad_material

`clad_material`	string	Optional
Units: N/A		
Applicable Value(s): zirc (default), zirc, ss, sic		
Limitation(s): None		
Description: Sets the clad material properties. Currently has no effect in CTF. Cladding material properties always default to Zircaloy.		
Notes: None		

epso epso

`epso`	float	Optional
Units: N/A		
Applicable Value(s): 1e-4 (default), > 0.0		
Limitation(s): None		
Description: Relative tolerance for the linear solver (pressure matrix solve). Only applicable when using an iterative solver. Setting too high can lead to numerical instability.		
Notes: None		

iitmax iitmax

`iitmax`	int	Optional
Units: N/A		
Applicable Value(s): 160 (default), > 0		
Limitation(s): None		
Description: Maximum number of iterations to take in the linear solve (pressure matrix solve). Only applicable when using an iterative solver. Setting too low can lead to numerical instabilities.		
Notes: None		

dtmin dtmin

`dtmin`	float	Optional
Units: s (default)		
Applicable Value(s): 1e-6 (default), > 0		
Limitation(s): None		
Description: Sets the minimum allowable timestep size. Used for both transients and steady state (because CTF solves a transient to get to steady state). If the timestep 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		
Description: Sets the maximum allowable timestep size. Used for both transients and steady state (because CTF solves a transient to get to steady state). CTF uses dynamic timestep selection which is mainly a function of the Courant number. This puts a ceiling on the dynamic timestep size to prevent numerical instability.		
Notes: None		

rtwfp rtwfp

`rtwfp`	float	Optional
Units: N/A		
Applicable Value(s): 100.0 (default), $\geq$ 1.0		
Limitation(s): None		
Description: Sets the ratio between the conduction and fluid timestep sizes. For steady state problems, the timestep sizes of the conduction equation can be set larger than the fluid timestep 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`	int	Optional
Units: N/A		
Applicable Value(s): 10000 (default), $\geq$ 1		
Limitation(s): None		
Description: 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.		

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maxits, continued...

Notes: None

courant courant

courant	float	Optional
Units: N/A		
Applicable Value(s): 0.8 (default), > 0.0		
Limitation(s): None		
Description: Sets the Courant number to use when setting timesteps size. Setting this value lower will lead to overall smaller timestep sizes being used in CTF and setting it larger will lead to overall larger timestep 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	int	Optional
Units: N/A		
Applicable Value(s): 3/5 (default), 0, 3, 5, 6, 7, 8		
Limitation(s): None		
Description: Selects the linear solver to use for the pressure matrix solve. Options are: 0 - Direct (Gaussian elimination) (serial runs only) 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	int	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0, 1		
Limitation(s): None		
Description: Instructs CTF to run in serial (0) or in parallel (1)		
Notes: None		

global_energy_balance global_energy_balance

global_energy_balance	float	Optional
Units: percent (default)		
Applicable Value(s): 0.01 (default), > 0.0		

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global_energy_balance, continued...

Limitation(s): None
Description: Sets 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: Sets 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: Sets tolerance for energy storage in the fluid (change in energy over a timestep) for steady state runs. Only applicable when using the storage-based convergence criteria (specify fluid_energy_storage/solid_energy_storage/mass_storage). See 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: Sets tolerance for energy storage in the solid (change in energy over a timestep) for steady state runs. Only applicable when using the storage-based convergence criteria (specify fluid_energy_storage/solid_energy_storage/mass_storage). See CTF User Manual for more details.		
Notes: None		

mass_storage mass_storage

mass_storage	float	Optional
Units: percent (default)		

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`mass_storage`, continued...

Applicable Value(s): 0.5 (default), > 0.0
Limitation(s): None
Description: Sets tolerance for mass storage in the fluid (change in mass in system over a timestep) for steady state runs. Only applicable when using the storage-based convergence criteria (specify fluid_energy_storage/solid_energy_storage/mass_storage). See CTF User Manual for more details.
Notes: None

pressure_criteria pressure_criteria

`pressure_criteria`	float	Optional
Units: N/A		
Applicable Value(s): 1e-4 (default), > 0.0		
Limitation(s): None		
Description: Sets tolerance on l-infinity of pressure change for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See CTF User Manual for more details.		
Notes: None		

Tcool_criteria Tcool_criteria

`Tcool_criteria`	float	Optional
Units: N/A		
Applicable Value(s): 1e-3 (default), > 0.0		
Limitation(s): None		
Description: Sets tolerance on l-infinity of coolant temperature for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See CTF User Manual for more details.		
Notes: None		

Tsolid_criteria Tsolid_criteria

`Tsolid_criteria`	float	Optional
Units: N/A		

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`Tsolid_criteria`, continued...

Applicable Value(s): 1e-3 (default), > 0.0
Limitation(s): None
Description: Sets tolerance on l-infinity of solid temperature for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See CTF User Manual for more details.
Notes: None

void_criteria void_criteria

`void_criteria`	float	Optional
Units: N/A		
Applicable Value(s): 1e-4 (default), > 0.0		
Limitation(s): None		
Description: Sets tolerance on l-infinity of void for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. Not checked for single phase runs. See CTF User Manual for more details.		
Notes: None		

vliq_criteria vliq_criteria

`vliq_criteria`	float	Optional
Units: N/A		
Applicable Value(s): 1e-3 (default), > 0.0		
Limitation(s): None		
Description: Sets tolerance on l-infinity of liquid velocity for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See CTF User Manual for more details.		
Notes: None		

vvap_criteria vvap_criteria

`vvap_criteria`	float	Optional
Units: N/A		
Applicable Value(s): 1e-2 (default), > 0.0		
Limitation(s): None		
Description: Sets tolerance on l-infinity of vapor velocity for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. Not checked for single phase runs. See CTF User Manual for more details.		
Notes: None		

vdrop_criteria vdrop_criteria

`vdrop_criteria`	float	Optional
Units: N/A		
Applicable Value(s): 1e-2 (default), > 0.0		
Limitation(s): None		
Description: Sets tolerance on l-infinity of droplet velocity for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. Not checked for single phase runs. See CTF User Manual for more details.		
Notes: None		

pressurea_criteria pressurea_criteria

`pressurea_criteria`	float	Optional
Units: bar (default)		
Applicable Value(s): 1e-3 (default), > 0.0		
Limitation(s): None		

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`pressurea_criteria`, continued...

Description: Sets absolute tolerance on l-infinity of pressure for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See CTF User Manual for more details.
Notes: None

Tcoola_criteria Tcoola_criteria

`Tcoola_criteria`	float	Optional
Units: K (default)		
Applicable Value(s): 1e-3 (default), > 0.0		
Limitation(s): None		
Description: Sets absolute tolerance on l-infinity of coolant temperature for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See CTF User Manual for more details.		
Notes: None		

Tsolida_criteria Tsolida_criteria

`Tsolida_criteria`	float	Optional
Units: K (default)		
Applicable Value(s): 1e-3 (default), > 0.0		
Limitation(s): None		
Description: Sets absolute tolerance on l-infinity of solid temperature for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See CTF User Manual for more details.		
Notes: None		

vliqa_criteria vliqa_criteria

`vliqa_criteria`	float	Optional
Units: m/s (default)		
Applicable Value(s): 1e-3 (default), > 0.0		
Limitation(s): None		
Description: Sets absolute tolerance on l-infinity of liquid velocity for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See CTF User Manual for more details.		
Notes: None		

vvapa_criteria vvapa_criteria

`vvapa_criteria`	float	Optional
Units: m/s (default)		
Applicable Value(s): 1e-2 (default), > 0.0		
Limitation(s): None		
Description: Sets absolute tolerance on l-infinity of vapor velocity for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. Not used for single-phase runs. See CTF User Manual for more details.		
Notes: None		

vdropa_criteria vdropa_criteria

`vdropa_criteria`	float	Optional
Units: m/s (default)		
Applicable Value(s): 1e-2 (default), > 0.0		
Limitation(s): None		

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`vdropa_criteria`, continued...

Description: Sets absolute tolerance on l-infinity of droplet velocity for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. Not used for single-phase runs. See 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): 1e-5 (default), > 0.0		
Limitation(s): None		
Description: Sets relative tolerance on l-2 of pressure for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See 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): 1e-4 (default), > 0.0		
Limitation(s): None		
Description: Sets relative tolerance on l-2 of coolant temperature for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See 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): 1e-4 (default), > 0.0		
Limitation(s): None		
Description: Sets relative tolerance on l-2 of solid temperature for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See 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): 1e-5 (default), > 0.0		
Limitation(s): None		
Description: Sets absolute tolerance on l-2 of void for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. Not used in single phase runs. See 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): 1e-4 (default), > 0.0		
Limitation(s): None		
Description: Sets relative tolerance on l-2 of liquid velocity for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See CTF User Manual for more details.		

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`vliq_criteria_l2`, continued...

Notes: None

vvap_criteria_l2 vvap_criteria_l2

`vvap_criteria_l2`	float	Optional
Units: N/A		
Applicable Value(s): 1e-4 (default), > 0.0		
Limitation(s): None		
Description: Sets relative tolerance on l-2 of vapor velocity for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. Not used for single-phase runs. See 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): 1e-4 (default), > 0.0		
Limitation(s): None		
Description: Sets relative tolerance on l-2 of droplet velocity for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. Not used for single-phase runs. See 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): 1e-5 (default), > 0.0		
Limitation(s): None		

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`pressure_criteria_l2`, continued...

Description: Sets relative tolerance on l-2 of pressure for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See 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): 1e-5 (default), > 0.0		
Limitation(s): None		
Description: Sets absolute tolerance on l-2 of coolant temperature for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See 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): 1e-5 (default), > 0.0		
Limitation(s): None		
Description: Sets absolute tolerance on l-2 of solid temperature for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See 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): 1e-5 (default), > 0.0		
Limitation(s): None		
Description: Sets absolute tolerance on l-2 of liquid velocity for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. See CTF User Manual for more details.		
Notes: None		

vvpaa_criteria_l2 vvapa_criteria_l2

`vvapa_criteria_l2`	float	Optional
Units: m/s (default)		
Applicable Value(s): 1e-4 (default), > 0.0		
Limitation(s): None		
Description: Sets absolute tolerance on l-2 of vapor velocity for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. Not used for single-phase runs. See 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): 1e-4 (default), > 0.0		
Limitation(s): None		

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vdropa_criteria_l2, continued...

