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WIMS-D4M USER MANUAL
REV. 0

by

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I. INTRODUCTION

The Winfrith Improved Multigroup Scheme (WIMS) code has been used extensively throughout the world for power and research reactor lattice physics analysis. There are many WIMS versions currently in use. The D4 version selected by the RERTR program was originally developed in 1980[1]. It was chosen for the accurate lattice physics capability and an unrestricted distribution privilege. The code and its 69-group library tape 166259 generated in Winfrith were obtained from the Oak Ridge National Laboratory Radiation Shielding Information Center (RSIC) in 1992[2]. Since that time the RERTR program has added three important features. The first was the capability to generate up to 20 broad-group burnup-dependent macroscopic or microscopic ISOTXS cross sections for each composition of the unit cell[3], a new ENDF/B-V based nuclear data library[4], and a new Supercell option[3]. As a result of these modifications and other minor ones, the code is now named WIMS-D4M[5-6]. A supplementary reference guide can be obtained from the RSIC that contains detailed explanations of all user options, library contents, along with several sample problems. Primary applications of WIMS for research reactor modeling do not require an extensive knowledge of all WIMS user options. This user guide is primarily addressed to the needs of the research reactor community although the code can be used for most thermal reactor lattices. The guide is written based on the experience of the RERTR staff with WIMS-D4M and will discuss only the most needed options for research reactor analyses.

II. OVERVIEW OF METHOD OF SOLUTION USED TO OBTAIN BROAD-GROUP CROSS SECTIONS

WIMS uses transport theory to calculate the neutron flux as a function of energy and spatial location in a one dimensional cell. Two main transport options that are most frequently used are DSN (discrete ordinates) and PERSEUS (collision probabilities). The transport solution can be performed with any user specified group structure up to 69-groups. This main transport solution is preceded by a SPECTROX flux spectra calculation for few spatial regions in 69 energy groups. It uses the SPECTROX flux solution to collapse the 69-group cross sections into the number of intermediate groups (FEWGROUPS) used in the main transport solution. Therefore, WIMS produces a SPECTROX eigenvalue as well as the main transport solution eigenvalue.

WIMS-D4M includes collision probability-based algorithms to model pin cells in a regular (x,y) array or rod clusters in a (r,θ) array. The algorithms do not provide an exact two-dimensional flux solution, but rather give a good approximation. The MULTICELL and cluster cell models have not been used extensively by RERTR staff, but are probably familiar to many WIMS users in the international community.

WIMS-D4M also has a homogeneous infinite medium flux solution using either the DSN or PERSEUS transport method.

After completion of the main transport solution, the intermediate group cross sections are collapsed to the broad group structure (≤ 20 groups) and may be written in the microscopic or macroscopic ISOTXS format for use in subsequent transport or diffusion theory codes. The microscopic ISOTXS cross sections contain the full P_o and P_1 scattering matrices for transport calculations, but their primary use will be in multigroup diffusion theory analyses. The cross sections are also burnup and spatially dependent. Further details of methods utilized to obtain these cross sections are in included in the reference list[3].

III. COMPUTATIONAL METHODS EMPLOYED

This section provides an overview of the methods used in WIMS. The information provided here should be sufficient for most users. More details on the code structure and methods are provided in Vol. 2, "Programmer's Manual".

3.1 SPECTROX Flux Solution

A SPECTROX one-dimensional, 69-group, coarse mesh collision probability flux solution is usually performed for an average unit cell at the beginning of the WIMS problem. The SPECTROX cell is determined by summing all fuel, clad, coolant, and moderator regions and constructing an "average" cell for the SPECTROX calculation. If only one fuel, clad, and coolant region is being modeled, then the SPECTROX calculation is performed for the single unit cell using one mesh point per region. The SPECTROX flux solution uses resonance self-shielded cross section data. The 69-group fluxes are used to collapse the cross sections for each material in each region of the cell to the number of main transport groups selected for the intermediate group structure.

The SPECTROX flux solution can be avoided for any or all materials if requested. If the user is requesting 69 main transport groups, the use of the SPECTROX flux solution is redundant. Also, for some complicated cells with multiple fuel regions or water holes, the method WIMS uses to construct the average cell can be detrimental for obtaining a representative 69-group flux spectrum. Exclusion of certain materials from the SPECTROX flux solution would be advisable in such cases. The Supercell option may also be appropriate (see Sect. 3.6). If a moderator region as well as a coolant region are specified in the model, the moderator zone will also be included in the SPECTROX calculation.

3.2 Main Transport Solution

The user must decide which transport solution is most appropriate for the cell being modeled. For most applications, the user usually selects either the PERSEUS (collision probability) or DSN (discrete Sn) transport solution methods. Either of these two methods can be used for single or multicell models in either slab or annular geometry. The other transport solution options available, which have not been used at ANL, are PIJ-PERSEUS and PRIZE-PERSEUS. These options model detailed rod-cluster geometries using one-dimensional transport solutions. For smaller unit cells, the PERSEUS method is recommended for shorter running times and good quality flux solutions. The DSN method is recommended for larger unit cells that might be more difficult to converge or require more core memory using the PERSEUS method. Using the DSN method the user has more control over the accuracy of the flux solution by choices in the Sn order and mesh widths. The main transport solution convergence criterion is controlled by selection of the TOLERANCE parameter.

The main transport group structure is usually less than the 69 library groups and more than the desired broad-group structure for subsequent diffusion or transport core calculations. As few as five main transport groups have been found to be an adequate predictor of flux spectrum and cell reactivity for simple three-region HEU unit cells. With the reduction in enrichment and additional regions modeled in a unit cell, more groups are required to be nearly equivalent to the same flux solution with the full 69 groups. It is recommended that 20-30 main transport groups be routinely used for most analyses and depletion studies. Approximately half of these groups will be in the thermal range below 4 eV and the remainder in the fast energy range. The difference in reaction rates and cell reactivity between the use of 30 and 69 main transport groups is usually very small.

The selection of the number of mesh points in a given region is primarily dependent on the mean-free path of thermal neutrons in a material. Strong thermal absorbers require more mesh points than structural or coolant materials. Difficulties in convergence of the main transport calculation can be encountered for unit cells with more than 100 mesh points. This usually occurs in cells with large regions with very small or very large absorption rates. A word of caution should be added that these unconverged cases do not abort but simply keep searching for convergence for exceedingly long periods of time.

3.3 Reaction Rate Edits

The reaction rate edits are for capture and fission events only. They are nuclide, group, region, and temperature dependent. The reaction rate group structure must have the same structure as the main transport solution or use fewer groups collapsed from the main transport group structure. These reaction rates are edited at each depletion time step unless selectively omitted. A unity-normalized reaction rate summary table is calculated at the end of each edit for all isotopes present in the reaction rate edit. The summary is normalized to one neutron absorbed in the cell.

3.4 Burnup of Unit Cell

There are two different timestep types for fuel depletion calculations. One has no change in flux spectrum between timesteps, the other is a recalculation of the flux spectrum for each timestep interval. The recalculation of flux spectrum for each depletion step is the recommended method. Another equally important consideration is the selection of timestep interval. In principle, the shorter the timestep interval the more accurate depletion one obtains. It is recommended that one use a very fine timestep case to check any coarser timestep depletion case. During the rapid buildup of equilibrium xenon, short time steps are needed. Comparisons with other codes suggested that smaller timesteps may be needed with WIMS. One should also be cautious about increasing the timestep interval near end of life. One should seek to find a maximum acceptable cell reactivity decrease per timestep that will yield results nearly identical to the fine timestep depletion mode.

The fuel depletion model uses 35 active fission products with the remaining fission products placed into one lumped fission product material. The choice of 35 fission products was based on reactor physics analyses performed at Winfrith. Our experience has shown that for long fuel lifetimes this fission product model is acceptable. For shorter fuel lifetimes additional fission products may be needed.

The only fuel depletion reactions that WIMS recognizes are absorption, fission, and decay. Other reaction types are not modeled. The (n, 2n) reaction is modeled as a negative absorption event. The fission product chains are identical to those used in the original WIMS-D4 code with the addition of I-135 and Pm-149 as precursors of Xe-135 and Sm-149, respectively. Other absorption event chains are provided for some reactor burnable poisons such as Cd-113, B-10, Er-166, and Er-167. A complete list of all depletion chains present in the existing WIMS-D4M library are given in Appendix A. Currently, depletion of materials in a unit cell must occur only in regions identified as fuel.

3.5 Generation of ISOTXS Cross Sections

Historically, WIMS-D4 generates cell-averaged, broad-group macroscopic cross sections in e.g. a SCRAMBLE output format. In order to use WIMS cross section data in the codes DIF3D, REBUS, and TWODANT, it was necessary to create a data interface in WIMS-D4M to compute and write broad group microscopic cross sections in the ISOTXS format. Most users request the microscopic option for generating ISOTXS data at selected burnup steps. However, one may also use the macroscopic option to write ISOTXS data. Other cross section formats may also be selected (see SIGPUNCH and ISOXS in Section 5.6).

The microscopic ISOTXS format allows the user to model each neutron reaction that is available on the cross section library. The original WIMS-D4 cross section library did not provide for this possibility so a secondary WIMS-D4 library was added such that each neutron reaction could be modeled in subsequent diffusion or transport theory core calculations. The primary WIMS-D4 library remains unchanged in format, while the secondary library expands the information that can be put into ISOTXS data files. Not only are more neutron reactions modeled, but also energy-per-capture data have been added for each material in the library. The energy per fission is present in the primary library. The secondary library provides a full complement of P_1 cross section data.

3.6 Supercell Model

The Supercell option eliminates some of the SPECTROX limitations (fuel, clad, coolant, [moderator] single mesh regions), provides properly homogenized and resonance-corrected cross sections for subsequent use in a more complex geometry, and supports the treatment of multiple resonance materials. A generalized SPECTROX solution can be selected with more spatial mesh per region. The Supercell model may be more appropriate for the treatment of experiment, reflector, and control regions. Using standard CELL or

SEQUENCE options in WIMS-D4, only one resonance material is permitted in each unit cell. This Supercell option is necessary when modeling control rod cells containing resonance materials or cells with more than one type of fuel material. More details on the application of this option are provided in Section 5.9.

IV. INPUT OPTIONS IN PRELUDE DATA

4.1 Method of Solution

The SEQUENCE keyword is used to select the main transport routine to be used. The PERSEUS collision probability method is recommended for most applications. The DSN method should be used when higher S_n orders are required for large cells. The CELL keyword defines the cell type. One option is for a single homogeneous material. This calculation must be performed using all 69 library groups.

4.2 Accuracy of Solution

The first numerical entry following the NGROUP keyword sets the number of main transport groups that will be used. Large numbers of groups usually result in a more accurate flux and cell reactivity calculation. If fewer than 69 groups are used, the accuracy of the solution also depends on where the group boundaries are assigned. If cross section data are slowly changing over a given group interval, the quality of the flux solution is not compromised by using a larger group interval. In addition, the number of group intervals should be increased in energy ranges with the highest reaction rates. This usually occurs in the thermal energy range. For LEU fuels, more reactions occur in the resonance region requiring additional care to the assignment of NGROUP for this region.

The NMESH keyword sets the total number of mesh points in the main transport calculation. There is an optimal number of points that should be used for each unit cell. Use of fewer than the necessary number can cause inaccurate flux solutions to be calculated. Use of more mesh lines than necessary results in the best flux solutions but with less efficient use of computational resources.

4.3 Dimensions of Geometry and Composition Descriptions

The NREGION keyword sets the number of regions or zones in a given unit cell. The number of regions in a unit cell is determined by changes in the material properties of a cell

or the need to edit the neutron spectra or reaction rates within a given material. The NMATERIAL keyword sets the number of materials described in the MATERIAL cards. It is commonly referred to as the number of compositions. If the same composition is present with more than one temperature, it must be counted more than once on the NMATERIAL card.

The NPLATE keyword is a slab geometry specification indicating the number of fuel plates to be included for self-shielding in the SPECTROX calculations. The NCELL keyword indicates how many cell types are present for multicell calculations.

4.4 Reaction Rate Selection

The NREACT keyword sets the number of nuclide reaction rate edits to be edited. These reaction rate edits are region, temperature, and group dependent. The number of groups for these edits is specified in the second entry on the NGROUP card. The group structure for these edits is input on the PARTITION card in the main data section. The actual isotopes to be edited are specified on the REACTION card, also in the main data section.

V. INPUT OPTIONS IN MAIN DATA

5.1 Geometry

For one-dimensional slab or radial geometry cases the dimensions of the unit cell are given using the SLAB or ANNULUS keywords. There is no limit to the number of SLAB or ANNULUS cards that may be necessary to describe any unit cell. For very large cells, convergence problems can emerge. The POLYGON keyword is used to specify the number of cell boundaries that are present in the unit cell lattice array. The DANCOFF factor is properly calculated for the lattice described. The code does not perform an exact calculation of a unit cell with a polygonal boundary but uses an equivalent volume annular outer region.