Description: Sets absolute tolerance on l-2 of droplet velocity for steady state runs. Only applicable when using the change-based convergence criteria (specify 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). Note that when using the change-based criteria, all criteria are optional. Not used for single-phase runs. See CTF User Manual for more details.
Notes: None

use_sol_stop_crit use_sol_stop_crit

use_sol_stop_crit	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
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		
Notes: NONE SPECIFIED		

proc_per_assem proc_per_assem

proc_per_assem	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 1 4 9 16		
Limitation(s): None		
Description: Sets the number of domains to divide each full assembly into for parallel runs. Only applicable 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-CS and the number of cores available on the system.		
Notes: None		

edit_gaps edit_gaps

`edit_gaps`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set 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: None		

edit_main_text_output edit_main_text_output

`edit_main_text_output`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set to 1 to write the main text output file from CTF summarizing solution data. This file will be large for full-core models.		
Notes: None		

edit_channels edit_channels

`edit_channels`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set to 1 to write the channel text output file from CTF summarizing solution data. This file will be large for full-core models.		
Notes: None		

edit_rods edit_rods

`edit_rods`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set to 1 to write rod data to the main text output file from CTF. This file will be large for full-core models.		
Notes: None		

edit_dnb edit_dnb

`edit_dnb`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		

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`edit_dnb`, continued...

Limitation(s): None
Description: Set to 1 to write DNB data to the VERA-CS HDF5 file.
Notes: None

edit_dnb_text_file edit_dnb_text_file

`edit_dnb_text_file`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set to 1 to write the DNB text file. This file will be large for full core models.		
Notes: None		

edit_convergence edit_convergence

`edit_convergence`	int	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0 1		
Limitation(s): None		
Description: Set to 1 to write the convergence information output file from CTF.		
Notes: None		

edit_hdf5 edit_hdf5

`edit_hdf5`	int	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0 1		
Limitation(s): None		
Description: Set to 1 to write CTF data to the VERA-CS HDF5 file. notes		
Notes: NONE SPECIFIED		

edit_native_hdf5 edit_native_hdf5

`edit_native_hdf5`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set 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-CS HDF5 file, which is organized by assembly and core location. This file contains more detailed information than the VERA-CS HDF5 file. This file can currently only be printed for serial runs.		
Notes: None		

edit_fluid_vtk edit_fluid_vtk

`edit_fluid_vtk`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set 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`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set 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`	int	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		
Description: Use to set the number of sub-levels to divide each CTF axial level into when forming the coupling mesh with MAMBA. Only applicable when using ROTHCON to reconstruct rod surface temperatures and TKE.		
Notes: None		

hi2lo_sub_theta hi2lo_sub_theta

`hi2lo_sub_theta`	int	Optional
Units: N/A		
Applicable Value(s): 1 (default), > 0		
Limitation(s): None		
Description: Use to set the number of sub-sectors to divide each CTF rod sector into when forming the coupling mesh with MAMBA. Only applicable when using ROTHCON to reconstruct rod surface temperatures and TKE.		
Notes: None		

model_corrosion model_corrosion

`model_corrosion`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set to 1 to turn on the clad corrosion model in CTF. Only applicable for crud simulations.		
Notes: None		

gap_model gap_model

`gap_model`	string	Optional
Units: N/A		
Applicable Value(s): constant (default), constant dynamic		
Limitation(s): None		
Description: Sets the fuel rod pellet/clad gap thermal conductivity model. 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 thom		
Limitation(s): None		
Description: Sets the boiling heat transfer model. Options are chen or thom.		
Notes: None		

property_evaluations property_evaluations

`property_evaluations`	string	Optional
Units: N/A		
Applicable Value(s): iapws1997_lookup (default), asme1968 iapws1997_direct iapws1997_lookup flibe		
Limitation(s): None		
Description: Sets the equation of state source to use for fluid properties. Options are: asme1968 - ASME 1968 tabls 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): 0.005 (default), ≥ 0.0		
Limitation(s): None		
Description: Sets the strength of turbulent mixing causing lateral cross-flow in CTF. The default is currently 0.005, but it has been found that 0.037 is more reasonable for bundles with mixing vane grids (will be updated in the future).		
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: 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), MAMBA cicada		
Limitation(s): None		
Description: Sets the crud modeling tool. Only applicable during a crud simulation.		
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: 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`	int	Optional
Units: N/A		

continued on next page...

crud_dT_feedback, continued...

Applicable Value(s): , 0, 1
Limitation(s): None
Description: Set to 0 to shut off the crud thermal resistance effect on the rod internal temperaure calculation. Note that the crud thermal resistance will still affect the corrosion growth calculation. Defaults to 1.
Notes: None

cicada_outer_radial_zone_num_cells_r cicada_outer_radial_zone_num_cells_r

cicada_outer_radial_zone_num_cells_r	int	Optional
Units: N/A		
Applicable Value(s): 100 (default), ≥ 1		
Limitation(s): None		
Description: Sets the number of rings in the oxide region of the clad for Cicada runs. Only applicable when Cicada used as the crud tool. Only applicable when cicada_dimension=3.		
Notes: None		

cicada_inner_radial_zone_num_cells_r cicada_inner_radial_zone_num_cells_r

cicada_inner_radial_zone_num_cells_r	int	Optional
Units: N/A		
Applicable Value(s): 20 (default), ≥ 1		
Limitation(s): None		
Description: Sets the number of rings in the clad region of the clad for Cicada runs. Only applicable when Cicada used as the crud tool. Only applicable when cicada_dimension=3.		
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): 100e-6 (default), > 0.0		
Limitation(s): None		
Description: Sets the thickness of the oxide modeling region of the clad. Only applicable for crud simulations where Cicada is being used as the modeling tool. Only applicable when cicada_dimension=3.		
Notes: None		

cicada_dimensions cicada_dimension

cicada_dimensions	int	Optional
Units: N/A		

continued on next page...

`cicada_dimensions`, continued...

Applicable Value(s): 1 (default), 1 3
Limitation(s): None
Description: Chooses the dimensions of the clad/oxide conduction solution in Cicada. Only applicable 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.
Notes: None

enable_corrosion_lithium enable_corrosion_lithium

`enable_corrosion_lithium`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set to 1 to turn on the lithium effect on clad corrosion. Only has an effect when modeling a crud simulation using MAMBA as the crud code.		
Notes: None		

crud_details crud_details

`crud_details`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set to 1 to turn on additional edits to the VERA-CS HDF5 file related to the crud simulation.		
Notes: None		

rod_details rod_details

`rod_details`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set to 1 to turn on additional edits to the VERA-CS HDF5 file related to the rod solution.		
Notes: None		

oxide_thermal_conductivity oxide_thermal_conductivity

`oxide_thermal_conductivity`	double	Optional
Units: W/cm/K (default)		
Applicable Value(s): 1.5 (default), Greater than or equal to 0.0		

continued on next page...

`oxide_thermal_conductivity`, continued...

Limitation(s): None
Description: The thermal conductivity of the clad oxide layer
Notes: None

clad_corrosion_model clad_corrosion_model

`clad_corrosion_model`	int	Optional
Units: N/A		
Applicable Value(s): 1 (default), 1 2 3		
Limitation(s): None		
Description: Selects the corrosion model to use. The corrosion model is based on the clad material. Options include: 1 - Zirc 4 2 - M5 3 - ZIRLO		
Notes: None		

trans_dnb trans_dnb

`trans_dnb`	int	Optional
Units: N/A		
Applicable Value(s): 0 (default), 0 1		
Limitation(s): None		
Description: Set to 1 to enable the transient CHF model. Only applicable for transients.		
Notes: None		

cross_flow cross_flow

`cross_flow`	int	Optional
Units: N/A		
Applicable Value(s): 1 (default), 0 1		
Limitation(s): None		
Description: Set to 0 to shut off lateral cross flow in CTF.		
Notes: None		

5.11. BLOCK COUPLING

epsk epsk

`epsk`	Float	Optional
Units: N/A, pcm		
Applicable Value(s):		
Limitation(s): > 0		
Description: Eigenvalue converence criteria.		

continued on next page...

epsk, continued...

Notes: None

epsp epsp

epsp	Float	Optional
Units: N/A, L2 norm		
Applicable Value(s):		
Limitation(s): > 0		
Description: Power convergence criteria.		
Notes: None		

eps_temp eps_temp

eps_temp	Float	Optional
Units: N/A, degrees F		
Applicable Value(s):		
Limitation(s): > 0		
Description: Temperature convergence criteria.		
Notes: None		

ctf_iters_max ctf_iters_max

ctf_iters_max	Integer	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): > 0		
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):		
Limitation(s): > 0		
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: N/A, ppm		
Applicable Value(s):		
Limitation(s): > 0		
Description: Boron convergence criteria.		
Notes: None		

rlx_power rlx_power

`rlx_power`	Float	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): $> 0, <= 1$		
Description: Power relaxation factor.		
Notes: Recommend 0.5.		

rlx_tfuel rlx_tfuel

`rlx_tfuel`	Float	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): $> 0, <= 1$		
Description: Fuel temperature relaxation factor.		
Notes: Recommend 1.0.		

rlx_den rlx_den

`rlx_den`	Float	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): $> 0, <= 1$		
Description: Density relaxation factor.		
Notes: Recommend 1.0.		

maxiter maxiter

`maxiter`	Integer	Optional
Units: N/A		
Applicable Value(s):		
Limitation(s): > 0		
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: Name of coupling restart file. Leave blank for no coupling restart.		
Notes: None		

5.12. BLOCK MPACT

transport_method transport_method

`transport_method`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): MOC (default)		
Limitation(s): None		
Description: This card is used to specify whether Method of Characteristics, Sn, or Nodal Diffusion transport methods are used for the global problem solution method.		
Notes: None		

sn_numcart sn_numcart

`sn_numcart`	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default)		
Limitation(s): None		
Description: This card is used to specify the number of X and Y sub-divisions 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		

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`ray_spacing`, continued...

Description: This card 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

shield_ray_spacing shield_ray_spacing **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 card is used to specify the characteristic ray spacing for the rays used in the MOC sheidling 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 card is used to specify which type of messages should be written to the log file.		
Notes: None		

refl_no_added_modules refl_no_added_modules

`refl_no_added_modules`	Boolean	Optional
Units: N/A		
Applicable Value(s): true (default), false		
Limitation(s): None		
Description: This card is used to allow for additional reflector modules to be added to the core geometry.		

continued on next page...

`refl_no_added_modules`, continued...

Notes: None

refl_highres refl_highres

`refl_highres`	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: This card 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)		
Limitation(s): None		
Description: This card is used to specify whether one-group or multi-group MOC kernels are used.		
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)		
Limitation(s): None		
Description: This card is used to specify whether one-group or multi-group MOC kernels are used for the shielding sweeper.		
Notes: None		

moc_mg_data_passing moc_mg_data_passing

`moc_mg_data_passing`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): true (default), false		
Limitation(s): None		
Description: This card is used to specify whether one-group or multi-group MOC data passing is used.		
Notes: This is primarily to bypass the MPI issues observed with MGAngFlux and is only applicable when using moc_kernel=MG.		

volume_corr volume_corr

`volume_corr`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): INTEGRAL (default)		
Limitation(s): None		
Description: This card is used to specify the volume correction being applied to the MOC segments.		
Notes: None		

modular_rays modular_rays

`modular_rays`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): TWO (default)		
Limitation(s): None		
Description: This card 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), 0,1		
Limitation(s): Zero or positive integers		
Description: This card 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), 0,1		
Limitation(s): Zero or positive integers		
Description: This card 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		

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power_edit, continued...

Limitation(s): None
Description: This card 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`	Fixed Character String	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 card 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 available regarding this is provided with the `par_file`.		

rod_treatment rod_treatment

`rod_treatment`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): none (default), polynomial,1dcpm		
Limitation(s): The pre-generated 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 may not be improved as much for reactors other than Watts Bar Unit 1.		
Description: This card toggles the use of volume-weighting for control rods in order 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 card will correct for these effects. The polynomial option uses pre-generated 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 1dcpm method uses the 1d collision probabilities method to generate radial shape functions for rodded and unrodded regions, then uses these shape functions to flux-volume homogenize the cross-sections for the MOC calculations.		

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`rod_treatment`, continued...

Notes: This card only has an effect 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 card is used to specify which method should be used for computing soluble boron in the critical boron search. The options are: • `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		

valid_on valid_on

`valid_on`	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: This card controls whether or not a secondary output will be generated. This output will be formatted for use in validation tests and is only ever needed for these tests.		
Notes: This card is for developers and is not intended for use by general users and is furthermore marked for depracation.		

valid_delim valid_delim

`valid_delim`	Character String	Optional
Units: N/A		
Applicable Value(s): space (default), comma		
Limitation(s): None		
Description: This card is used to set the delimeter used when `valid_on` is set to true.		
Notes: This card is for developers and is not intended for use by general users and is furthermore marked for depracation.		

checkpoint_mode checkpoint_mode

`checkpoint_mode`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): I (default), T, F, R, W, RW which correspond to: • `I` — specifies that a checkpoint file may be written through a user interrupt. • `T` — specifies that the case will be started from a checkpoint file. • `F` — disables initialization of the checkpoint file. • `R` — same as T. • `W` — specifies that a checkpoint file is to be written. • `RW` — same as T and R but after the checkpoint file is read it can be overwritten during the calculation.		
Limitation(s): File system permissions must be configured such that MPACT can interact with files, as needed.		
Description: This card is used to control whether the calculation is restarted from a checkpoint file. The user can send the interrupt signal to MPACT after execution has begun by creating a file named "MPACT_CHECKPOINT_FILE" in the simulation's working directory. The existence of this file causes a checkpoint file to be written after every outer iteration. Likewise, the removal of "MPACT_CHECKPOINT_FILE" disables the writing of a checkpoint file. See the `checkpoint_file` card regarding checkpoint file naming.		
Notes: None		

checkpoint_file checkpoint_file

`checkpoint_file`	Free-form Character String	Optional
Units: N/A		
Applicable Value(s): `<CASEID>`.mcp (default)		
Limitation(s): The filename must be specified with characters valid for use on the computer system being executed on. As a general practice, one should avoid the use of "special" characters. Similarly, one must not specify a name that conflicts with other files that are (or will be) created within the MPACT directory.		
Description: If a checkpoint file will be used, then the user can optionally specify the name of this file of his or her choosing.		
Notes: There is no strict limit on how many characters can be used to to specify the filename; however, good judgment should be used to keep the filename a reasonable length.		

rst_compress rst_compress

`rst_compress`	Free-form Character String	Optional
Units: N/A		

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`rst_compress`, continued...

Applicable Value(s): 5 (default), none and 0 through 9. "None" means the HDF5 Filter forgzip 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.
Limitation(s): This only affects the WRITING of the restart file. `restart_read` cases and texttrestart_shuffle cases are not affected. notes
Description: NONE SPECIFIED
Notes: NONE SPECIFIED

vis_edits vis_edits

`vis_edits`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): core (default), none, fsr. These are described as: 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		
Limitation(s): None		
Description: This card is used to specify the type of visualization a 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.		
Notes: The FSR edits will be very large and may consume 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. These are described as: 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`		
Limitation(s): None		

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rr_edits, continued...

Description: This card 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.
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), The user specified isotope and reaction pairs in a format `isotope_reaction`.		
Limitation(s): This card can only be used if `rr_edits` is turned on.		
Description: This card 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: Select 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), ignore, combine, explicit. These are described as: 1. `ignore` — will ignore Xe-135m in transport calculation 2. `combine` — will combine Xe-135m into Xe-135 in transport calculation 3. `explicit` — will treat Xe-135m explicitly as other isotopes in transport calculation		
Limitation(s): None		
Description: This card is used to specify the treatment of Xe-135m. By default, MPACT ignores Xe-135m when performing transport calculation although depletion solver may consider it. When combining Xe-135m into Xe-135, cross sections of the two isotopes are assumed the same. Explicit treatment can be enabled only for the latest MG library that has Xe-135m data based on TENDL data.		
Notes: None		

explicit_erg_deposit explicit_erg_deposit

`explicit_erg_deposit`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `false` (default), `true`		
Limitation(s): None		

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explicit_erg_deposit, continued...

Description: This card is used to specify if 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: Presently the capture kappa data are only available in simplified AMPX library. MPACT library uses the hard-coded values. Other libraries do not support this card.

nodal_edits nodal_edits

nodal_edits	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): false (default), true, false. These are described as: 1. `true` — enables MPACT nodal cross section edits 2. `false` — disables MPACT nodal cross section edits		
Limitation(s): None		
Description: This card 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.		
Notes: None		

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 card is used to set the energy cut-off between the two groups when generating nodal data. The default cut-off is the energy between the last group with no up-scatter and the first group with up-scatter. This value is library-dependent and automatically determined during the calculation. The user may specify any of the energy group boundaries defined by the transport library as an input to this card.		
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 card must be present if using the Nodal transport method and nodal data must be provided for every state		

continued on next page...

`nodal_data_filename`, continued...

Description: This card 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 have within it *ADF*, *CHI*, *KXSF*, *NXSF*, *XSF*, *XSRM*, *XSS*, and *XSTR*. These nodal dataset must have the same shape as their as their corresponding output counterparts.

nodal_edits_adapt_adf nodal_edits_adapt_adf

`nodal_edits_adapt_adf`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): false (default), true, false. These are described as: 1. `true` — enables MPACT adaptive ADF calculations 2. `false` — disables MPACT adaptive ADF calculations		
Limitation(s): None		
Description: This card 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.		
Notes: Has no effect if `nodal_edits` is set to `false`.		

grid_treatment grid_treatment

`grid_treatment`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `homogenize` (default), `equal_mass`, `equal_thickness` • `homogenize` — will take the mass specified in the grid card, 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 the thickness the grid would be within each pincell, 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 has the same grid material mass in it.		

continued on next page...

grid_treatment, continued...

Limitation(s): For grids with a large mass that fall in a narrow (axially) lattice, there is a possibility that the grid will intersect one or more pins for the `equal_thickness` and `equal_mass` options. If this event occurs, MPACT will raise an error, and the user will need to change the axial meshing options, change the geometry of the lattice, or simply use the `homogenize` option for the `grid_treatment` card.
Description: This card 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 card 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 card is used to enable or disable crud depletion.		
Notes: None		

`crud_depfrac`	Float	Optional
Units: N/A		
Applicable Value(s): , >= 0		

continued on next page...

crud_depfrac, continued...

Limitation(s): None
Description: This card 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 card present) *or* matbound (axial_mesh card not present) (default), nonfuel, all • useraxialmesh — Requires the use of the axial mesh card and no auto meshing is performed in this instance. This option will not use the values specified by the automesh_bounds since it does not do 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 since it does not do 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 non-fuel regions. Homogenization will only occur within those regions.		
Limitation(s): Must be set in conjunction with the axial_edit_bounds card in the EDIT block of the VERA input when the option is not useraxialmesh. This data is required to set up the axial mesh for every input option except the useraxialmesh where it is separately specified.		
Description: This card specifies the type of axial meshing to be used. If this card is not present, the method will default to useraxialmesh if the axial_mesh card is present or it will default to matbound if the axial_mesh card is not present.		
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 homogenzied.		

automesh_bounds automesh_bounds

automesh_bounds	Array of Floating-Point Real Numbers, Length = 2	Optional
Units: cm (default)		

continued on next page...

`automesh_bounds`, continued...

Applicable Value(s): 2.0 10.0, 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 card specifies the minimum and maximum desired axial mesh for the auto axial meshing. Any geometry or mesh region larger than the specified value will be broken up into smaller mesh regions that have a height 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.
Notes: The region where these values are applied is specified by the `meshing_method` card. This card is ignored when the `useraxialmesh` and `matbound` method is specified. It should also be noted that specifying min and max values that are close together will most likely result in more axial homogenization than may be desired by the user. It would mean that most of the material interfaces will be homogenzied 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 card 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 card must be equal to the total geometric height of the problem.		
Description: This card is used to specify the axial mesh used in the 2-D/1-D simulation. The input is the thickness of each axial section the user wishes to model. This card is optional if the `meshing_method` card 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.		

pin_cell_mod_mesh pin_cell_mod_mesh

`pin_cell_mod_mesh`	Array of mixed types int and string, Length = 2	Optional
Units: cm (default)		

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`pin_cell_mod_mesh`, continued...