5.2 Composition

The MATERIAL cards are used for specifying the compositions to be used in the unit cell. These cards allow the user to specify the density, temperature, and spectrum type. If the user wishes to use atoms/b-cm for isotopic density specifications, one must set the second number following the MATERIAL card equal to -1. The spectrum type field is important for the setup of the SPECTROX calculation. Use of spectrum = 4 for moderator zones should be

used with caution. The DANCOFF factor will be altered by inclusion of a moderator zone, which may not be the user's intent. This change can be overcome by specifying the DANCOFF factor and not allowing WIMS to calculate it. Unit cells with large moderator zones relative to the unit cell volume can result in fluxes that do not agree well with identical Monte Carlo results.

For WIMS multiple step cases, the MATERIAL can be altered in subsequent steps by reintroducing the MATERIAL card or by introducing a TEMPERATURE or DENSITY card.

5.3 Lattice Characteristics

The lattice geometry of the unit cell determines the DANCOFF and BELL factors. A resonance group-dependent DANCOFF factor is calculated by WIMS. A default value of the BELL factor of 1.16 is used unless the user overrides this default. One expression for the BELL factor is given by Leslie, et al.,[7]

$$a = \frac{b^2}{b^2 - 1.866\ (1-C)},$$

where

$$b = 2.366 + \sqrt{1-C}$$

and

1-C = DANCOFF factor

a = BELL factor

The DANCOFF factor can be input as a group-dependent or group-independent parameter. If the user is modeling a unit cell in a REGULAR lattice array, use of the REGULAR keyword forces a calculation of the BELL and DANCOFF factors. The use of a BELL factor equal to 1.4 for all slab geometry unit cells has been found to be the better choice when using the ENDF/B-V data library.

The FREE keyword can be used to obtain no return current (vacuum) boundary conditions.

5.4 Burnup

The POWERC keyword determines how fuel depletion or other types of separate dependent WIMS cases will be calculated. The recommended fuel depletion parameter selection for POWERC is 1) input the specific power in MW/Kg of initial heavy metal, 2) specify the timestep interval in days, and 3) request flux spectrum recalculation before each timestep. Other options for burnup are described in the RSIC WIMS-D4 input description. The POWERC must be used each time the user wishes to change the timestep characteristics, otherwise the fuel will continue depletion using the most recent POWERC specification. The user must have two BEGINC cards for each burn step.

5.5 Reaction Rate Edits

The REACTION and PARTITION cards are needed for any reaction rate edits to be calculated in WIMS. The LEAKAGE card can also be added for a leakage spectrum to be imposed on the edited reaction rates. The REACTION card is used to specify the isotope identification numbers and temperatures. The PARTITION card is used to set the reaction rate group structure collapsed from the main transport group structure. The absorption, fission, and nu*fission reaction rates are edited. The sum of all absorption rates is unity. The edit provides reaction rates for each group and the sum of all groups for a given isotope in a specified region of the unit cell. A tabulation of all three reaction types is provided for each isotopic material summed over all groups and regions in the unit cell at the end of the reaction rate edits. This is useful in comparisons with other codes.

5.6 Writing ISOTXS Cross Sections

In order to write either micro or macroscopic ISOTXS-formatted cross sections to an output data file, nine card types must be provided as part of WIMS-D4M input. A brief explanation of each input specification follows:

ISOXS imacro imicro nburn ipfp ism0 isec ispr ilfp ivel

1	imacro -	0/1 No macroscopic data/Write macroscopic data file MACRXS.
2	imicro -	0/1/3 No microscopic data/Write microscopic ISOTXS file/also write macroscopic data formed from microscopic.
3	nburn -	1/n No burnup/n burn steps to be processed.
4	ipfp -	0/1 No LFP assigned/Assign LFP.

5	ism0 -	0/1 No LFP MCNPXS/Generate LFP MCNPXS file.
6	isec -	0/1 No secondary library/Secondary library used.
7	ispr -	0/1/2 Edit all ISOTXS data/Principal cross section data only/Labels only.
8	ilfp -	0/1 Microscopic LFP/Macroscopic LFP formed.
9	ivel -	0/m Use velocities from edit set 1/Use velocities from edit set m.

ISOXS cards control many options that may be selected in the writing of not only ISOTXS but MACRXS and MCNPXS, as well. MACRXS is a macroscopic cross-section set written in the binary ISOTXS format. With burn-up dependent cases, the number of burn steps is set as nburn. Lumped fission products (LFP) may be included by setting the flag ipfp. On option, the code will write 69-group LFP data for the MCNP code in the file MCNPXS at selected burn steps. The ENDF/B-V library, as noted earlier, consists of a primary and secondary library, and WIMS-D4M may be run with only a single (or primary) library, including the original WIMS library, by using the flag isec. With the flag ilfp, the user may elect to write LFP as macroscopic data in ISOTXS. Since multiple edit sets (see EDITCELLS Card) may be selected, the user must select which velocities are to be used for the ISOTXS data. The edit cells are specified through the REGION card for macroscopic ISOTXS, and EDITCELLS for microscopic ISOTXS.

REGION (ifirst (i), ilast (i), i = 1, ipairs)

ifirst (i)	First spatial region numbers in the i-th set of pairs.
ilast (i)	Last spatial region number for the i-th set of pairs.
ipairs	Number of sets of pairs of region edits on the REGION card.

This REGION card allows the input of spatial region number pairs that define a range of regions, i.e. edit sets, over which macroscopic cross-section data are to be extracted. The last set should cover the entire cell (if no REGION card is present, this is the default edit).

LETTERS n
X Y Z . . .

n Number of letters entered on the following card defining labels for edit regions defined by the above REGION card data.

X Letter to be used for the first edit region label to make 'Xj km', where j = ifirst (i), k = ilast (i) and m is the burn step number, etc.

Thus, an A6 label is made up that shows the range of regions for the edit set and the burn step that make up the macroscopic data accumulated for each selected burn step in the ISOTXS format as MACRXS. The letters for the label must be input in a 30A2 format on the line following the LETTERS card. If no LETTERS card is present, a default sequence of A B C . . . is assigned.

HUSE
fileid

fileid A twelve character identifier for either the ISOTXS or MACRXS files, where the string is entered on the line following the HUSE card.

HSETID
setid

setid A 72 character set identifier for either the ISOTXS or MACRXS files, where the string is entered on the line following the HSETID card..

The following ISOTOPES and ISONAMES cards are used to select and label isotopic data to be included in the microscopic data for the ISOTXS file:

ISOTOPES (isonum (i), i = 1, nmicro)

isonum (i) The i-th isotope number selected for inclusion in the ISOTXS data. This must correspond to an isotope number identification in the WIMS-D4M cross section library (see also ISONAMES card). With burnup dependence, lumped fission product data may be included in the set with the default label of PFP1, and with multiple sets duplicate labels can be generated. Thus, a new 901 isotope number has been assigned for the lumped fission products only for the reassignment of a new isotope label in the ISONAMES set. The library contains no data for 901.

nmicro The accumulated number of isotope numbers entered on the card. The usual ($) continuation rules apply if additional input cards are needed.

ISONAMES
(isonam (i), i = 1, nmicro)

isonam (i) The i-th four character isotope label assigned in a one-to-one correspondence to the i-th isotope number selected on the above ISOTOPES card. The ISONAMES data must follow the ISOTOPES card input. The nmicro labels must be entered in a 12 (A4,2x) format on cards following the ISONAMES card. A burnup dependent A6 label is formed by combining the A4 label provided with a number (00-99) corresponding to the burnup steps.

The following card types have been added or significantly modified to control the edits and cross sections obtained from WIMS-D4M:

EDITCELLS (ismear (i), i = 1, nmat)

ismear (i) The i-th material region in the total of nmat materials assigned in the problem. All material regions assigned the same > zero integer are smeared into an edit set of microscopic ISOTXS data. Material regions assigned zero are not included. If the number entered is less than nmat, zeros are assigned. Multiple edit sets may be assigned, e.g. 1 1 1 2 assigns the first three material regions to the same edit set while the fourth material region is assigned to a second edit set. An isotope that appears in more than one material will be averaged over the edit set.

PRTOPT n

n Only a value of 1 is currently used. The presence of the PRTOPT card following the INITIATE card restores the full original edits, while omission of the card (or n = 0) gives a much-shortened form of the output as the default.

IBURN (ibn (i), i = 1, nburn)

ibn (i) Data control for the i-th burn step, where a value of zero includes cross section data for the selected isotopes in ISOTXS or a value of one omits data for that burn step. The number of burn steps, nburn, is the value entered on the ISOXS card. If fewer numbers are entered, a value of

zero is assigned. Data at each burn step are included when no IBURN card is present.

IREACT (irt (i), i = 1, nburn)

irt (i) Reaction rate data control for the i-th burn step, where a value of zero allows reaction rates to be computed for the selected nuclides or a value of one omits any computation for that burn step. A value of zero is assigned for burn steps omitted when no card is present.

SIGPUNCH The use of the SIGPUNCH card has been reassigned to now signal the writing of macroscopic data at each selected burn step to the file MACRO.XS for use with WIMSIT/UM2DB or UM3DB codes.

The following keywords have been disabled as no longer relevant to the current version of the code: BORON, CALEB, GOG, KRYPTON, MISCELLANEOUS, ODDS, OPTION, SPU AND ZADOC.

5.7 Unit Cell Leakage

The default unit cell boundary condition of no net leakage at the unit cell boundaries can be modified by selecting either the DBSQUARED, BUCKLING, or BEEONE option. The DBSQUARED and BUCKLING options are described in the original WIMSD4 RSIC manual.

The leakage spectrum given in WIMS-D4M (chain 14) can now be included in the 69 group flux spectrum. This can be done with the n = 1 option of the following LEAKAGE card:

LEAKAGE m n

m The original spectrum type selection.

n 0/1 - no leakage treatment/use leakage spectrum from chain 14 for ISOTXS data.

The BEEONE option has been altered as follows:

BEEONE i n

i the original parameter for the BEEONE card.

n the number of nuclides in the primary library file having P1 scattering data (4 for the original WIMS-D4 library, 5 for the Romanian library with ZrH_x, and 7 for the ENDF/B-V library).

5.8 Multicell

In a multicell problem, the user defines two or more unit cells and assigns a probability that a neutron leaving one cell enters another cell. Thus, these multicell cases are not two-dimensional flux solutions but by assigning probabilities of neutrons entering another adjacent cell in the multicell problem the spatial flux changes can be approximated. This probability is approximated by the fraction of the perimeter of the first cell adjacent to the second cell. All of the needed options for a multicell case are fully explained in the RSIC manual. Note the examples 4 and 8 in Appendix C.

5.9 Supercell

Selecting CELL 8 will invoke the Supercell option expanding the number of resonance materials in a given WIMS case and improving the treatment of experiment, reflector and control regions. The following input is required:

CELL i n igeom isol ires chord

i	The cell type number assigned.
n	The number of cells of this type.
igeom	The cell geometry - 0/1 = cylindrical/slab.
isol	Method of solution - 0/1 = normal SPECTROX/generalized S_n.
ires	The ID of the additional resonance material number, if present in the cell.
chord	The mean chord length for the resonance region in the cell, if ires is non-zero.

CSPECTRUM k irn

k	A value of -1 is assigned for the first cell (Supercell geometry) or n for an auxiliary cell type.
irn	Resonance computation Standard/Alternate (See ires on Cell card) - 0/1.

NEWXS m icol idc mat

m	The material ID.
icol	Create a homogenous material from list mat - -1/1 = no/yes.
idc	The number of the auxiliary cell from which the collapsing flux spectrum is taken.
mat	The list of materials present in cell idc, if icol = 1.

At present only two materials in the Supercell model can be homogenized materials. For icol = 1 the intermediate group-structure cross sections are formed by homogenizing the list of material in mat, and the homogenized material in the MATERIAL card must have the following form:

MATERIAL m -1 temp spec id 1.0E-18

where temp and spec are the usual temperature and spectrum index input, (spec should be 1 if this is a resonance material and resonance shielding will be included), but id is any nuclide in the library to satisfy the code input processing. For icol = -1 the intermediate group structure cross sections are simply formed from the 69-group cross sections for material m.

The Supercell model includes the Supercell geometry, a detailed description, as cell type number one (1) followed by separate auxiliary cell types that may include a fuel cell for a resonance treatment (typical unit cell with fuel, clad and coolant), and experiment, reflector or control region cell(s) with a homogenized and resonance-corrected fuel region included as a source. Any important region in the reactor may be modeled as an auxiliary cell to provide an improved spectrum for the main Supercell model.

The auxiliary cells may contain fuel or control materials that require a separate resonance treatment. Without the Supercell option, each resonance isotope is assigned only one self-shielding correction. Therefore, if one tries to model a cell with two or more different thicknesses of coolant channel or fuel meat, or a separate resonance absorber, the standard model uses a single self-shielding approximation for each resonance isotope in the mix and introduces corresponding errors in the resulting cross sections. The Supercell option removes this limitation by expanding the number of regions (auxiliary cells) that can be assigned a separate resonance treatment (see ires and chord on CELL card and irn on CSPECTRUM card).

The Supercell option is not a single fixed prescription that can be applied to all problems, but rather a collection of tools that allow the user to break down a complex geometry into simpler cells (auxiliary cells - CELL 2, 3, etc.). These auxiliary cells provide optionally homogenized, resonance-corrected, and in general improved spectra over the selected regions of the problem. A SPECTROX or generalized S_n solution may be selected with the mesh selection no longer limited to one mesh per region (see isol on CELL card). The spectra by material are assigned through the NEWXS cards. The auxiliary cells may be combinations of slab, annular or pin geometries. The possibilities for the selection of different auxiliary cells is without limit, however, many different choices will give essentially

the same spectrum and end result. These auxiliary cell spectra are then included in the Supercell geometry (CELL 1) at the intermediate group level. With these improved spectra and resonance treatment the Supercell option should give improved results for a class of problems not well suited to the standard WIMS solution.

For example, when a small reactor with an experimental location at the center is modeled with the Supercell option, the Supercell geometry (CELL 1) should model as accurately as possible the actual reactor geometry. The first auxiliary cell (CELL 2) can be used to generate a homogenized and resonance shielded fuel material using a simple unit cell geometry (fuel/clad/coolant) with these materials combined using NEWXS. This new material can now be used in subsequent auxiliary cell(s), as well as, the Supercell. A second auxiliary cell (CELL 3) might consist of the central experimental geometry surrounded by a region of the homogenized fuel material. The central experimental location can contain experimental fuel or other resonance material which can be given a separate resonance treatment. An additional auxiliary cell (CELL 4) could be used to represent the materials exterior to the fuel region, e.g. reflector(s), vessel, etc. This cell might be a slab model with an inner slab of homogenized fuel from CELL 2 and additional slabs for coolant, vessel and reflector. The boundary conditions for such an auxiliary cell can be reflective on both the homogenized fuel center line and the outer reflector, or free boundary conditions can be applied at the outer reflector. The proper auxiliary cell spectra must be assigned in the NEWXS data materials, and these materials must be assigned to the proper regions of the Supercell. Some examples of the application of the Supercell option are provided in Appendix C.

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APPENDIX A

WIMS-D4M CROSS SECTION LIBRARY CONTENTS

Table 1
Materials Contained on WIMS-D4M ENDF/B-V Library

WIMS-D4M Label	Material Name	Depletable Material	Resonance Material	P1 data on Primary Library	Temp (K)
2001	HinH2O	no	no	yes	296,350,400,450
2191	HinZrH	no	no	yes	296,400,700,1000
2091	ZrinZrH	no	no	yes	296,400,700,1000
4002	DinD2O	no	no	yes	296,350,400,450
5002	DinD2O ENDF5 data w/ Winfrith transprt XS				296,350,400,450
9	Be	no	no	yes	296,400,500
10	B-10	yes	no	no	300
11	B-11	no	no	no	300
12	Graphite	no	no	yes	296,400,500,1000
16	O-16	no	no	yes	296,350,400,450,1000
27	Al-27	no	no	no	300
29	Si	no	no	no	300
52	Cr	no	no	no	300
55	Mn-55	no	no	no	300
56	Fe	no	no	no	300
58	Ni	no	no	no	300
167	Er-167	yes	yes	no	300,500,1000
91	Nat Zr	no	no	no	300
233	U-233	yes	yes	no	300,560,1000
1233	Pa-233	yes	yes	no	300,560,1000
1003	H-3	yes	no	no	300
3	He-3	yes	no	no	300
4	He-4	no	no	no	300
6	Li-6	yes	no	no	300
7	Li-7	yes	no	no	300
14	N-14	no	no	no	300
19	F-19	no	no	no	300
23	Na-23	no	no	no	300
63	nat Cu	yes	yes	no	300
176	Lu-176	yes	yes	no	300
92	Mo-92	no	no	no	300
94	Mo-94	yes	yes	no	300
95	Mo-95	yes(fp)	no	no	300
951	Mo-95	yes	yes	no	300
96	Mo-96	yes	yes	no	300
97	Mo-97	yes	yes	no	300
98	Mo-98	yes	yes	no	300
991	Mo-99	yes	no	no	300
100	Mo-100	yes	yes	no	300
83	Kr-83	yes(fp)	no	no	300
99	Tc-99	yes(fp)	no	no	300
101	Ru-101	yes(fp)	no	no	300
1103	Ru-103	yes(fp)	no	no	300
103	Rh-103	yes(fp)	no	no	300
105	Rh-105	yes(fp)	no	no	300
1105	Pd-105	yes(fp)	no	no	300
108	Pd-108	yes(fp)	no	no	300
127	I-127	yes(fp)	no	no	300
131	Xe-131	yes(fp)	no	no	300
133	Cs-133	yes(fp)	no	no	300
134	Cs-134	yes(fp)	no	no	300
135	Xe-135	yes(fp)	no	no	300
1135	Cs-135	yes(fp)	no	no	300
143	Nd-143	yes(fp)	no	no	300
145	Nd-145	yes(fp)	no	no	300
147	Pm-147	yes(fp)	no	no	300
1147	Pm-147	yes(fp)	no	no	300
2147	Sm-147	yes(fp)	no	no	300

WIMS-D4M Label	Material Name	Depletable Material	Resonance Material	P1 data on Primary Library	Temp (K)
148	Pm-148m	yes(fp)	no	no	300
1148	Pm-148	yes(fp)	no	no	300
149	Sm-149	yes(fp)	no	no	300
150	Sm-150	yes(fp)	no	no	300
151	Sm-151	yes(fp)	no	no	300
152	Sm-152	yes(fp)	no	no	300
153	Eu-153	yes(fp)	no	no	300
154	Eu-154	yes(fp)	no	no	300
155	Eu-155	yes(fp)	no	no	300
2135	I-135	yes(fp)	no	no	300
1149	Pm-149	yes(fp)	no	no	300
1238	Pu-238	yes	yes	no	300
166	Er-166	yes	yes	no	300,560,1000
112	Nat. Cd	yes	yes	no	300
178	Nat. Hf	yes	yes	no	300
107	Ag-107	yes	yes	no	300
1109	Ag-109	yes	yes	no	300
59	Co-59	yes	yes	no	300
197	Au-197	yes	yes	no	300
1155	Gd-155	yes	yes	no	300
1157	Gd-157	yes	yes	no	300
1115	In-115	yes	yes	no	300
232	Th-232	yes	yes	no	300,560,1000
234	U-234	yes	yes	no	300,560,1000
235	U-235	yes	yes	no	300,560,1000
236	U-236	yes	yes	no	300,560,1000
238	U-238	yes	yes	no	300,560,1000
3239	Pu-239	yes	yes	no	300,560,1000
240	Pu-240	yes	yes	no	300,560,1000
241	Pu-241	yes	yes	no	300,560,1000
242	Pu-242	yes	yes	no	300,560,1000
902	Lumped FP	yes	no	no	300
1113	Cd-113	yes	yes	no	300
207	Pb-207	yes	yes	no	300
109	Ag-109	yes(fp)	no	no	300
157	Gd-157	yes(fp)	no	no	300
115	In-115	yes(fp)	no	no	300
113	Cd-113	yes(fp)	no	no	300
1241	Am-241	yes	yes	no	300
24	Mg	no	no	no	300
3147	Nd-147	no	no	no	300
1143	Pr-143	no	no	no	300
1010	B-10	no	no	no	300
93	Nb-93	yes	yes	no	300,560,1000
1212	C-12	no	no	no	300
2012	HinCH2	no	no	no	296
164	Dy-164	yes	yes	no	300
163	Dy-163	yes	yes	no	300
162	Dy-162	yes	yes	no	300
161	Dy-161	yes	yes	no	300
160	Dy-160	yes	yes	no	300

Materials that are designated "resonance material" can be used as control or burnable absorbers. There are four materials that are both fission products and resonance materials. The fission product (fp) materials are assumed to be infinitely dilute.

TABLE 2
WIMSD4M ENDF/B-V LIBRARY RESONANCE MATERIALS

Material	Material ID	Resonance Data		σ_p (barns)
		Capture	Fission	
^{166}Er	166.1	yes	no	10^{10}, 10^5, $4x10^4$, 5000, 2500, 1000, 500
^{167}Er	167.1	yes	no	10^{10}, 10^5, $4x10^4$, 5000, 2500, 1000, 500
^{63}Cu	63.1	yes	no	10^{10}, 10.0
^{164}Dy	164.1	yes	no	10^{10}, 10^4, 1000, 500, 50, 10
^{176}Lu	176.1	yes	no	10^{10}, 10^4, 1000, 500, 50, 10
^{94}Mo	94.1	yes	no	10^{10}, 500, 10
^{95}Mo	951.1	yes	no	10^{10}, 500, 10
^{96}Mo	96.1	yes	no	10^{10}, 500, 10
^{97}Mo	97.1	yes	no	10^{10}, 500, 10
^{98}Mo	98.1	yes	no	10^{10}, 500, 10
^{99}Mo	99.1	yes	no	10^{10}, 500, 10
^{100}Mo	100.1	yes	no	10^{10}, 500, 10
nat Cd	112.1	yes	no	10^{10}, 10^4, 10^3, 500, 50, 10
nat Hf	178.1	yes	no	10^{10}, 10^4, 10^3, 500, 50, 10, .0001
^{107}Ag	107.1	yes	no	10^{10}, 10^5, 10^4, 10^3, 500, 100
^{109}Ag	1109.1	yes	no	10^{10}, 10^5, 10^4, 10^3, 500, 100
^{59}Co	59.1	yes	no	10^{10}, 10^5, 10^4, 10^3, 500, 100, 50, 10
^{197}Au	197.1	yes	no	10^{10}, 10^5, 10^4, 10^3, 500, 100, 50, 10
^{155}Gd	1155.1	yes	no	10^{10}, 10^4, 10^3, 500, 50
^{157}Gd	1157.1	yes	no	10^{10}, 10^4, 10^3, 500, 50
^{115}In	1115.1	yes	no	10^{10}, 10^4, 10^3, 500, 50, 10
^{207}Pb	207.1	yes	no	10^{10}, 10^3, 10
^{113}Cd	1113.1	yes	no	10^{10}, 10^4, 10^3, 500, 50, 10
^{93}Nb	93.1	yes	no	10^{10}, 5000, 750, 100
^{232}Th	232.1	yes	no	10^{10}, 5.0+4, 5000, 10^3, 500, 200, 75, 50, 25, 5
^{233}Pa	1233.1	yes	no	10^{10}, 10^5, $4x10^4$, 10^4, 5000, 2500, 10^3, 500
^{233}U	233.1	yes	yes	10^{10}, 10^5, $4x10^4$, 10^4, 5000, 2500, 10^3, 500
^{234}U	234.1	yes	yes	10^{10}, 10^5, $4x10^4$, 10^4, 5000, 2500, 10^3, 500
^{235}U	235.1	yes	yes	10^{10}, 5000, 2000, 10^3, 750, 500, 350, 200, 75, 25
^{236}U	236.1	yes	yes	10^{10}, 10^5, 4000, 10^4, 5000, 2500, 10^3, 500
^{238}U	238.1	yes	no	10^{10}, 10^4, 5000, 2000, 500, 250, 100, 50, 25, 5
^{238}Pu	1238.1	yes	yes	10^{10}, $5x10^4$, 5000, 10^3, 500, 200, 75, 50, 25, 5
^{239}Pu	3239.1	yes	yes	10^{10}, $5x10^4$, 5000, 10^3, 500, 200, 75, 50, 25, 5
^{240}Pu	240.1	yes	yes	10^{10}, $5x10^4$, 5000, 10^3, 500, 200, 75, 50, 25, 5
^{241}Pu	241.1	yes	yes	10^{10}, $5x10^4$, 5000, 10^3, 500, 200, 75, 50, 25, 5
^{242}Pu	242.1	yes	yes	10^{10}, $5x10^4$, 5000, 1000, 500, 200, 75, 50
^{241}Am	1241.1	yes	yes	10^{10}, $5x10^4$, 5000
^{160}Dy	160.1	yes	no	10^{10}, 10^4, 500, 50, 10
^{161}Dy	161.1	yes	no	10^{10}, 10^4, 500, 50, 10
^{162}Dy	162.1	yes	no	10^{10}, 10^4, 500, 50, 10
^{163}Dy	163.1	yes	no	10^{10}, 10^4, 500, 50, 10