Applicable Value(s): `num_rings` = 1, and `pin_cell_type` = fuel (default), • `num_rings` — positive integers. Practially less than 10. • `pin_cell_type` — "fuel", "nonfuel", "both".
Limitation(s): This option does not work with explicit grid spacers. To use with grid spacers set the `grid_treatment` option to `homogenize`.
Description: This card is used to specify the MOC flat source region mesh in 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 accuracy of calculations at room temperature
Notes: When this card 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 card is specified, that value changes to the following: `max_radii = 0.95*(0.5*pitch*sqrt(2))` , which is equal to 95% of the way from the pin cell center to the corner.

crud_mesh crud_mesh

`crud_mesh`	One Floating-Point Real and One Integer	Optional
Units: microns (default)		
Applicable Value(s): N/A (default), 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.		
Limitation(s): None		
Description: This card is used to specify the radial mesh that is added for each cell to account for CRUD build-up on the surface of the fuel pins.		
Notes: None		

quad_type quad_type

`quad_type`	Fixed Character String	Required
Units: N/A		
Applicable Value(s): None (default), listed below		

Quadrature Name	Type	Order	Order Θ
`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]

Limitation(s): None
Description: This card is used to specify the name of the angular quadrature to use for determining the angles at which the rays are traced throughout the problem.

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quad_type, continued...

Notes: None

shield_quad_type shield_quad_type

shield_quad_type	Fixed Character String	Required
Units: N/A		
Applicable Value(s): None (default), listed below		
Limitation(s): None		
Description: This card is used to specify the name of the angular quadrature to use for determining the angles at which the rays are traced throughout the problem for the shielding calculation.		
Notes: None		

Quadrature Name	Type	Order	Order Θ
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]

azimuthals_octant azimuthals_octant

azimuthals_octant	Integer	Required
Units: N/A		
Applicable Value(s): None (default), Column Order in the above table		
Limitation(s): None		
Description: This card is used to specify the number of azimuthal angles per octant and corresponds to the Order column in the table in quad_type card.		
Notes: None		

polars_octant polars_octant

polars_octant	Integer	Required
Units: N/A		
Applicable Value(s): None (default), Column Order Θ in the above table		
Limitation(s): None		
Description: This card 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 card. Note the number of polar angles may be limited by the quadrature type used. Also, any non-product quadrature types will not use this input card (i.e., in the only applicable case LEVEL-SYMMETRIC).		
Notes: None		

shield_azimuthals_octant shield_azimuthals_octant

`shield_azimuthals_octant`	Integer	Required
Units: N/A		
Applicable Value(s): None (default), Column Order in the above table		
Limitation(s): None		
Description: This card 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` card.		
Notes: None		

polars_octant polars_octant

`polars_octant`	Integer	Required
Units: N/A		
Applicable Value(s): None (default), Column Order Θ in the above table		
Limitation(s): None		
Description: This card 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` card. Note the number of polar angles may be limited by the quadrature type used. Also, any non-product quadrature types will not use this input card (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): `NONE` (default), `ORNL` or `SIMPLIFIED_AMPX`		
Limitation(s): None		
Description: This card 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	Required
Units: N/A		
Applicable Value(s): No default value (default), filename of a supported cross section library		
Limitation(s): None		
Description: This card 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 card is used to specify the name of the indexing file of continuous-energy 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		
Limitation(s): The xs_shielder card must be enabled (default) in order to enable this card, otherwise unshielded cross section (infinite-dilute) will be used.		
Description: This card is used to specify the method used to shield the cross sections.		
Notes: In general, subgroup is slower than essm (by a factor of 2 to 5 depending on the subgroup_set option). However, 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, subgroup method is an option with better accuracy in the current version.		

shield_nbatch shield_nbatch

shield_nbatch	Integer	Optional
Units: N/A		
Applicable Value(s): 5 (default)		
Limitation(s): None		
Description: This card 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 card is used to specify whether to shield the cross sections or not: ture–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 card is used to specify whether to perform the spatial 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		
Applicable Value(s): `false` (default), `true`,`t`,`f`		
Limitation(s): None		
Description: This card is used to specify whether to perform the quasi-1D slowing-down correction for self-shielding calculation. Currently, this option can only be toggled 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 card is used to specify whether to use the resonance data that incoporates the epithermal upscattering model. Currently, this option is only supported for ORNL library from version 4 and thereafter.		
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 card 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 non-uniform temperature effect in calculating the equivalence cross sections for subgroup method.		

dep_filename dep_filename

dep_filename	Free-Form Character String, Max. Length = 200	Required
Units: N/A		
Applicable Value(s): No default value (default), filename of a supported cross section library		
Limitation(s): The format of this file should be consistent with the standard MPACT depletion library file `MPACT.dpl`.		
Description: This card 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.		
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 card 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 card 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`. ESSM ignores the `subgroup_set` option.		
Description: This card is used to specify the subgroup set.		
Notes: In most cases, 4 (the default) should be used. This option finds a good balance on 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 card 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 means a fast and 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 user speficies. User can also specify zero or a negative integer number to use 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 card is used to specify the beginning and ending groups that resonance self-shielding calculation will be performed.		
Notes: None		

k_tol k_tol

k_tol	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0E-5 (default), >0		
Limitation(s): None		
Description: This card 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): 1.0E-4 (default), >0		
Limitation(s): None		
Description: This card is used to specify the tolerance on the convergence of the 2-norm of the flux.		
Notes: None		

cmfd_num_outers cmfd_num_outers

`cmfd_num_outers`	Integer	Optional
Units: N/A		
Applicable Value(s): 20 (default), Any positive value.		
Limitation(s): None		
Description: This card is used to specify the number of outer eigenvalue power iterations to perform during a CMFD acceleration calculation.		
Notes: NONE SPECIFIED		

cmfd_num_inners cmfd_num_inners

`cmfd_num_inners`	Integer	Optional
Units: N/A		
Applicable Value(s): 100 (default), Any positive integer.		
Limitation(s): None		
Description: This card is used to specify the max. number of linear solver iterations per power iteration during a CMFD acceleration calculation.		
Notes: NONE SPECIFIED		

cmfd_up_scatter cmfd_up_scatter

`cmfd_up_scatter`	Integer	Optional
Units: N/A		
Applicable Value(s): 2 (default), Any positive integer.		
Limitation(s): Only applies to `1gsweep` CMFD solver.		
Description: This card 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		

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 card 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 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		

TL_treatment TL_treatment

`TL_treatment`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): lflat (default), flat. These are described as: • `lflat` — checks the total / transport cross section. If the value is below the threshold, leakage will not be put into that region. This process is usually to avoid leakage in the fuel-clad gap. It will then redistribute the leakage to the other regions in that pin. • `flat` — does not perform leakage threshold checks.		
Limitation(s): None		
Description: This card is used to specify the type of spatial shape of the axial transverse leakage applied to the 2-D problem. Flat means it is constant over a pin cell. This is primarily used to ensure stability of the iteration.		
Notes: None		

trim_Pn_moments trim_Pn_moments

`trim_Pn_moments`	Boolean	Optional
Units: N/A		
Applicable Value(s): true (default), true, false		
Limitation(s): None		
Description: This card is used to toggle the logic to trim unused scattering moments when using Pn scattering techniques.		
Notes: None		

boundary_update boundary_update

`boundary_update`	string	Optional
Units: N/A		
Applicable Value(s): P0 (default), This card 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. limitations		
Limitation(s): NONE SPECIFIED		
Description:		
Notes: The `DP0` and `P1` options are more complex and generally do no provide significant convergence improvement. The default option of `P0` is recommended.		

depl_time_method depl_time_method

`depl_time_method`	Fixed Character String	Required
Units: N/A		
Applicable Value(s): `p-c`(predictor-corrector) (default), `semip-c`(semi-predictor-corrector) or `postcorrector`(semi-predictor-corrector-post-corrector)		
Limitation(s): None		
Description: This card 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 time step, which is then averaged with the corrected nuclide concentration based on the steady state flux condition at the end of time step. Two steady-state eigenvlaue calcualtions 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 becomes more efficient in small time step depletion calculation. The `postcorrector` method is identical to `semip-c` method with the exception that the number densities used for the beginning of times step steady-state eigenvalue calculation are "post-corrected" so that they more closely representthe averaged number densities of the full `p-c` method. This allows for accuracy coparable to the full `p-c` method while still skipping the second steady-state eigenvalue calculation		
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.		

depl_origen_solver depl_origen_solver

`depl_origen_solver`	Fixed Character String	Required
Units: N/A		
Applicable Value(s): `cram`(CRAM solver) (default), `matrex`(MATREX solver)		
Limitation(s): None		
Description: This card is used to specify the solver method used by ORIGEN when performing depletion calculations. The `cram` method is the Chebyshev Rational Approximation Method. The `matrex` method is a hybrid matrix exponential / linear chain method, and is the legacy ORIGEN solution method		
Notes: Compared to the `matrex` solver, `cram` has similar runtimes 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. Hence, 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		

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`num_space`, continued...

Description: This card 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. 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 description of card `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 options 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` (the user should note that the terms octant and quadrant are interchangable in the context of azimuthal angles). The azimuthal angles are divided into `num_angle` groups, and each groups 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. Due to the increase in inter-process communication with increased parallel decomposition, excessive parallelization will not yield speedup of the solution. The proper amount of paralleization will have to be determined on a case-by-case basis.		

num_energy num_energy

`num_energy`	Integer	Optional
Units: N/A		
Applicable Value(s): , 1		
Limitation(s): None		
Description: Energy decomposition is not yet supported. MPACT will only run 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 card 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): `DEFAULT` (default), `EXPLICITFILE`		
Limitation(s): The `EXPLICITFILE` option may 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 card is used to specify the method of parallel decomposition. • `DEFAULT` — The parallelization is specified by three input options listed below: `num_angle`, `num_space`, `num_threads`. The meanings of these input options are explained below. `DEFAULT` is the simpler method for parallelizing the problem, and is recommended for most users. • `ASSEMBLY` — The parallelization scheme for decomposing a problem spatially. The problem will be decomposed radially first, and if there are more processors, will then attempt to parallelize the problem axially. This process is done automatically, and only requires the user to specify the number of spatial processors available in the `num_space` card described below. It is the recommended method for large problems. • `EXPLICITFILE` — For more advanced users who are running large problems, using the `EXPLICITFILE` option may enable the user to parallelize the problem more effectively. For a description of the `EXPLICITFILE` method, see the input option `par_file`.		
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 card 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 broken 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 3 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 3 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 6 integers. The first pair of integers are the starting and stopping module indices in the x direction, the second pair are the starting and stopping module indices in the y direction, and the last pair is for the z direction, but they 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 (south-west) corner of the module. When specifying the starting and stopping indices, it is important to 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 non-existent assemblies are "partitioned" in the explicit file, nothing there will be run. So 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 example below, 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 2378 processors, which should be input into the num_space card. Also, it may 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, 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		

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par_xdim, continued...

Description: This card 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 card 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 multi-line map should contain the indexes each module should be a part of. These domains must be contiguous (all modules in a domain must neighbor at least one other module in the domain) and 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): , 'RSB', 'RIB', 'REB'		
Limitation(s): None		
Description: This card is used to read the decomposition/partition algorithms which will 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): None		

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graph_refn_method, continued...

Description: This card is used to read the communication refinement algorithms which will 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)		
Applicable Value(s):		
Limitation(s): Positive		
Description: This card reads inputs for smallest graph size (modules) for each decomposition method.		
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 COBRA-TF) *or* `ctf` (if configured with COBRA-TF) (default), `ctf_external`, texttuser_defined, `none` The `simplified` option uses MPACT's internal TH solver. The `ctf` option internally couples COBRA-TF to MPACT, and `ctf_external` couples MPACT and COBRA-TF through the lime interface. The `user_defined` option uses TH conditions defined in the HDF5 file specified by the texttuser_defined_th_filename card in the texttMPACT 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`.		
Limitation(s): The `feedback` card in the `STATE` block must be set to `on` for any of the TH coupling methods		
Description: This card is used to indicate which TH coupling method should be used.		
Notes: For either the `ctf` or `ctf_external` options, MPACT must be configured with COBRA-TF. The `internal` option may regardless of whether MPACT was configured with COBRA-TF or not.		

extend_coupling_mesh extend_coupling_mesh

extend_coupling_mesh	Logical	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: This card is used to specify whether to enable coupling above and below the active fuel when using CTF.		

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extend_coupling_mesh, continued...

Notes: None

th_nonlinear_solver th_nonlinear_solver

th_nonlinear_solver	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): picard (default), picard, anderson The picard option uses a direct underrelaxation of the power. The anderson option uses the Anderson acceleration method in Trilinos to accelerate on the power.		
Limitation(s): For anderson the anderson_options card should be used to set parameters.		
Description: This card is used to indicate which nonlinear solver should be used for the coupling.		
Notes: For the anderson option, MPACT must be configured with Trilinos. The picard option may regardless of how MPACT is configured.		

anderson_options anderson_options

anderson_options	Integer, Floating-Point Real Number, Integer	Optional
Units: N/A		
Applicable Value(s): 2, 0.5, 1 (default), The depth can be any non-negative integer which represents depth of the Anderson solver. The mixing parameter must be greater than 0 and less than or equal to 1. The starting iteration must be a positive integer which represents how many iterations of picard to perform before starting anderson.		
Limitation(s): None		
Description: This card is used to define the solver parameters for the Anderson nonlinear solver.		
Notes: NONE SPECIFIED		

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): 4, 25.0, 0.005 (default), or any positive integer and any 2 positive real numbers 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 last input is the minimum change in moderator density for which MPACT will perform cross-section shielding calculations following a TH update.		
Limitation(s): If the xs_shielder card is set to f or false, this card does nothing, since cross-section shielding calculations will never be performed.		

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`shielder_th`, continued...

Description: This card is used to control how many cross-section shielding calculations are performed when using TH feedback. It sets a maximum number of iterations with shielding calculations, and also sets parameters to stop the shielding calculations earlier if the TH feedback effects on temperature and moderator density are small enough.
Notes: If multiple state points are performed in the calculation, the counter for the ¡shield_max_outers¿ input is reset for each state point. If the `xs_shielder` card is not set to `f` or `false`, 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), or any positive integer		
Limitation(s): None		
Description: This card is used to indicate how many outer iterations MPACT should perform before performing an additional TH update.		
Notes: None		

average_ftemp average_ftemp

`average_ftemp`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: If true, this card applies a volume-avergaed 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`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `true` (default), `true`		
Limitation(s): None		
Description: If true, this card 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	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `true` (default), `true`		
Limitation(s): None		
Description: If true, this card 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	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): `true` (default), `true`		
Limitation(s): None		
Description: If true, this card will use the radial fuel temperature Zernike coefficients from CTF to set the fuel temps in MPACT. If false, the coefficents 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 COBRA-TF is run in serial) *or* `pdeck` (when COBRA-TF is run in parallel) (default), Any filename base for valid COBRA-TF input decks.		
Limitation(s): Filename must have ".inp" extension.		
Description: This card 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_dhfrac sth_dhfrac

sth_dhfrac	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 0.02 (default), 0.0–1.0		
Limitation(s): It is ignored if feedback is off or if coupling with COBRA-TF is being used.		
Description: This card is used to set the fraction of the power which is directly deposited in the moderator in internal TH calculations.		
Notes: None		

sth_hgap sth_hgap

`sth_hgap`	Floating-Point Real Number	Optional
Units: W/m^2· K (default)		
Applicable Value(s): 4500.0 (default), or any positive real number		
Limitation(s): It is ignored if feedback is off or if coupling with COBRA-TF is being used.		
Description: This card is used to set the gap conductance value for internal TH calculations.		
Notes: Typical values range from 1000 (very low) to 10000 (very high).		

temptable_filename temptable_filename

`temptable_filename`	Free-Form Character String, Max. Length = 200	Optional
Units: N/A		
Applicable Value(s): N/A (default), Filename of any valid fuel temperature table file		
Limitation(s): If the card is present, temperature tables in the named file will be used to calculate fuel temperatures instead of the internal conduction solvers or COBRA-TF. If this card is not present, then internal or COBRA-TF solvers are used.		
Description: This card is used to indicate the name of the file containing the 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 COBRA-TF 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.		

sth_tabletype sth_tabletype

`sth_tabletype`	Character String	Optional
Units: N/A		
Applicable Value(s): ctf (default), simplified		
Limitation(s): It is ignored if feedback is off or if coupling with COBRA-TF is being used.		
Description: This card is used to set the table type for internal TH calculations.		
Notes: None		

temptable_filename temptable_filename

`temptable_filename`	Free-Form Character String, Max. Length = 200	Optional
Units: N/A		
Applicable Value(s): N/A (default), Filename of any valid fuel temperature table file		
Limitation(s): If the card is present, temperature tables in the named file will be used to calculate fuel temperatures instead of the internal conduction solvers or COBRA-TF. If this card is not present, then internal or COBRA-TF solvers are used.		
Description: This card is used to indicate the name of the file containing the temperature tables.		

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`temptable_filename`, continued...

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 COBRA-TF 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_shape temptable_shape

`temptable_shape`	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
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 card is present, temperature tables in the named file will be used to calculate fuel temperatures instead of the internal conduction solvers or COBRA-TF. If this card is not present, then internal or COBRA-TF solvers are used.		
Description: This card is used to define 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 COBRA-TF 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_filename temptable_filename

`temptable_filename`	Free-Form Character String, Max. Length = 200	Optional
Units: N/A		
Applicable Value(s): N/A (default), Filename of any valid fuel temperature table file		
Limitation(s): If the card is present, temperature tables in the named file will be used to calculate fuel temperatures instead of the internal conduction solvers or COBRA-TF. If this card is not present, then internal or COBRA-TF solvers are used.		
Description: This card is used to indicate the name of the file containing the temperature tables.		

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`temptable_filename`, continued...

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 COBRA-TF 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 the fuel temperatures		
Limitation(s): If the card is present, temperature tables in the named file will be used to calculate fuel temperatures instead of the internal conduction solvers or COBRA-TF. If this card is not present, then internal or COBRA-TF solvers are used.		
Description: This card 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 COBRA-TF 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 card is present, temperature tables will be used to calculate fuel temperatures instead of the internal conduction solvers or COBRA-TF. If this card is not present, then internal or COBRA-TF solvers are used.		
Description: This card is used to indicate the data for 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 COBRA-TF 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		

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`user_defined_th_filename`, continued...

Limitation(s): If the card is present, TH conditions defined for each state and pincell will be used to set the TH variables of each pincell in the model instead of calculating the TH condition using the internal TH solver or CTF
Description: This card 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 name 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 shape as their corresponding output counterparts. Users are not required to provide the TH conditions for all states and TH variables, and those which are absent will be populated based on the global state variables such as `tinlet`.

dep_edit dep_edit

`dep_edit`	Fixed Character String	Optional
Units: atomsvolume of pincell (default)		
Applicable Value(s): `true` (default), `false`		
Limitation(s): None		
Description: This card is used to specify if the depletion `Isum` and `Pnum` files are written, which print the pin-wise averaged isotope number densities. `Isum` prints the isotope summary file with isotopes tracked in XSMesh and `Pnum` file prints the particle number density file with all isotopes in the depletion library.		
Notes: The option has excessive memory requirements and is not advised for general usage. Only use when absolutely necessary.		

dep_substep dep_substep

`dep_substep`	Integer	Optional
Units: N/A		
Applicable Value(s): 1 (default), Positive integers greater than 0		
Limitation(s): None		
Description: This card is used to read the number of substep 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. Since the depletion calculation typically takes less time than the transport calculation this with high order depletion or renormalization will often save computational time.		
Notes: When not using the High Order Depletion Methodology or substep renormalization, 1 substep is recommended for CRAM and 3 substeps for MATREX or internal BATEMAN. This card 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), Positive integers greater than 0		
Limitation(s): None		
Description: This card is used to read the number of substep 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. Since the depletion calculation typically takes less time than the transport calculation this with high order depletion or renormalization will often save computational time.		
Notes: When not using the High Order Depletion Methodology or substep renormalization, 1 substep is recommended for CRAM and 3 substeps for MATREX or internal BATEMAN. This card 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), Positive integers greater than 0		
Limitation(s): None		
Description: This card is used to read the number of substep 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. Since the depletion calculation typically takes less time than the transport calculation this with high order depletion or renormalization will often save computational time.		
Notes: When not using the High Order Depletion Methodology or substep renormalization, 1 substep is recommended for CRAM and 3 substeps for MATREX or internal BATEMAN. This card is also valid in OPTION block.		

dep_kernel dep_kernel

`dep_kernel`	Fixed Character String	Required
Units: N/A		
Applicable Value(s): `internal`(MPACT's internal depletion kernel) (default), `origen`(coupled `origen` kernel)		
Limitation(s): None		
Description: This card 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		

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`include_depl_mats`, continued...

Applicable Value(s):
Limitation(s): None
Description: This card is used to list the names of materials the user wishes to deplete. The inputs for this card are a 1-D 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 card is used to list the names of materials the user does not wish to deplete. The inputs for this card are a 1-D 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): cmfd (default), cmfd, none described as: • `cmfd` — default CMFD method (currently adcmfd.) • `adcmfd` — artificially diffusive CMFD method. (same as cmfd) • `scmfd` — standard CMFD method. • `mlcmfd` — a multi-level (currently 2) cmfd method. • `msed` — same as `adcmfd`, but the CMFD system is now solved via the MSED method • `none` — disables CMFD and can only be used in 2-D problems.		
Limitation(s): None		
Description: This card is used to specify which CMFD method will be used.		
Notes: CMFD must be present for every 3-D problem because it is the basis for the solution transfer between 2-D and 1-D.		

multilevel multilevel

`multilevel`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): energy (default), energy,space		
Limitation(s): None		

continued on next page...