TABLE 3
NON-FISSION PRODUCT DEPLETION CHAINS

Initial Nucleus	Reaction	Product Nucleus
Cd	(n, γ)	none
^{166}Er	(n, γ)	^{167}Er
^{167}Er	(n, γ)	none
^{232}Th	(n, γ)	^{233}Pa
^{233}Pa	(n, γ)	^{234}U
^{233}Pa	decay	^{233}U
^{233}U	(n, γ)	^{234}U
^{234}U	(n, γ)	^{235}U
^{235}U	(n, γ)	^{236}U
^{238}U	(n, γ)	^{239}Pu
^{239}Pu	(n, γ)	^{240}Pu
^{240}Pu	(n, γ)	^{241}Pu
^{241}Pu	decay	^{241}Am
^{241}Pu	(n, γ)	^{242}Pu
^{207}Pb	(n, γ)	none
^{3}H	decay	^{3}He
^{3}He	(n, γ)	^{3}H
^{6}Li	(n, γ)	^{3}H
^{94}Mo	(n, γ)	^{95}Mo
^{95}Mo	(n, γ)	^{96}Mo
^{96}Mo	(n, γ)	^{97}Mo
^{97}Mo	(n, γ)	^{98}Mo
^{98}Mo	(n, γ)	^{99}Mo
^{99}Mo	decay	^{99}Tc
^{99}Mo	(n, γ)	^{100}Mo
^{100}Mo	(n, γ)	^{101}Ru
^{10}B	(n, a)*	none
^{7}Li	(n, γ)	none
^{63}Cu	(n, γ)	none
^{164}Dy	(n, γ)	none
^{176}Lu	(n, γ)	none
^{107}Ag	(n, γ)	none
^{109}Ag	(n, γ)	none
^{59}Co	(n, γ)	none
^{197}Au	(n, γ)	none
^{155}Gd	(n, γ)	none
^{157}Gd	(n, γ)	none
^{115}In	(n, γ)	none
^{93}Nb	(n, γ)	none
Hf	(n, γ)	none
^{160}Dy	(n, γ)	^{161}Dy
^{161}Dy	(n, γ)	^{162}Dy
^{162}Dy	(n, γ)	^{163}Dy
^{163}Dy	(n, γ)	^{164}Dy

*Absorption

TABLE 4
69-GROUP ENERGY BOUNDARIES FOR WIMS

Group	Eupper (ev)	Lethargy Width
Fast Groups 1-14		
1	1.0000+7	.500
2	6.0655+6	.500
3	3.6790+6	.500
4	2.2310+6	.500
5	1.3530+6	.500
6	0.8210+6	.496
7	0.5000+6	.503
8	0.3025+6	.503
9	0.1830+6	.500
10	0.1110+6	.500
11	6.7340+4	.500
12	4.085+4	.500
13	2.4780+4	.500
14	1.5030+4	.500
Resonance Groups 15-27		
15	9.1180+3	.500
16	5.530+3	.452
17	3.5190+3	.452
18	2.2395+3	.452
19	1.4251+3	.452
20	9.0690+2	.904
21	3.6726+2	.904
22	1.4873+2	.678
23	7.5501+1	.452
24	4.8052+1	.551
25	2.7700+1	.551
26	1.5968+1	.480
27	9.877+0	.904

Group	Eupper (ev)	Lethargy Width
Thermal Groups (28-69)		
28	4.000+0	.192
29	3.300+0	.238
30	2.600+0	.214
31	2.100+0	.336
32	1.500+0	.143
33	1.300+0	.123
34	1.150+0	.024
35	1.123+0	.023
36	1.097+0	.024
37	1.071+0	.025
38	1.045+0	.024
39	1.020+0	.024
40	0.996+0	.024
41	0.972+0	.023
42	0.950+0	.043
43	0.910+0	.068
44	0.850+0	.086
45	0.780+0	.222
46	0.625+0	.223
47	0.500+0	.223
48	0.400+0	.134
49	0.350+0	.090
50	0.320+0	.065
51	0.300+0	.069
52	0.280+0	.113
53	0.250+0	.128
54	0.220+0	.201
55	0.180+0	.251
56	0.140+0	.336
57	0.100+0	.223
58	8.000-2	.178
59	6.700-2	.144
60	5.800-2	.148
61	5.000-2	.174
62	4.200-2	.182
63	3.500-2	.154
64	3.000-2	.182
56	2.500-2	.223
66	2.000-2	.288
67	1.500-2	.405
68	1.000-2	.693
69	5.000-3	6.215

APPENDIX B

WIMS-D4M Revised Input Options

INDEX

1. PRELUDE DATA

Keyword	Data	Usage
CELL	i	Defines the cell type Pin/slab-cell. i = 4 Homogeneous i = 5 Pin/slab-cell, no energy condensation i = 6 Pin/slab-cell with energy condensation i = 7 Cluster i = 8 Supercell
NPLATE	i	+ i specifies a slab geometry to be divided into i unit cells for resonance shielding and SPECTROX calculations. - i specifies spherical geometry (DSN only). All geometry is input as for cylindrical geometry except that the annulus radii must be r = $\sqrt{4\frac{R^3}{3}}$ so that πr^2 is the required spherical volume.
SEQUENCE	i	Defines the main transport routine to be used. i = 1 DSN i = 2 PERSEUS i = 4 PIJ-PERSEUS (cylindrical only) i = 5 PRIZE-PERSEUS (cylindrical only) With CELL option 7, a negative sign causes the unsmearing process to be omitted. To change SEQUENCE option during a WIMS run, see SWITCH data.
NGROUP	i j k	i = the number of intermediate main transport routine groups. (See FEWGROUPS) j = the number of reaction edit groups. (See PARTITION) k = the number of broad groups. (See VECTOR)
NMESH	i j	i = the number of main transport routine mesh points. j = the number of edit mesh points. (defaulted to I +3 x number annuli containing rods). If the switch option is used to change to PIJ, the number of meshes will be increased automatically to the number of PIJ meshes. For Supercell option, the number of mesh for cell 1.

Keyword	Data	Usage
NREGION	i j k	i = the number of slabs or annuli j = the number of annuli containing rods. (default 0) k = the number of edit regions (default i + 3j).
NMATERIAL	i j k	i = the total number of problem materials j = the number of materials which undergo burnup. k = the number of materials used in PERSEUS. (If k is 0 or blank, the code supplies an adequate default value - an explicit value for k could be useful for saving space in multi-cell jobs.)
NRODS	7 integers	Data required only for PIJ, or for DSN/PERSEUS calculations with more than 5 rod types, or more than 5 rod-subs in any type. 1 = number of rods in the cluster (≥1). 2 = cluster symmetry factor j. θ = 0 is the reflection plane) + for j fold rotational symmetry - for j/2 fold rotational and j fold reflectional symmetry. 3 = number of lines in PIJ mesh 4 = number of angles in PIJ mesh 5 = number of rod types 6 = maximum number of rodsubs in any type 7 = maximum number of sectors in any rodsub
NREACT	i	The number of nuclide reaction rate edits.
NCELLS	i	The number of cell types for multicell calculations.
POISON	i	The number of regions in a subsidiary burnable poison pin cell calculation. (Default 7 or 2 + 6th NRODS integer)
NTHERMAL	i	The maximum number of temperatures at which thermal library data is tabulated.
NISOTOPES	i	The number of nuclides used (Default = number of nuclides in the library)
TILT	None	This allocates sufficient data storage space to calculate heat flux tilt across cluster fuel pins. No main data required.
PREOUT	None	This must be the last prelude data card.

2. MAIN DATA

Keyword	Data	Usage
INITIATE	None	The first card of a complete set of main data.
PRTOPT	n	Only a value of 1 is used. Restores original full edits (shortened form - default).
SLAB	j r m	j = the slab number, counting from the center. r = the distance from the center to the slab outer edge. m = the material number.
ANNULUS	j r m	j = the annulus number counting from the center. r = its outer radius in cm. m = the material number for all parts of the annulus not occupied by rods. NOTE that if intermediate annuli as are usually required for PIJ calculations are not defined in the input, the code automatically supplies appropriate data by linear interpolation in r.
SQUARE	j r m	j = the outermost 'annulus' of the problem. r = the radius of the inscribed circle of a square boundary which is orientated so that its corners lie on the x and y coordinate axes. m = the material number for all parts of the outer region not occupied by rods. If annuli are specified with radii greater than r and less than $r\sqrt{2}$ segments will be correctly masked off by the square boundary. Rods f spectrum type 4 materials may be located at corners of the square and will not count as rods in the SPECTROX 'average pin' procedure. The problem will be suitably homogenized and cylindricalized for DSN or PERSEUS but will calculated explicitly by PIJ if the number of PIJ "annuli" is j.
CRAIG	None	For cluster geometries with one annulus per ring of fuel pins, the radii of the annuli containing pins will be adjusted to preserve the fuel to coolant ratio throughout the cluster, and to minimize the differences between the fuel positions and the midpoints of the annuli.

Keyword	Data	Usage
POLYGON	j n m r	j = the 'annulus' number n = the number of sides of the polygon m = the material number r = the 'radius' to the midpoint of a side. This option merely generates appropriate ANNULUS data and is not treated explicitly by any WIMS-D4M geometry or transport routine.
ARRAY	N (m n p θ)	All rods of type N have their positions given by one ARRAY card. Up to 12 sets of the four numbers (m n p θ) are allowed, with m being an option on the co-ordinate used. m = 1: a ring radius p of n rods, one with angular co-ordinate θ (radians). m = 2: (p,θ) specify (x, y) co-ordinates of one rod m = 3: a ring of n rods separation p, one with angular co-ordinate θ m = 4: a hollow square of n rods, separation p,θ is the angular co-ordinate of the first corner of the hexagon m = 6: a hollow hexagon of n rods, separation p,θ is the angular co-ordinate of the first corner of the hexagon Options 4 and 6 are untested; θ is irrelevant except in PIJ. If the cell boundary is square, non-fuel rods may be placed at the corners. They will be smeared for DSN or PERSEUS but if PIJ is used the NPIJAN card must specify the total number of regions, i.e. the first number of the SQUARE card.
RODSUB	n k r (me)	n the rod type (see ARRAY card) k the rod sub-division number counting from the rod center r its outer radius (me) material number and angle at the end of each sector. Except in a sectored PIJ calculation only the first m need be specified. The number of pairs must not exceed the 7th number on the Prelude NRODS card.
PLOT	r s	After the first set of Main data has been read, the geometry is 'plotted' on the lineprinter. This option may be used to redefine the maximum outer radius of the plot (r) and the scale (s) to which the pins are plotted. A geometry plot will be obtained after every set of Main data containing this card. Default values are r = outer annulus radius, and s = 0.7 (for improved readability).

Keyword	Data	Usage

COMPOSITION DATA

MATERIAL m d t n list

m = the material number
d = the density (g/cm^3)
t = the temperature (^{0}K)
n = the spectrum type (fuel, can, coolant, moderator).

list pairs of nuclide identifier and weight per cent (the code renormalizes these to total 100%) A negative n causes the material be excluded from SPECTROX.

m -l t n list

m t n defined as above list pairs of nuclide identifier and atom density in atoms/b.cm. If the material has been specified in a previous lattice calculation, any nuclides not specified in list will retain their existing number densities.

-m d t n list

d = redundant, t and n defined as above, list pairs of nuclide identifier and a constant by which the number density of a nuclide in an existing material, m, will be multiplied.

For example (135 1E-8) will effectively zero the xenon content for a perturbation calculation and the inverse (135 1E8) will restore it prior to the next burnup step.

m M

material m will be given the same temperature, spectrum type and composition as material M (which must have been specified previously). Note that subsequent redefinition of M does not affect m.

RESTART

Use of this keyword request that all material number densities be read from Fortran dataset 3, which has been saved from a previous job. ALL MATERIAL data will be ignored.

ENRICHMENT (m d e s)

m = the material number
d = the density (g/cm^3)
(temperature and spectrum type must be specified by a MATERIAL CARD)
e = the enrichment (wt % of total heavy atoms, of U235 if uranium fuel, or of total plutonium if plutonium enrichment fuel. In the latter case the input ratio of U235/U238 will be unaltered).
s = the stoichiometric ratio (e.g. 2.0 for UO_2)

An enrichment specification will over-ride the isotopic specification of a MATERIAL card but an appropriate default value of s will be derived from the MATERIAL data if zero is input. Several sets of (m d e s) values can be input on one ENRICHMENT card.

Keyword	Data	Usage
DENSITY	list	a string of constants by which existing material densities are multiplied. This is a useful option for changing coolant density. (The code will fill out a truncated list with 1's).
TEMPERATURE	list	a string of temperature increments, one for each material.
DTDR	d	The temperature of all materials of spectrum type 1 (fuel) will be overwritten by T_c + d x Rating, where T_c is the temperature of the 'COOLANT' material and Rating is taken from the second item on the POWER C card. Note that subsequent changes in rating will have no effect on fuel temperature unless another DTDR card is supplied.
		CROSS SECTIONS AND FLUX SOLUTION
BELL	a	a = Bell factor (default 1.16)
DANCOFF	($\gamma\mu$n)	Externally calculated Dancoff factors may be input by sets of three numbers γ = the infinite lattice Dancoff factor μ = for a cluster is the average Dancoff factor including the outermost ring of ring of rods ($\mu>\gamma$) n = energy group γ_i and μ_i apply to all library groups n_{i-1}+ 1 to n_i. If n_1 is absent single values of γ and μ apply to all library groups.
PIJDANCOFF	g	automatic computation of cluster Dancoff and Bell factors. The job must be set up as a PIJ run and g defines the main transport energy group for which factors are evaluated. The recommended numbers of lines and angles in the PIJ mesh are 100 and 11 respectively. No Edit data is required for this option and the computed factors are saved for the next lattice calculation.
LAMBDA	ℓ list	ℓ = can λ value for the PIJDANCOFF option (default value is 0.3923 - appropriate for (Zircaloy cans) ℓ list may contain up to 6 numbers defining the PIJ mesh regions containing cans. Defaulted values are correct unless a gas gap between fuel and can is specified by RODSUB data.
REGULAR	a	a is normally 1. For a regular infinite lattice Dancoff factors will be calculated by tracking routine with maximum error 0.0005, and Bell factors will be evaluated. 0.625 for edge pin and 0.375 for corner pin. The option can also be used for clusters. The use of both DANCOFF and REGULAR options to obtain computed Bell factors is not recommended.

Keyword	Data	Usage
RESXSECS	r m list	To input resonance cross sections (must follow MATERIAL Cards) r = nuclide resonance identification (e.g. 235.1) m = the number of cross section types (type 1 is absorption, and type 2 is fission yield) list inner cross sections for each resonance group for each type in turn, followed by a similar set of outer cross sections. (Inner and outer refer to the positions of fuel pins in a cluster.)
NORESONANCE	None	The resonance shielding calculation is bypassed and infinite dilution cross sections will be used.
DBSQUARED	i list	To take account of leakage by adding DB^2 to Σ_a in the g main transport groups. i = -1 list is g values of B^2. ($B^2/3\Sigma_{tr}$ is added to Σ_a for every material). i = 1 list is g values of B^2 and g values of D (DB^2 is added to Σ_a for every material). i = 2 list is g values of B^2, g values of D, and a trigger j for every material j = -1, $B^2/3\Sigma_{tr}$ is added to Σ_a j = 0, Σ_a is unaltered j = 1, DB^2 is added to Σ_a Note that material 0 (void) is never altered. Note also that if |I| is increased by |10|, i.e. to -11, 11 or 12 the DB^2 will be removed before the edit data is executed.
DIFFERENTIAL	i	If i is omitted thermal hyperfine disadvantage factors will be calculated for each fuel ring in a cluster. i = -1 a request for the option will be canceled.
FEWGROUPS	list	list the division of library groups into main transport routine groups. The length of the list is the first number on the prelude NGROUPS card.
MESH	list	list the number of mesh intervals of equal volume in each of the annuli or slabs. The length of the list is the first number of the prelude NREGION card. See NPIJAN, page 48.
FREE	None	This is used to obtain free (black) boundary condition ($\varnothing \rightarrow 0$). Note that group dependent albedos can be input to a collision probability calculation by use of the PCELL option, even in single cell cases.

Keyword	Date	Usage
TOLERANCE	a	a = the convergence tolerance of the main transport routine (default 0.0001).
OMEGA	a	a = the acceleration parameter for the main transport routine (default 1.25).
S	n	n = the order of the DSN calculation (SEQUENCE 1) (default 4)
CARDS	None	Cross sections in DSN format will be punched by the main transport routine.
NPIJAN	j t i	j = the number of annuli (including a square outer region) to be treated by PIJ, all outer annuli being treated by PERSEUS. The first j numbers on the MESH card are arbitrary except that they must add up to the total number of zones in the PIJ calculation. t = the maximum number of mean free paths for which neutrons will be tracked. The default (maximum) value is 10 but 7 is almost certainly adequate; even 4 is probably sufficient. i = must be non-zero if the user requires to suppress track renormalization (which is used to correct for inaccurate volume integration). Note that default value (0) will give results differing slightly from results produced by earlier versions of the code.
LINES	i j k	i = the number of lines used in the PIJ integration mesh j = the number of angles i and j can be used to over-ride the values specified on the NRODS card, or to provide values for the NRODS card generated automatically by the PROLOG routine (see SAVE data) k = the maximum number of boundary reflections which are tracked in a square PIJ calculation (default = 2)
POWERC I, RQ, RTAU, INDNB, RMAXDT,INDG, list		I the units for RQ I = 1 RQ is MW/te initial heavy elements. I = 2 RQ is fissions /cm^3/ sec cell averaged. I = 3 RQ is fissions /cm^3/ sec averaged over burnup materials. I = 4 RQ is total flux. I = 5 RQ is flux in group INDG If RQ = -1 the value reached by the previous burnup step is assumed. e.g. I = 1, RQ = 20 on the first step and I = 4,

Keyword	Data	Usage
		RQ = -1 on the second gives a burnup at a constant flux corresponding to an initial 20 MW/te.
		RTAU = the timestep between criticality calculations and flux renormalization to the input power level.
		INDNB = the number of such timesteps between lattice calculations.
		+ RMADT= the maximum fractional nuclide density change per integration step 0.05)
		- RMADT = a constant integration step length in days.
		INDG = the group used to normalize the flux level in the I = 5 option (default 1.)
		In options I = 4 and 5 list contains a trigger for each material which is 1 if the material is to be included in the flux normalization and 0 otherwise. If no values are specified in the list, all are assumed to be 1.
BUCKLING	list	list consists of B_r^2 B_z^2 $B_r'^2$ $B_z'^2$ where B_r^2 and B_z^2 enable a keff spectrum to be used for burnup. If $B_r'^2$ or $B_z'^2$ are specified a critical spectrum will be used with bucklings $B_r^2 + \lambda B_r'^2$ and $B_z^2 + \lambda B_z'^2$ with λ chosen to give keff = 1.
		If the list contains more than 4 numbers it is assumed that values have been specified in sets of 4 for each group.
DWRITE	None	Without this card Ariadne D's are used in the burnup calculation if available (SEQUENCE 2), otherwise transport averaged D's are used. This option results in the use of D_r and D_z as computed by the leakage edit, the order of preference being Ariadne, Benoist and Σ_{tr}.
FUEL	a b list	As burnup is normally specified in MWD/te of initial heavy atoms it may be desirable, on restarting a burnup run, to specify the original fuel mass. The appropriate value of a is printed in the burnup output of the code under the heading 'Initial Inventory'.
		If a = -1 is input, burnup will be evaluated as MWD/te of <u>current</u> heavy atoms. The fuel mass is recalculated at every burnup step - in very early versions of WIMS this was the default.

Keyword	Data	Usage
		The value of b is an irradiation increment for File 6 output and is required only if a file output job is restarted from a non-zero irradiation. The values in list are the remaining percentage weights of each burnable material and the cluster average at the restart irradiation. Appropriate values can be obtained from the WIMS burnup printout. Default values are 100.0.
POISON	i j	The burnup of highly absorbing poison pins in a cluster can be refined by means of a pin cell collision probability calculation at each criticality calculation in the burnup segment. i = the number of regions in the pin cell calculation ($\leq$ Prelude POISON data value) j = the number of regions in the poison pin itself. The POISON card must be followed immediately by i cards in the form 4 (I3, E12.5) specifying region number, region radius and up to 3 pairs of material number and volume fraction. There will normally be more than one pair only when the outer region of the pin cell, containing a fuel-can-coolant paste, is specified.
		MULTICELL AND SUPERCELL CALCULATIONS
CELL	i n igeom isol ires chord	In a multicell calculation all geometry data refer to the immediately preceding CELL card i = the cell type n = the number of cells of this type (n = 1 for Supercell case) The following entries apply only to Supercell: igeom the cell geometry - 0/1 = cylinder/slab isol method of solution - 0/1 = Normal SPECTOX/generalized (S_n) res the material number of second resonance material, if present in cell chord the mean chord length for resonance region in cell, if ires is non-zero
CSPECTRUM	k irn	If this card is supplied with any value k $\neq$ i on the CELL card, the condensation spectra and microscopic resonance cross sections for cell I will be set equal to those of cell type i - 1. For Supercell geometry (k=-1): k = 1 must be assigned. irn = Resonance computation -0/1 = Standard/Auxiliary (See ires on Cell card)

Keyword	Data	Usage
NEWXS		m icolm = material ID
	idc mat	icol = create a homogenized material from list mat-- 1/1 = no/yes
		idc = number of auxiliary cell from which collapsing flux spectrum is taken
		mat = list of materials present in cell idc, if icol = 1
PCELL	i (Pij for all)	i = the cell type
		Pij = the probabilities that a neutron leaving cell type i will immediately enter a cell of type j (without necessarily colliding in that cell). The list of Pij values can be repeated for each group in turn. When the list is terminated the last set will be used for all remaining groups.

FUEL CYCLE CALCULATIONS

HISTORY	None	An option coded by CEGB and not recently tested. It is designed to produce a history tape containing all relevant output from a run to be edited for fuel cycle calculations. It would require little effort to be made operative.
CYCLE	i k_m X δX RATU INDNB w j	To perform automatic fuel cycle calculations i = 1 or 2 (See definition of X). k_m = the irradiation averaged value of keff at which burnup will terminate. X ± δX = the required initial keff if i = 1, or the target irradiation if i = 2. RTAU, INDNB replace the standard quantities on the POWERC card after the first burnup step, and determine the length of all subsequent steps. W = the irradiation at which plutonium will be extracted for recycle purposes (end of cycle if zero or not specified). j = 0, k_m is defined by averaging keff j = 1, k_m is defined as the ratio of integrated neutron production to integrated neutron losses. An entire fuel cycle is treated as a single WIMS lattice calculation for data preparation, i.e. only one set of main and edit data is supplied.

Keyword	Data	Usage
RECYCLE	j r	To continue a CYCLE run by recycling fuel j = 1 to the basic fuel (as specified by MATERIAL cards) will be added the plutonium from the previous cycle + specified enrichment to meet the objective specified by the CYCLE card. j = 2 to the basic fuel will be added sufficient plutonium of the composition extracted from the previous cycle to meet the objective. j = 3 to the basic fuel will be added only that plutonium extracted from the previous cycle, the objective is ignored and the cycle terminated when the average keff is k_m. r = an estimate of the required enrichment relative to that required for the previous cycle (default 1.0).
PROCESS	t_1 t_2 f	The composition of the recycled plutonium should be corrected for Pu241 decay and processing losses. t_1 = the time in days between removal of the fuel from the reactor and processing t_2 = the time in days between processing and refueling f = the fractional efficiency of plutonium extraction.
ENRICHMENT	list	Note that in all cases other than RECYCLE options this card is interpreted as described under the MATERIAL data section. In a RECYCLE calculation, list specifies the relative amounts of U235, Pu239, Pu241, Pu242, Am241 in the external enrichment for RECYCLE option 1.
DIFFERENTIAL	i or list	i = 0 or blank give the DIFFERENTIAL option described above i = -1 suppresses that option list contains up to 6 numbers specifying the required enrichment ratio in the fuel materials. For example, if materials 7, 8, 9 were fuel the first three items in the list would determine the proportional enrichment in those materials. (Default is uniform enrichment).
		PRINTOUT CONTROL
TESTPRINTS	None	More extensive printout is produced, particularly in the resonance and transport calculations.
SUPPRESS	list	up to 16 integers i_n = 0 gives normal printout in 'Chain n' $i_n \neq 0$ suppresses all printout in 'Chain n' except for input data listings, but including Fortran error messages.

Keyword	Data	Usage
		i_{16} = 2 suppresses both printout and tape or disc output (i.e. files 1 to 5) in Chain 16. File 0 and file 6 output will be unaffected. (Default values are 0 for n = 1-15 and 1 for n =16). Note that 'Chain 16' is the segment which produces the WIMSE - type file output.
		SEQUENCE CHANGES
SWITCH	i j k l	This option may be used for changing the SEQUENCE option, e.g. from PIJ to DSN in a burnup run. i = new SEQUENCE data (1 = DSN, 2 = PERSEUS, 4 = PIJ/PERSEUS) j = new number of annuli (replaces first item on the NREGION card) k = new number of meshes (replaces first item on the MESH card l = 1/0 the contents of subsequent File 6 records will/will not be incremented by the differences between the previous File 6 and this one. This option could be invoked to ensure a smooth transition, e.g. from PIJ to DSN, by doing two lattice calculations at the same irradiation, but is probably not necessary in general. j and k may be zero (or blank) if the new values equal the old ones. If j changes the number of annuli, the SWITCH record must be followed by a complete new set of ANNULUS and MESH data.
		'WIMSD3' LIBRARY DATA
REPLACE	i_1 i_2 list	The following library modification options are available only when the in-core option is used (see Prelude STORE data). The required information on storage locations is obtained with the LIBRARY option in the Prelude data. The library tape itself is not affected. i_1 i_2 are the addresses of the first and last library locations to be modified. list is i_2-i_1 + 1 new values for the library data. The list will be expanded with values equal to the last one specified if it is too short or truncated if too long.
MULTIPLY	i_1 i_2 list	The list will be expanded or truncated to i_2-i_1 + 1 values as above and will then be used to multiply the library data stored in addresses i_1 to i_2 inclusive.