`multilevel`, continued...

Description: This card is used to specify whether space or energy multilevel CMFD is used
Notes: Only active when mlcmfd is specified.

prolongation prolongation

`prolongation`	Character String	Optional
Units: N/A		
Applicable Value(s): flat (default), linear		
Limitation(s): None		
Description: Flag to indicate if 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), `mgnode`, `mggroup` described as: • `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-Relaxtion 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-Relaxtion iteration. • `reducedmg` – same as mgnode, except it solve 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.		
Limitation(s): None		
Description: This card is used to specify how the CMFD linear system is setup and solved.		
Notes: `1gsweep` requires less memory than the others, but is generally slower to converge than mgnode.		

cmfd_linear_solver cmfd_linear_solver

`cmfd_linear_solver`	Fixed Character String	Optional
Units: N/A		

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cmfd_linear_solver, continued...

Applicable Value(s): PETSC (default), PETSC or TRILINOS described as: • PETSC — Uses PETSC (ANL) for linear solver and SLEPC for eigenvalue problems. • TRILINOS — Uses Trilinos (SNL) solvers Belos for linear solves and Anasazi for eigenvalue problems.
Limitation(s): None
Description: This card is used to specify which linear solver package will be used.
Notes: CMFD must be present for every 3-D problem because it is the basis for the solution transfer between 2-D and 1-D.

petsc_linear_solver_method petsc_linear_solver_method

petsc_linear_solver_method	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): gmres (default), gmres, bicgstab, or multigrid		
Limitation(s): None		
Description: This card 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 SPECIFIED		

petsc_linear_solver_method petsc_linear_solver_method

petsc_linear_solver_method	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): gmres (default), gmres, bicgstab, or multigrid		
Limitation(s): None		
Description: This card 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 SPECIFIED		

multigrid_cg_solver multigrid_cg_solver

multigrid_cg_solver	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): gmres (default), sor, bjacobi, gmres, bicgstab, or lu		
Limitation(s): None		

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`multigrid_cg_solver`, continued...

Description: This card is used to control the solver used on the coarsest grid of multigrid. The options are: • `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` card
Notes: NONE SPECIFIED

multigrid_cg_solver_its multigrid_cg_solver_its

`multigrid_cg_solver_its`	Integer	Optional
Units: N/A		
Applicable Value(s): 15 (default), Any positive integer.		
Limitation(s): NONE SPECIFIED		
Description: Number of cg_solver iterations to perform on coarsest grid of the multigrid solver.		
Notes: NONE SPECIFIED		

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: None		

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, gmres, bicgstab, or lu		
Limitation(s): None		

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`multigrid_cg_solver_1G`, continued...

Description: This card is used to control the solver used on the coarsest grid of multigrid. The options are: • `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` card
Notes: NONE SPECIFIED

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), Any positive integer.		
Limitation(s): NONE SPECIFIED		
Description: Number of cg_solver iterations to perform on coarsest grid of the multigrid solver.		
Notes: NONE SPECIFIED		

multigrid_cg_tol_1G multigrid_cg_tol_1G

`multigrid_cg_tol_1G`	Float	Optional
Units: N/A		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Set the tolerance for the coarsest grid on the 1G multigrid system.		
Notes: None		

multigrid_smoother multigrid_smoother

`multigrid_smoother`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): sor (default), sor, bjacobi		
Limitation(s): None		

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`multigrid_smoother`, continued...

Description: This card is only used when petsc_linear_solver_method is set to multigrid, or if petsc_linear_solver_method_1G is set to set to multigrid, and the corresponding 1G quantity is not available. The same is true of any card beginning with "multigrid_". This card is used to control the smoother used on all but the coarsest grid in multigrid. The options are: • `sor` – PCSOR from PETSc. It's not really SOR since we don't 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: NONE SPECIFIED

multigrid_num_smooth multigrid_num_smooth

`multigrid_num_smooth`	Integer	Optional
Units: N/A		
Applicable Value(s): 1/0 (default), Any positive integer.		
Limitation(s): None		
Description: This card 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: NONE SPECIFIED		

multigrid_smoother_1G multigrid_smoother_1G

`multigrid_smoother_1G`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): sor (default), sor, bjacobi		
Limitation(s): None		
Description: This card is only used when petsc_linear_solver_method_1G is set to multigrid This card is used to control the smoother used on all but the coarsest grid in multigrid. The options are: • `sor` – PCSOR from PETSc. It's not really SOR since we don't 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: NONE SPECIFIED		

multigrid_num_smooth_1G multigrid_num_smooth_1G

`multigrid_num_smooth_1G`	Integer	Optional
Units: N/A		
Applicable Value(s): 1/0 (default), Any positive integer.		
Limitation(s): None		
Description: This card 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: NONE SPECIFIED		

multigrid_log_flag multigrid_log_flag

`multigrid_log_flag`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): false (default), true or false		
Limitation(s): None		
Description: This card 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. You must also provide MPACT with the command line option -pc_mg_log at runtime.		
Notes: NONE SPECIFIED		

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 or false		
Limitation(s): None		
Description: This card 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. You must also provide MPACT with the command line option -pc_mg_log at runtime.		
Notes: NONE SPECIFIED		

multigrid_precond_flag multigrid_precond_flag

`multigrid_precond_flag`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): false (default), true or false		
Limitation(s): None		
Description: Setting this card to true makes the code use multigrid as a preconditioner to GMRES rather than as a standalone solver.		
Notes: NONE SPECIFIED		

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 or false		
Limitation(s): None		
Description: Setting this card to true makes the code use multigrid as a preconditioner to GMRES rather than as a standalone solver.		
Notes: NONE SPECIFIED		

multigrid_cg_solver_its multigrid_cg_solver_its

multigrid_cg_solver_its	Integer	Optional
Units: N/A		
Applicable Value(s): 15 (default), Any positive integer.		
Limitation(s): NONE SPECIFIED		
Description: Number of cg_solver iterations to perform on coarsest grid of the multigrid solver.		
Notes: NONE SPECIFIED		

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 described as: • `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.		
Limitation(s): None		
Description: This card is used to specify which eigenvalue solver will be used.		
Notes: CMFD must be present for every 3-D problem because it is the basis for the solution transfer between 2-D and 1-D.		

k_shift k_shift

k_shift	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.5 (default)		

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`k_shift`, continued...

Limitation(s): Can only be used with the mgnode CMFD solver. This card is irrelevant unless the `constant` option is used for the `cmfd_shift_method` card.
Description: This card 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 only be used with the mgnode CMFD solver. This card is irrelevant unless the `constant` option is used for the `cmfd_shift_method_1G` card and the `msed` option is used for the `cmfd` card.		
Description: This card 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): description		
Description: NONE SPECIFIED		
Notes: NONE SPECIFIED		

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		

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cmfd_dhat_relaxation, continued...

Description: This card 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 under-relax the CMFD dHat update to provide stability for cases with very large flux gradients. For typical neutronics problems, no under-relaxation should be needed to achieve stability when using the CMFD option, and any under-relaxation will probably degrade the converegence rate. When running an external source driven problem, under-relaxation may be necessary to obtain convergence, In the most extreme cases, under-relaxation may 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 garuanteed!
Notes: NONE SPECIFIED

cmfd_shift_c0 cmfd_shift_c0

cmfd_shift_c0	Floating-Point Real Number	Optional
Units: N/A		
Applicable Value(s): 0.02 valuesapplicable (default), NONE SPECIFIED		
Limitation(s): Can only be used with the mgnode CMFD solver. This card is irrelevant unless the adaptive, ileps, or ilaps shift is being used.		
Description: This card 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_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 card 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 under-relax the CMFD dHat update to provide stability for cases with very large flux gradients. For typical neutronics problems, no under-relaxation should be needed to achieve stability when using the CMFD option, and any under-relaxation will probably degrade the converegence rate. When running an external source driven problem, under-relaxation may be necessary to obtain convergence, In the most extreme cases, under-relaxation may 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 garuanteed!		
Notes: NONE SPECIFIED		

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. See textttcmfd_shift_method card for description. This card is only applicable if a 1G CMFD system is being used to accelerate the MG CMFD system.		
Limitation(s): This card is only used if the CMFD card is set to msed		
Description: This card is used to specify which wielandt shift method will be used to accelerate the power iterations on the 1G CMFD problem.		
Notes: None		

cmfd_ktol cmfd_ktol

`cmfd_ktol`	Floating Point Number	Optional
Units: N/A		
Applicable Value(s): 1.e-6 (default), Any positive value.		
Limitation(s): None		
Description: This card is used to specify the tolerance for the convergence of k in the overall CMFD eigenavlue problem.		
Notes: NONE SPECIFIED		

cmfd_rtol cmfd_rtol

`cmfd_rtol`	Floating Point Number	Optional
Units: N/A		
Applicable Value(s): 1.e-6 (default), Any positive value.		
Limitation(s): None		
Description: This card is used to specify the tolerance for the relative residual reduction in a CMFD linear system solved each power iteration.		
Notes: NONE SPECIFIED		

cmfd_ktol_1G cmfd_ktol_1G

`cmfd_ktol_1G`	Floating Point Number	Optional
Units: N/A		
Applicable Value(s): 1.e-6 (default), Any positive value.		
Limitation(s): None		
Description: This card is used to specify the tolerance for the convergence of k in the 1G CMFD eigenavlue problem in MSED.		
Notes: NONE SPECIFIED		

cmfd_flxtol_1G cmfd_flxtol_1G

cmfd_flxtol_1G	Floating Point Number	Optional
Units: N/A		
Applicable Value(s): 1.e-6 (default), Any positive value.		
Limitation(s): None		
Description: This card is used to specify the tolerance for the convergence of the flux in the 1G CMFD eigenavlue problem in MSED.		
Notes: NONE SPECIFIED		

max_1G_eig_its max_1G_eig_its

max_1G_eig_its	Integer	Optional
Units: N/A		
Applicable Value(s): 20 (default), Any positive value.		
Limitation(s): None		
Description: This card is used to specify the maximum number of power power iterations allowed on the 1G CMFD system in MSED.		
Notes: NONE SPECIFIED		

cmfd_num_inners cmfd_num_inners

cmfd_num_inners	Integer	Optional
Units: N/A		
Applicable Value(s): 100 (default), Any positive integer.		
Limitation(s): None		
Description: This card is used to specify the max. number of linear solver iterations per power iteration during a CMFD acceleration calculation.		
Notes: NONE SPECIFIED		

cmfd_num_inners_1G cmfd_num_inners_1G

cmfd_num_inners_1G	Integer	Optional
Units: N/A		
Applicable Value(s): 100 (default), Any positive integer.		
Limitation(s): None		
Description: This card is used to specify the maximum number of linear solver iterations allowed per power iterations in the 1G CMFD system in MSED.		
Notes: NONE SPECIFIED		

linear_solver_tol linear_solver_tol

linear_solver_tol	Floating Point Number	Optional
Units: N/A		

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`linear_solver_tol`, continued...