Keyword	Data	Usage
INCREASE	i_1 i_2 list	The list will be expanded or truncated as above and will then be used to increment (by negative amounts if required) the existing data in addresses i_1 to i_2).
		END OF DATA
TERMINATE	None	A WIMS run is terminated immediately this card is read and the Prelude is re-entered. The data following this card should therefore be a complete new set of data. This option has a more practical use in the data block input option.
BEGINC	n	The final main data card. If n is omitted a normal lattice calculation proceeds. The only recommended alternative is n = 13 which is used to generate more than one edit of a single lattice calculation.

Keyword	Data	Usage

3. **EDIT DATA**

MISCELLANEOUS EDIT FACILITIES

THERMAL	n	the number of thermal main transport groups in the two group leakage edit (Default (number of groups + 1) /2).
REGION	(n m)	cell edit(s) will be taken over region pairs n to m. The total cell absorption of 1 is not renormalized. The last set should cover the entire cell (default, if card omitted).

ISOTXS AND/OR MACRXS DATA

ISOXS	imacr imicro nburn ipfp ism0 isec ispr ilfp ivel	imacro	0/1 No macroscopic data/Write macroscopic data file MACRXS
		imicro	0/1/3 No microscopic data/Write microscopic data file ISOTXS/Also write macroscopic data formed from microscopic
		nburn	1/n No burnup/n burnsteps
		ipfp	0/1 No lumped fission products (LFP)/Assign LFP
		ism0	0/1 No LFP MCNPXS/Generate LFP MCNPXS file
		isec	0/1 No secondary library/Use secondary library
		ispr	0/1/2 Edit all ISOTXS data/Principal data only/Labels only
		ilfp	0/1 Microscopic LFP/Macroscopic LFP formed
		ivel	0/m Use velocities from edit set 1/Use velocities from edit set m
LETTERS X Y Z ... (30A2 format)		n	number of letters entered on the <u>following</u> card defining labels for each edit region, (region number pairs in REGION card).
		X	letter used to form edit label 'X km', where j k is the first region number pair from the REGION card data and m is the burn step number 00, 01, 02, ..., 99. A6 labels are assigned to each edit region. If no LETTER card is used, a default sequence of ABC ..., is assigned. MACRXS only.

Keyword	Data		Usage
HUSE fileid			A twelve (2A6) character identifier for either the ISOTXS or MACRXS files, where the string of characters is entered on the line following the HUSE card.
HSETID setid			A 72 (12A6) character identifier for either the ISOTXS or MACRXS files, where the string is entered on the line following the HSETID card.
ISOTOPES	(isonum (i), i = 1, nmicro)	isonum (i)	the i-th isotope number to be included in the ISOTXS file as selected from the isotopes included in the MATERIAL card(s). These numbers must be consistent with the cross-section library labels (See Appendix A).
		nmicro	the accumulated number of isotope numbers entered on the card. The usual $ continuation rules apply if additional space is required.
ISONAMES (isonam (i), i = 1, nmicro)	isonam (i)		the i-th four character label to be assigned in a one-to-one correspondence to the i-th isotope number on the ISOTOPES card. The label is used together with a two character burn step number (00-99) to form an A6 isotope label for ISOTXS. The four character labels must be entered on the card(s) following the ISONAMES card in a 12 (A4, 2X) format (each four character label followed by two blank spaces, etc.).
EDITCELLS	(ismear (i) i = 1, nmat)	ismear (i)	the i-th material region of the nmat total number of ismear materials assigned in the problem. All material regions assigned the same non-zero integer are smeared into an edit set of ISOTXS data. Multiple edit set may be assigned, e.g. 1112 would assign the first three material regions to one edit set while the fourth material region is assigned to a second edit set. An isotope that appears in more than one material will be averaged over the edit set.
IBURN	(ibn(i), i=1, nburn)	ibn(i)	data control for the selection of burnup dependent data to include in ISOTXS - 0/1 include data for the i-th burn step/omit data for burn step. The number of burn steps, nburn, is the value entered on the ISOXS card. If fewer number are entered, a value of zero is assigned. Data at each burn step is included when no IBURN card is present.

Keyword	Data	Usage
IREACT	(irt(i), i=1, nburn)	irt(i) data control for the selection of reaction rate edits - 0/1 include reaction rate edits for i-th burn step/omit edits for burn step. Same defaults as IBURN above. Applies only when NREACT and REACTION cards are included and NBURN on the ISOXS card is greater than 1.
VECTOR	list	is a partition vector referring to the main transport group structure. The condensed broad group structure is limited to 20 groups.
SIGPUNCH		Write macroscopic cross-section file MACRO.XS for use with WIMSIT/UM2DB or UM3DB
MATERIALS	n	n = -1 cancels a previous request for the output n = 0 or blank MATERIAL data cards will be punched for each burnable material, in the correct format for WIMS input, in order to restart a burnup run. Note the FUEL card in the Main Data.
DOPPLER	n T k	n = 1 This card should be included in the edit data of a case in which the fuel temperature have been perturbed. n = 2 This card should be included in the edit data of an otherwise identical subsequent case with the standard fuel temperature. T and k should be included only if the DOPPLER 1 case has not been run in the same job. T = the perturbed volume averaged fuel temperature k = the perturbed 2-group k_∞. The output is the X8 factor required in reactor codes.

BURNUP CONTROLS

ALPHA	i j	Pu240 self shielding can be varied continuously through burnup i = is the first (highest energy) main transport group occupied by the Pu240 resonance at 1.06 eV j = is the lowest such group (default j =1)
SATURATE	n	The identification number of a single nuclide required to be in equilibrium throughout burnup (normally n = 500 for the pseudo-Samarium nuclide)

Keyword	Data	Usage

LEAKAGE CALCULATIONS

BEEONE i n

i = 1 B_1 flux solution in the leakage edit, or B_o edit if all D's on the DNB cards are set to zero
i = 0 Transport corrected diffusion theory solution in the leakage edit
i = -1 Both the above (Default 0)
n number of nuclides in the primary library file having P_1 matrices (4 for original library, 5 for Romanian modified library with ZrHx and 7 for ENDF/B-V library.

DNB m D_1 D_2 D_3 ...D_n

In the B_1 approximation a DNB card should be present for every material.
m = the material number
D_1 to D_n are the number densities of those nuclides whose P_1 matrices are on the tape. Note that non-zero D's should be specified only if all the principal nuclides in the material have P_1 matrices.

DIFFUSION j k l

Leakage flux calculations will be made by the following methods:
j = 1 Benoist
j = 2 Transport
j = 3 Ariadne (Valid only for SEQUENCE 2)
j = 4 Benoist + Transport + Ariadne
j = 5 Benoist + Transport
j = 6 Benoist + Ariadne
j = 7 Transport + Ariadne
(Default j = 2)

For the Benoist treatment:
If l is an integer, it is taken to be the number of edit regions forming the outer region of a three-region cell. However, if l is not integral, it is taken to be the inner radius of the outer region. This mode of input eliminates the need to know how edit regions are defined.

The middle region is defined by k.
k = 1 Air gap with a tube on both sides
k = 2 Air gap with a tube on the inside
k = 3 Air gap with a tube on the outside
k = 4 Air gap only
k = 5 Tube only, divided between fuel and moderator
k = 6 Tube only with infinitesimal air gap on the outside
k = 7 Tube only with infinitesimal air gap on the inside
k = 8 Two air gaps with a sleeve between them
k = 9 Three air gaps with two sleeves between them

Keyword	Data	Usage
TESTTUBES	None	If this card is included the tubes specified by the DIFFUSION card will be smeared with adjacent fuel or moderator in those groups where the tube thickness is greater than the tube material diffusion coefficient.
NO CORRELATION	None	An earlier Benoist prescription without correlation terms will be used.
BUCKLING	B_r^2 B_z^2	B_r^2 is the radial buckling (or xy buckling in slabs) B_z^2 is the axial buckling
NO BUCKLING	None	The search for critical bucklings will be omitted
LEAKAGE	m n	The value of m determines which leakage spectrum is to be used for the keff nuclide reaction edit. m = 5 spectrum with input bucklings m = 6 spectrum with critical bucklings, input ratio m = 7 spectrum with critical bucklings, input radial buckling m = 8 spectrum with critical bucklings, input axial buckling n = 0/1no leakage treatment/use leakage spectrum from chain 14 for ISOTXS data
ENDCAP	list	The list described in the reference is incomplete for WIMSD. The required 5 items are: 1. The material number (used elsewhere in the cell) of which the endcap is made. 2. The fraction of the total fuel + endcap length which is endcap. 3. The density reduction factor of the central tie rod (-1 if no tie rod). 4. The density reduction factor of the material in the endcap. 5. The outermost edit region occupied by the endcap. The code produces an extra leakage edit including the endcap effects but the remaining output is unaffected.
BEHADD	list	Behrens slots are specified by a list of 3N (≤30) numbers comprising N values of hole volume ($n\pi r^2$ for cylindrical holes of radius r) N values of hole radius (2v/s for non-circular holes) N values of the Behrens shape factor (1.3333 for circular cylindrical holes)

Keyword	Data	Usage
		For rectangular holes the volume may be replaced by-V and the radius and shape factor by the side lengths of the rectangle. If list is absent or contains less than 3 numbers any previous request for the Behrens option will be canceled.
		REACTION RATE EDITS
REACTION	list	pair of numbers (i, T_i), the nuclide identification number and its temperature (°K), for each nuclide for which a reaction edit is required (NREACT data is the Prelude). The temperature is relevant only for those nuclides which have temperature dependent absorption or fission cross sections.
PARTITION	list	the combination of library groups required in the edit. The length of the list is the second number on the Prelude NGROUPS card and the last number in the list is the number of library groups. The partition vector should be specified to give a group cut tallying with the FEWGROUPS and THERMAL data when the CALEB and MISCELLANEOUS options are used.
PRINTC	i j k l	i = 0/1 reaction rates by mesh interval will be printed/suppressed j = 0/1 reaction rates by material will be printed/suppressed k = 0/1 reactions by material will be printed/suppressed l = 0/1 the k_∞ reaction edit will be printed/suppressed (Default values are all zero)
		END OF DATA
BEGINC	None	The last card of the edit data

APPENDIX C

SAMPLE WIMS-D4M CASES

APPENDIX C

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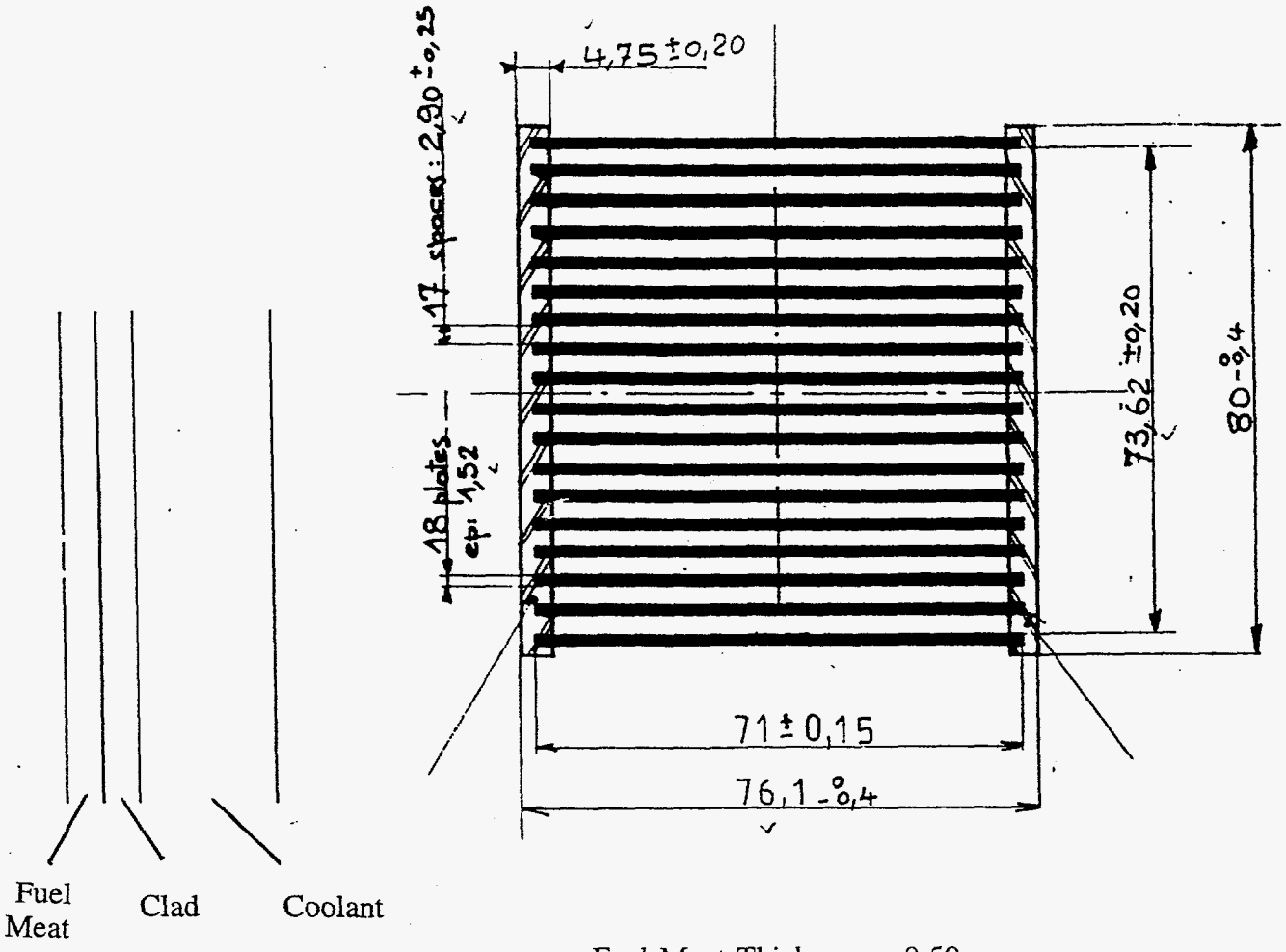
*
*                          Example 1
*
* Homogeneous Medium 69 Main Transport Group DSN Calculation
*    with 2 Group Reaction Rate Edits and 20 Broad Group
*             ISOTXS Microscopic Cross Sections
*
*
*             ****PRELUDE INPUT DATA****
CELL 4
SEQUENCE 1
NGROUPS 69 2 20
NREACT 7
PREOUT
INITIATE
*               ****MAIN INPUT DATA****
*Homogeneous Cell Model for ORNL-1 Unreflected Sphere
FEWGROUPS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $
21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 $
41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 $
61 62 63 64 65 66 67 68 69
MATERIAL 1 -1 300 1 235.1 4.8066E-5 2001 .066228 16 .033736 $
 238.1 2.807E-6 236.1 1.37E-7 234.1 5.38E-7 14 1.869E-4
BEGINC
*
*               ****EDIT INPUT DATA****
PARTITION 42 69
REACTION 235 300 14 300 2001 300 16 300 238 300 236 300 234 300
THERMAL 42
NOBUCKLING
ISOXS  0 1 1 0 0 1 1 0
REGION 1 1
HUSE
WIMS HOMO
HSETID
*Homogeneous Cell ORNL-1 20 broad group cross sections
ISOTOPES 234 235 236 238 2001  16 14
ISONAMES
U4H1  U5H1  U6H1  U8H1  HYH1  OXH1  N4H1
EDITCELLS 1
BUCKLING 1.E-15  1.E-15
VECTOR 1 2 3 4 5 6 7 8 9 10 15 27 42 60 61 62 63 65 67 69
BEGINC
```

Example 2

MTR Slab Geometry Model

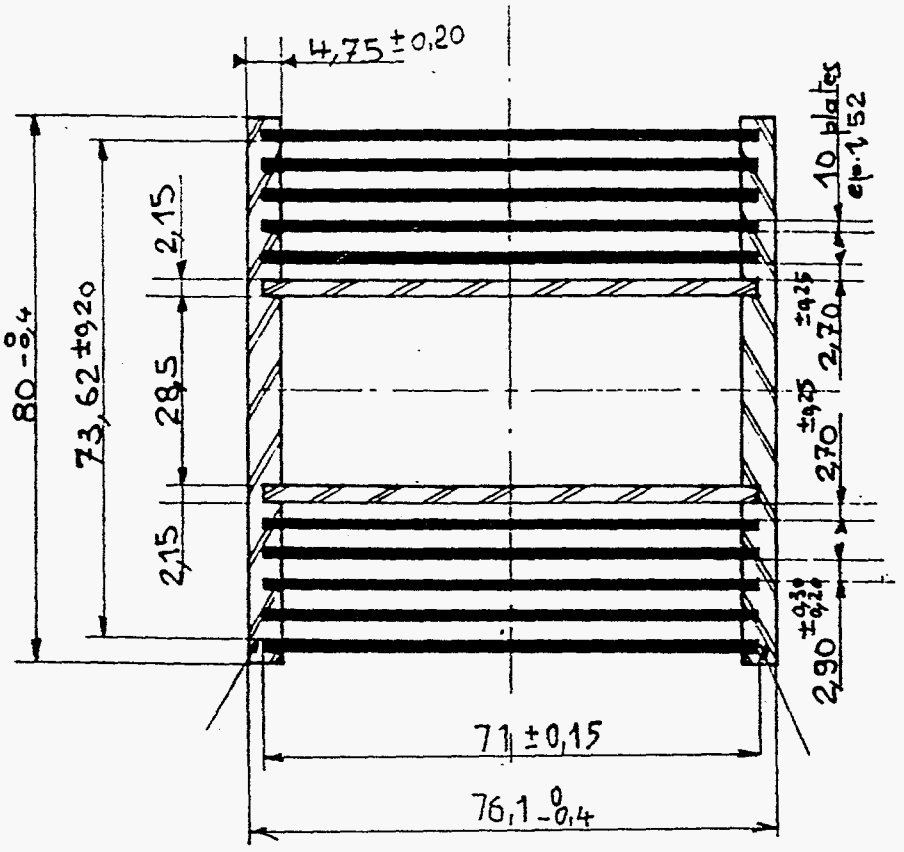


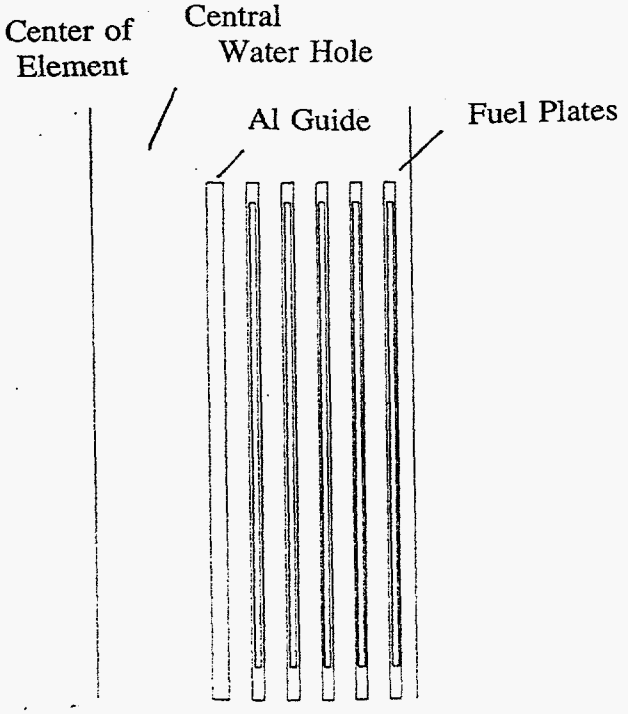
Fuel Meat Thickness = 0.50 mm

```
*
*                          Example 2
*
* MTR Slab Geometry Model Using 30 Main Transport Groups in
* a PERSEUS Collision Probabilities Flux Spectrum Calculation
*     with 2 Group Reaction Rate Edits, 15 Group ISOTXS
* Microscopic Cross Sections and 2 Depletion Burnup Steps
*
*
*                  *****PRELUDE INPUT DATA******
CELL 6
NPLATE 1
SEQUENCE 2
NGROUPS 30 2 15
NMESH 9 9
NREGION 3 0 3
NMATERIAL 3 1 3
PREOUT
INITIATE
*                   *****MAIN INPUT DATA******
*
* LEU Standard Fuel Design 30 Groups Using ENDF/B-V Data
BELL 1.1104
SLAB 1 0.0250 1
SLAB 2 0.0760 2
SLAB 3 0.2210 3
MESH 2 1 6
FEWGROUPS 3 5 6 8 10 13 15 16 18 20 22 24 26 27 $
29 34 37 40 42 45 47 50 52 54 56 60  61 64 66 69
MATERIAL 1 -1 300 1 235.1 1.70170E-3 238.1 6.8272E-3 27 4.0820E-2 $
3239.1 1.E-20 240.1 1.E-20 241.1 1.E-20 242.1 1.0E-20 149 1.E-20 $
 236.1 1.E-20 1241.1 1.E-20 29 .0053888 1149 1.0E-20 135 1.E-20 $
 147 1.E-20 1147 1.E-20 148 1.E-20 1148 1.E-20
MATERIAL 2 -1 300 2 27 6.020289E-2
MATERIAL 3 -1 300 3 2001 .06677753 16 .0333888
*
*  The POWERC card specifies the characteristics of the fuel depletion
POWERC 1 147.311 .2 1
BEGINC
*                   *****EDIT INPUT DATA******
THERMAL 2
PARTITION  45 69
LEAKAGE 5
ISOXS 0 1 3 1 0 1 1 0 0
IBURN 0 0 0
REGION 1 3
HUSE
WIMS MTR
HSETID
* LEU Standard Fuel Design 15 Broad Groups
ISOTOPES 235 236 238 3239 27 29 2001 16 1149 149 135 2135 240 241 $
242 147 1147 148 1148
ISONAMES
U235  U236  U238  PU39  AL27  SI    HYDR  O-16  P149  S149  X135  I135
PU40  PU41  PU42  P47A  P47B  P48M  P148
EDITCELLS 1 1 1
BUCKLING  1.E-15  1.E-15
VECTOR    2 5 6 7 9 10 12 13 14 17 20 22 24 27 30
BEGINC
POWERC 1 147.311 0.8 1
BEGINC
BEGINC
POWERC 1 147.311 5.0 1
BEGINC
BEGINC
```

Example 3

MTR Multiplate Slab Geometry of LEU Control Element





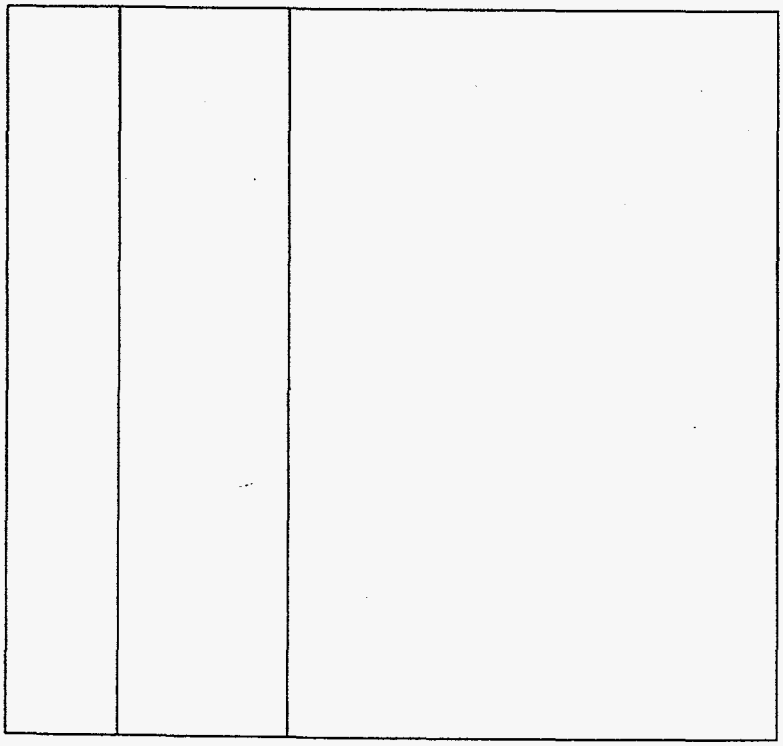
```
*
*                        Example 3
*
*      Multiplate Slab Geometry Case with a Large Central
*            Water Hole for Control Rod Insertion
*
*
*
*
*                  *****PRELUDE INPUT DATA******
*
CELL 6
SEQUENCE 2
NPLATE 5
NGROUPS 19 5 5
NMESH 54 54
NREGION 23 0 23
NREACT 5
NMATERIAL 4 1 4
PREOUT
INITIATE
*                   *****MAIN INPUT DATA******
*
* LEU UAlx Control Element Fuel Design 123g U-235/El. 19 Groups
BELL 1.1080
DANCOFF .505
*
* Specifying the DANCOFF factor for the average plate is recommended
*
FEWGROUPS 5 10 15 19 22 24 26 28 30 34 37 41 45 49 52 55 60 65 69
SLAB 1 1.4250 4
SLAB 2 1.6400 2
SLAB 3 1.9300 3
SLAB 4 1.9680 2
SLAB 5 2.0440 1
SLAB 6 2.0820 2
SLAB 7 2.3720 3
SLAB 8 2.4100 2
SLAB 9 2.4860 1
SLAB 10 2.5240 2
SLAB 11 2.8140 3
SLAB 12 2.8520 2
SLAB 13 2.9280 1
SLAB 14 2.9660 2
SLAB 15 3.2560 3
SLAB 16 3.2940 2
SLAB 17 3.3700 1
SLAB 18 3.4080 2
SLAB 19 3.6980 3
SLAB 20 3.7360 2
SLAB 21 3.8120 1
SLAB 22 3.8500 2
SLAB 23 4.0500 3
MESH 10 2 4 1 2 1 4 1 2 1 4 1 2 1 4 1 2 1 4 1 2 1 2
MATERIAL 1 -1 300 1 235.1 1.11330E-3 238.1 4.4666E-03 27 4.8923E-2
MATERIAL 2 -1 300 2 27 6.020289E-2
MATERIAL 3 -1 300 3 2001 .06677753 16 .0333888
MATERIAL 4 -1 300 -3 2001 .06677753 16 .0333888
*
* Note that material 4 has been excluded from the SPECTROX calculation
*
BEGINC
*                   *****EDIT INPUT DATA******
*
PARTITION 5 15 30 45 69
REACTION 235.1 300 238.1 300 27 300 16 300 2001 300
```