Applicable Value(s): 1.e-10 (default), Any positive value.
Limitation(s): None
Description: This card is used to specify the tolerance of linear solver used at each power iteration during a CMFD acceleration calculation.
Notes: NONE SPECIFIED

linear_solver_tol_1G linear_solver_tol_1G

`linear_solver_tol_1G`	Floating Point Number	Optional
Units: N/A		
Applicable Value(s): 1.e-10 (default), Any positive value.		
Limitation(s): None		
Description: This card is used to specify the tolerance of linear solver used at each power iteration on the 1G system in MSED.		
Notes: NONE SPECIFIED		

cmfd_num_outers cmfd_num_outers

`cmfd_num_outers`	Integer	Optional
Units: N/A		
Applicable Value(s): 20 (default), Any positive value.		
Limitation(s): None		
Description: This card is used to specify the number of outer eigenvalue power iterations to perform during a CMFD acceleration calculation.		
Notes: NONE SPECIFIED		

cmfd_up_scatter cmfd_up_scatter

`cmfd_up_scatter`	Integer	Optional
Units: N/A		
Applicable Value(s): 2 (default), Any positive integer.		
Limitation(s): Only applies to `1gsweep` CMFD solver.		
Description: This card 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		

subplane_target subplane_target

`subplane_target`	Floating-Point Real Number	Optional
Units: cm (default)		

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`subplane_target`, continued...

Applicable Value(s): N/A (default), Positive real numbers
Limitation(s): None
Description: This card 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), Positive real numbers		
Limitation(s): None		
Description: This card is used to designate the maximum thickness of axial meshes in the CMFD system. All MOC planes with thicknesses greater than this will be sub-divided in the CMFD system using the `subplane_target` value.		
Notes: None		

subgrid_spacers subgrid_spacers

`subgrid_spacers`	Logical	Optional
Units: N/A		
Applicable Value(s): false (default), true,false		
Limitation(s): None		
Description: This card is used to designate whether or not spacer grids are 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: Thsi card is used to designate the number of subplanes used for each MOC plane in the CMFD system. Every MOC plane will be split into `num_subplanes` subplanes. This card overrides both the `subplane_target` and `subplane_max` cards. Any of these cards may be used to control the subplane meshing, but this card is recommended since the other two result in parallel imbalance.		
Notes: None		

cmfd_angle_decomp cmfd_angle_decomp

`cmfd_angle_decomp`	Logical	Optional
Units: N/A		
Applicable Value(s): true (default), false		
Limitation(s): If angle decomposition or CMFD is not used this card has no effect.		
Description: This card 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`	Logical	Optional
Units: N/A		
Applicable Value(s): true (default), false		
Limitation(s): Only applies to 3-D models run with 2-D/1-D.		
Description: This card is used to specify whether transverse leakage splitting will be enabled for a calculation using a 2-D/1-D method. In the 2-D/1-D method the axial transverse leakage is subtracted from the total fission and scattering sources, thus in regions with relatively large axial streaming sources, the total source may become negative. To avoid negative total sources the transverse leakage is split between the right hand side and left hand side of the 2-D transport equation, thus ensuring positivity of the total source and neutron balance.		
Notes: None		

split_RTL split_RTL

`split_RTL`	Logical	Optional
Units: N/A		
Applicable Value(s): true (default), false		
Limitation(s): Only applies to 3-D models run with 2-D/1-D.		
Description: This card is used to specify whether radial leakage splitting will be enabled for a calculation using a 2-D/1-D method. In the 2-D/1-D method the radial transverse leakage is subtracted from the total fission and scattering sources, thus in regions with relatively large radial streaming sources, the total source may become negative. To avoid negative total sources the radial leakage is split between the right hand side and left hand side of the 1-D 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. These are described as: • `lflat` — checks the total / transport cross section. If the value is below the threshold, leakage will not be put into that region. This process is usually to avoid leakage in the fuel-clad gap. It will then redistribute the leakage to the other regions in that pin. • `flat` — does not perform leakage threshold checks.		
Limitation(s): None		
Description: This card is used to specify the type of spatial shape of the axial transverse leakage applied to the 2-D problem. Flat means it is constant over a pin cell. This is primarily used to ensure stability of the iteration.		
Notes: None		

nodal_method nodal_method

`nodal_method`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): sp3 (default), sanm, sn-0, sn-1, sn-2, sn-3, p1, p3, p5, hyp3, fhp1, fhp3, none. Described as:		
Limitation(s): Only applies to 3-D models run with 2-D/1-D.		
Description: This card is used to specify the type of nodal axial solver that will be used to solve the 1-D portion of the 2-D/1-D solution.		
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.		

Input Option	Full Name
SANM	Semi-Analytic Nodal Method
NEM	Nodal Expansion Method
NEM-MG	Multi-Group 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
P3	Pn 3rd Order with One-Node NEM
P5	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
NONE	Finite-Difference Method

sntype sntype

`sntype`	Character String	Optional
Units: N/A		
Applicable Value(s): , isotropic, aziint, explicit, moment, p3-moment, none		
Limitation(s): Only applies to 3-D models run with 2-D/1-D.		
Description: This card is used to specify the type of axial sn sweeper that will be used to solve the 1-D portion of the 2-D/1-D 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		

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`homtype`, continued...

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 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 aniosotropic XS, which 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 2-D/1-D.		
Notes: None		

mesh mesh

`mesh`	Fixed Character String Followed by Two Arrays of Integers Separated by a '/'	Required
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 sub-divided radii.		
Limitation(s): None		
Description: This card is used to specify the radial and azimuthal mesh for each cell. Currently two cell types are used: `fuel` and `gtube`. 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 sub-divided radial ring. The last azimuthal value applies to the region outside the pin.		

continued on next page...

`mesh`, continued...

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 3 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 1 radial sub-division, and the fourth subdivided radius to the end of the pin cell would have 8 azimuthal sub-divisions, including the region outside the pincell. If the mesh is specified too finely, or rather, finer than the value for ray spacing, instabilities may occur where 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 above 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` needs to be well over 100 for this problem to arise, and this number is impractical given the memory it will consume.

prompt prompt

`prompt`	Fixed Character String	Required
Units: N/A		
Applicable Value(s): , `true`		
Limitation(s): None		
Description: This option is used to specify whether to use prompt kinetics calculation during the transient solver. The default is true. For now, this option is set to be true, no matter which option is input.		
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. See texttcmfd_shift_method card for description. This card is only applicable if a 1G CMFD system is being used to accelerate the MG CMFD system.		
Limitation(s): This card is only used if the CMFD card is set to msed		
Description: This card is used to specify which wielandt shift method will be used to accelerate the power iterations on the 1G CMFD problem.		
Notes: None		

1gacceltr 1gacceltr

1gacceltr	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Flag for 1GCMFD acceleration for transport part of transient simulations.		
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	Boolean	Optional
Units: N/A		
Applicable Value(s): false (default), true		
Limitation(s): None		
Description: Flag for using 1GCMFD for fission source and MGCMFD for flux (true) or using 1GCMFD for flux (false)		
Notes: None		

delayenergy delayenergy

delayenergy	Fixed Character String	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 solver. The default is false. The equilibrium delayed energy (about 7 percent of total fission energy including delayed beta and gamma) is assumed in default.		
Notes: None		

kinetics_data kinetics_data

kinetics_data	Fixed Character String	Optional
Units: N/A		

continued on next page...

kinetics_data, continued...

Applicable Value(s): library (default), scale,keepin,tuttle,jeff3,santamarina,library,spert70f,spert250f,spert500f. These are described as: 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 MPACT cross section library from ENDF 7. `spert70f,spert250f,spert500f` — the 6-group transient data measured in spert experiments
Limitation(s): None
Description: This card is used to specify the set of kinetics data used in transient calculation. This card is only applied to MPACT cross section library for now. By default, MPACT uses the 6-group transient data provided in MPACT MG cross section library.
Notes: None

kinetics_lambda kinetics_lambda

`kinetics_lambda`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): fissweight (default), isotopic,fissweight,precursorconsv. These are described as: 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		
Limitation(s): None		
Description: This card controls the calculation of decay constant for each fissile region. The isotopic lambda is the exact approach, but can use a lot more memories. In general, it is recommended to use precursor conservation option rather than fission source weighting.		
Notes: None		

kinetics_otfbeta kinetics_otfbeta

`kinetics_otfbeta`	Fixed Character String	Optional
Units: N/A		

continued on next page...

`kinetics_otfbeta`, continued...

Applicable Value(s): false (default), `true`
Limitation(s): None
Description: This option specifies whether to compute the problem dependent nubar for on-the-fly calculation of beta. By default, problem-independent beta computed from a typical PWR spectrum is used.
Notes: None

rx_components rx_components

`rx_components`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): , `true`		
Limitation(s): Can only be used 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 steadystate 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 card is used for separating flux shape reactivity.		
Notes: None		

summary_edits summary_edits

`summary_edits`	Fixed Character String	Optional
Units: N/A		
Applicable Value(s): , `true`		
Limitation(s): Only used for transient cases.		
Description: This option is used to specify whether to print a summary file (¡caseid¿.sum) containing data for each transient timestep. The default is false. This option is ignored for steadystate calculations.		
Notes: None		

split_TL split_TL

`split_TL`	Logical	Optional

continued on next page...

split_TL, continued...

Units: N/A
Applicable Value(s): true (default), false
Limitation(s): Only applies to 3-D models run with 2-D/1-D.
Description: This card is used to specify whether transverse leakage splitting will be enabled for a calculation using a 2-D/1-D method. In the 2-D/1-D method the axial transverse leakage is subtracted from the total fission and scattering sources, thus in regions with relatively large axial streaming sources, the total source may become negative. To avoid negative total sources the transverse leakage is split between the right hand side and left hand side of the 2-D transport equation, thus ensuring positivity of the total source and neutron balance.
Notes: None

tmllevel nCMFD nEPKE/n1GCMFD n1GCMFD/nEPKE

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. Is always the first entry in the /textttmllevel card		
Notes: Is only used when /texttttml 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. If there are only 2 numbers listed in the /textttmllevel card, the second number should be /texttnEPKE. If there are 3 numbers listed in the /textttmllevel card, the third number should be /texttnEPKE.		
Notes: Is only used when /texttttml 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. This variable is only set if there are 3 numbers listed in the /textttmllevel card. In which case, the second number is /texttnEPKE.		
Notes: Is only used when /texttttml is set to `true`.		

transmethod transmethod

`transmethod`	Fixed Character Array, Postive Real Number or Integer. Length 1	Optional
Units: N/A		
Applicable Value(s): {`theta 0.5`} (default), The first option is used to specify time the discretization method, `theta` refers to theta method and `BDF` refer to 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, the default order is 2		
Limitation(s): None		
Description:		
Notes: None		

timestep timestep

`timestep`	Fixed double precision numbers. Length 3	Optional
Units: seconds (default)		
Applicable Value(s): , • `<dt>` — the standard time step for transient calculation • `<dt_min>` — the minimum time step for transient calculation • `<t_max>` — the end time for the transient		
Limitation(s): None		
Description: This is used for defining the time steps and transient simulation time		
Notes: Presently `<dt_min>` is ignored.		

perturb perturb

`perturb`	Array of String and doubles	Required
Units: N/A		

continued on next page...

perturb, continued...

Applicable Value(s): , This card is used to specify the parameters for drive the transient. The options for perturbing the system are as follows: • t1 — The start time of perturbation • t2 — The end time of perturbation • dt — The time step of perturbation (optional) For the option mat, its interpretation varies with the perturbation type. • STEP — For this perturbation type, the initial condition for the ith material is mat0(i), at time t2, it is turned into mat0 instantaneously. • RAMP — For this perturbation type, the initial condtion for the ith material is mat0(i). Then it changes gradualy from mat1(i) to mat2(i). This change is a fractional time weighted mixture of the two materials. The mixture at t1 is only mat1, halfway through the perturbation it is 0.5 (mat1) and 0.5 mat2. At the end of the perturbation, it is only mat2. • CONST — For this perturbation there are no changes to the system. • MVCR — This perturbation is for moving a bank of control rods. The rod positions are specified in [STATE] blocks corresponding to each time step occuring during the perturbation.
Limitation(s): None
Description:
Notes: None

mat_emit_src mat_emit_src

mat_emit_src	Fixed Character String.	Optional
Units: N/A		
Applicable Value(s): false (default), 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.		
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.		
Notes: None		

5.13. BLOCK MAMBA

A_NiFe2O4_out surface_prefactor

A_NiFe2O4_out	Floating-point Real Number	Optional

continued on next page...

A_NiFe2O4_out, continued...

Units: N/A
Applicable Value(s): , > 0
Limitation(s): None
Description: Prefactor for NiFe2O4 surface growth
Notes: None

E_NiFe2O4_out surface_activation_energy

E_NiFe2O4_out	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Activation energy for NiFe2O4 surface growth		
Notes: None		

A_NiFe2O4_in nucleation_prefactor

A_NiFe2O4_in	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Prefactor for NiFe2O4 nucleation		
Notes: None		

E_NiFe2O4_in nucleation_activation_energy

E_NiFe2O4_in	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Activation energy for NiFe2O4 nucleation		
Notes: None		

ksnb_Fe2O4 boiling_growth_rate

ksnb_Fe2O4	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Boiling enhanced surface growth rate		
Notes: None		

D_Ni diffusion_coefficient

D_Ni	Floating-point Real Number	Optional
Units: cm^2/s (default)		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Diffusion coefficient for Ni		
Notes: None		

D_Fe diffusion_coefficient

D_Fe	Floating-point Real Number	Optional
Units: cm^2/s (default)		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Diffusion coefficient for Fe		
Notes: None		

D_BOH3 diffusion_coefficient

D_BOH3	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

D_Li	Floating-point Real Number	Optional
Units: cm^2/s (default)		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Diffusion coefficient for Li		
Notes: None		

D_H2 diffusion_coefficient

D_H2	Floating-point Real Number	Optional
Units: cm^2/s (default)		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Diffusion coefficient for H_2		

continued on next page...

D_H2, continued...

Notes: None

CRUD_porosity porosity

`CRUD_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

`CRUD_solid_dens`	Floating-point Real Number	Optional
Units: g/cm^3 (default)		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Density of solid NiFe2O4		
Notes: None		

dep_frac fraction

`dep_frac`	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): 0.25 (default), > 0		
Limitation(s): None		
Description: Fraction of the B-10 reaction rate applied to depletion		
Notes: None		

chimney_htc htc

`chimney_htc`	Floating-point Real Number	Optional
Units: W/cm^2-K (default)		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Heat transfer coefficient inside a chimney		
Notes: None		

chimney_dens dens

chimney_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

chimney_rad	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

chimney_vf	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

CRUD_therm_cond	Floating-point Real Number	Optional
Units: W/cm-K (default)		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Thermal conductivity of precipitate in CRUD		
Notes: None		

CRUD_heat_capacity Cp

CRUD_heat_capacity	Floating-point Real Number	Optional
Units: J/g-K (default)		
Applicable Value(s): , > 0		
Limitation(s): None		
Description: Heat capacity for the CRUD skelaton		
Notes: Currently Cp is unused		

tke_scale factor

`tke_scale`	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 errosion		
Notes: None		

src_mult_A multiplier

`src_mult_A`	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

`src_mult_E`	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), > 0		
Limitation(s): None		
Description: Multiplier for activiation energy for source term model		
Notes: None		

steam_generator_age age

`steam_generator_age`	Floating-point Real Number	Optional
Units: years (default)		
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 this data from the restart file.		

sg_mult multiplier

`sg_mult`	Floating-point Real Number	Optional
Units: N/A		
Applicable Value(s): 1.0 (default), ≥ 0		
Limitation(s): None		

continued on next page...

`sg_mult`, continued...

Description: Multiplier on steam generator source term
Notes: This is required to scale the source term model to smaller reactor geometries, i.e. single asm.

mass_mult multiplier

`mass_mult`	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 asm.		

piping_age age

`piping_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 this data from the restart file.		

chem_mass_bal option

`chem_mass_bal`	Integer	Optional
Units: N/A		
Applicable Value(s): 0 (default), The options are: 1. 0 — no mass balance enabled (user must specify particulate NiFe2O4 concentration) 2. 1 — Mass balance will be calculated by MAMBA		
Limitation(s): None		
Description: Option to select mass balance model		
Notes: None		

model_erosion option

`model_erosion`	Integer	Optional
Units: N/A		

continued on next page...

model_erosion, continued...

Applicable Value(s): 2 (default), The options are: 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
Limitation(s): None
Description: Option to select erosion model
Notes: None

li_table boron lithium

li_table	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		

5.14. BLOCK RUN

email list_of_emails

email	Character String	Optional
Units: N/A		
Applicable Value(s): Default email is the users system email (default)		
Limitation(s): None		
Description: Email that is used to inform user of job status. A list of emails can be input by comma seperating the emails.		
Notes: None		

pmem memory per processor

pmem	Floating-point Number	Optional
Units: GB (default)		
Applicable Value(s): System memory per processor (default), Greter than 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), Greater than 0		
Limitation(s): None		
Description: Number of processors that will be used per node		
Notes: None		

walltime maximum expected runtime

`walltime`	Floating-point Number	Optional
Units: hours (default)		
Applicable Value(s): 24 hours (default)		
Limitation(s): None		
Description: The walltime that is used for pbs submission		
Notes: None		

6. EXAMPLES

This chapter includes several input examples. Additional examples can be found in the VERAIn Git repository.

6.1. EXAMPLE 1 – FULL-CORE

The first example is a complete input for a full-core problem. This problem is Problem 7 of the CASL Progression Benchmark Problems and is based upon 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:

- "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]
```

6.2. 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 CASL Progression Benchmark Problems. See:

- A. Godfrey, "VERA Core Physics Benchmark Progression Problem Specifications," CASL Technical Report: CASL-U-2012-0131-004, August 2014.

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 Problem 1, and show how blocks can be re-used in different input decks. These blocks are not included here, but 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
```

6.3. EXAMPLE 3 – 2D LATTICE GEOMETRY

The third example is a complete input for a 2D lattice. This problem is Problem 2A of the CASL Progression Benchmark Problems. See:

- A. Godfrey, "VERA Core Physics Benchmark Progression Problem Specifications," CASL Technical Report: CASL-U-2012-0131-004, August 2014.

A single-assembly is defined by creating a core with a 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* card with one level and defining reflective boundary conditions on the top and bottom of the core with the *bc_top* and *bc_bot* input cards.

This example problem also shows how multiple assembly, insert, and control types can be defined by using multiple *axial* cards 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 cards

  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
```

7. 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.

7.1. RUNNING A CASE

VERARun is run by specifying **verarun** on the command line, followed by the name of the input file. There are additional command line options that are shown below.

```
verarun <input file>
```

For example, if you input deck is called "2a.inp", you would enter:

```
verarun 2a
```

Additional command line options can be found by typing **verarun** with no arguments. Doing so will return the following options.

```
usage: verarun [-x] [-e email_addr] [-h] [-c config_file] [-N job_name] [-l]
               [-n nprocs] [-O] [--ppn cpus_per_node] [-m mem_per_process]
               [-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:
  -x, --dry-run         dry run only, create but don't execute the PBS script
  -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 job (mpiexec
                        -np param), defaults to value computed from input
  -O, --output-job-name
                        print the job name to stdout
  --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
  -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 case 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
```

7.2. VERARUN OUTPUT

Upon completion of a VERA job, several output files may be created depending on the code options used. Some typical outputs include:

- VERAIn XML file. This file is written upon the successful completion of VERAIn
- VERA HDF output file. This is a binary file with results that can be visualized in VERAView, or post-processed 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.

7.3. INPUT ERRORS

If the `verarun` command does not work, the user should make sure that it is in the path. The user may 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 the input processor (VERAIn), the errors will be written to the standard error file. Common errors from the input processor include

1. invalid keywords
2. invalid map sizes
3. invalid input options

If the input processor works correctly, an error may still occur in one of the VERA component codes. The user used look at the error message and consult the user manual for the component code.