```
THERMAL 6
ISOXS  0 1 1 0 0 1 1 0 0
REGION 1 23
HUSE
WIMS CNTL
HSETID
CONTROL CELL LEU FUEL ASSEMBLY W/0 CR
ISOTOPES 235 238 27 16 2001
ISONAMES
U235  U238  AL27  O-16  HYDR
VECTOR    1 3  9 13 19
LEAKAGE 5
BUCKLING  1.E-15  1.E-15
*       *****CELL AVERAGED MICROSCOPIC CROSS SECTION EDIT ******
*
EDITCELLS 1 1 1 1
BEGINC
```

Example 4

MTR LEU Fuel Plate Cell

One Dimensional Slab Geometry



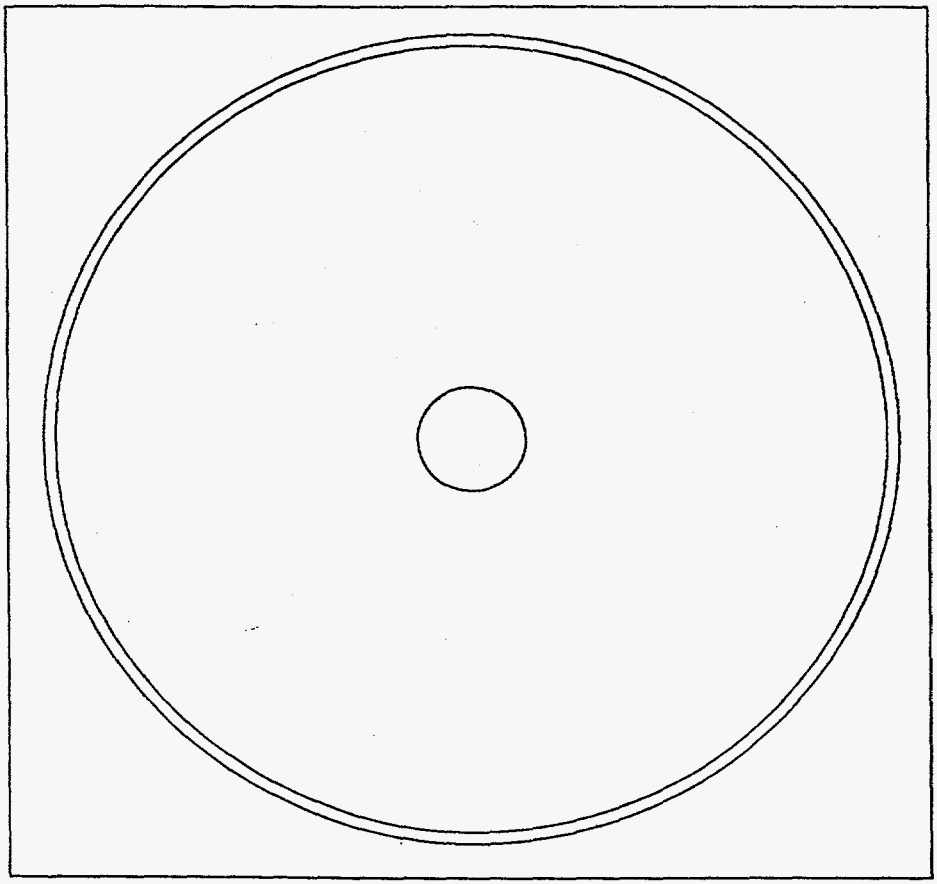
Fuel Meat Thickness	=	0.51 mm
Cladding Thickness	=	0.38 mm
Coolant Channel Half Thickness	=	1.115 mm

```
*
*                    Example 4
*
* MTR LEU Fuel Plate Cell with Fuel Depletion for IAEA Benchmark
*    Problem Using 20 Main Transport Groups Collapsed to 5
*   Reaction Rate and Microscopic ISOTXS Cross Section Groups
*            Edited at Selected Burnup Steps
*
*
*                 *****PRELUDE INPUT DATA******
CELL 6
NPLATE 1
SEQUENCE 2
NGROUPS 20 5 5
NREACT 3
NMESH 7
NREGION 3
NMATERIAL 3 1
PREOUT
INITIATE
*                  *****MAIN INPUT DATA******
*
*IAEA Benchmark with 20%/E Std Plate  -  B-1 Approx. with Burnup
BELL 1.141
FEWGROUPS 3 5 15 21 25 26 27 30 34 38 40 45 47 52 55 58 59 63 66 69
SLAB 1 0.0255 1
SLAB 2 0.0635 2
SLAB 3 0.1750 3
MESH 5 1 1
MATERIAL 1 -1 300 1 235.1 1.7552E-3 238.1 7.0419E-3 27 3.8898E-2  $
 29 5.9437E-3 236.1 1.E-20 3239.1 1.E-20 240.1 1.E-20 241.1 1.E-20  $
 242.1 1.E-20 1241.1 1.E-20
MATERIAL 2 -1 300 2 27 6.0260E-2
MATERIAL 3 1.0 300 3 2001 11.19 16 88.81
POWERC 1 250.04 0.01 1
BEGINC
*                  *****EDIT INPUT DATA******
*
THERMAL 13
LEAKAGE 5
PART 5 15 30 45 69
REACTION 235 300  238 300  3239 300
ISOXS  0 1 9 1 0 1 1 0 0
*
*   The IBURN = 0  determines at which timesteps cross section
*   data are written to ISOTXS file
IBURN 0 0 1 0 0 1 1 0
*
*   The IREACT= 0  determines at which timesteps isotopic
*   reaction rates are edited
IREACT 0 1 1 1 1 1 1 0 0
REGION 1 3
HUSE
WIMS  PLATE
HSETID
Benchmrk Test
ISOTOPES 2135 135 147 1147 1149 235 238 3239 236 240 241 242 1241 901
ISONAMES
I135  X135  PM7A  PM7B  PM49  U235  U238  P239  U236  P240  P241  P242
A241  LFPD
EDITCELLS  1 1 1
BUCKLING  6.5E-3  6.5E-3
NOBUC
BEEONE  1  7
DNB  3 0.066875 0. 0. 0. 0. 0. 0.033441
VECTOR 2 3 8 12 20
```

```
BEGINC
POWERC 1 250.04 1.0 5
BEGINC
BEGINC
POWERC 1 250.04 10.0 1
BEGINC
BEGINC
BEGINC
BEGINC
BEGINC
BEGINC
BEGINC
BEGINC
BEGINC
BEGINC
BEGINC
BEGINC
BEGINC
BEGINC
BEGINC
```

Example 5

TRIGA LEU 20 - 30 Fuel in Square Lattice

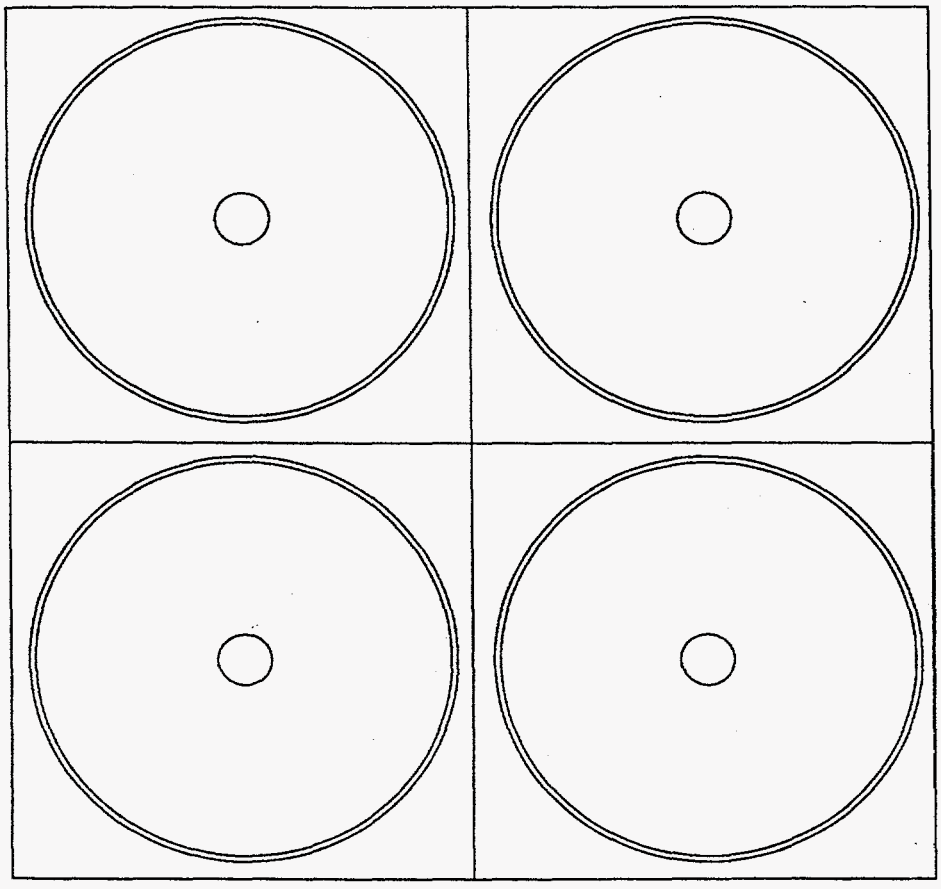


Central Zr Rod O.D.	=	0.457 cm
Fuel Pellet O.D.	=	3.482 cm
Fuel Rod O.D.	=	3.584 cm
Fuel Rod Pitch	=	3.886 cm

```
*
*                          Example 5
*
* TRIGA LEU 20-30 Fuel in Square Lattice Using 69 Transport Groups
* and 69 Group Reaction Rate Edits Collapsed to 7 Broad Groups
* Cell Averaged Microscopic Cross Section Data in ISOTXS Format
*
*
*                  *****PRELUDE INPUT DATA******
*
CELL 6
SEQUENCE 1
NGROUP 69 69 7
NMESH 15 15
NREGION 4 0 5
NREACT 14
NMATERIAL 4 1 5
PREOUT
INITIATE
*                   *****MAIN INPUT DATA******
*
* LEU 20-30 Fuel WIMS 69 Group Int. & 7 Group GA
ANNULUS 1 0.2286 1
ANNULUS 2 1.74117 2
ANNULUS 3 1.79197 3
SQUARE  4 1.94310 4
MATERIAL  1 -1 300 2 91 .042909
MATERIAL  2 -1 300 1 235.1 1.07526E-3 238.1 4.2924E-3 2191 0.04989 $
2091 0.030912 166.1 7.1978E-5  167.1 4.9164E-5 91 .0014238      $
234.1 8.2015E-6 236.1 1.3553E-5
MATERIAL  3 -1 300 2 56 0.060414 52 0.017384 58 0.0081033
MATERIAL  4 -1 300 3 2001 0.0666913 16 0.0333456
FEWGROUPS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 $
23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44  $
45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66  $
67 68 69
MESH 2 9 1 3
BEGINC
*                   *****EDIT INPUT DATA******
*
PARTITION 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $
21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 $
41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 $
61 62 63 64 65 66 67 68 69
THERMAL  42
LEAKAGE  5
REACTION 235 300 238 300 2191 300 91 300 166 300 167 300 2091 300 $
16 300 2001 300 56 300 52 300 58 300 234 300 236 300
ISOXS  0 1 1 0 0 1 0 0 0
REGION 1 4
HUSE
WIMS TRGA
HSETID
LEU 20-30 7 Group GA Cell Averaged Data
ISOTOPES  235 234 236 238 2191 2091 91 166 167 16 2001 56 52 58
ISONAMES
U235  U234  U236  U238  ZR-H  H-ZR  ZR    ER66  ER67  O-16  HYDR  FE
CR    NI
EDITCELLS 1 1 1 1
BUCKLING 1.E-15  1.E-15
VECTOR 6 14 34 47 55 60 69
BEGINC
```

Example 6

TRIGA LEU Multicell Case



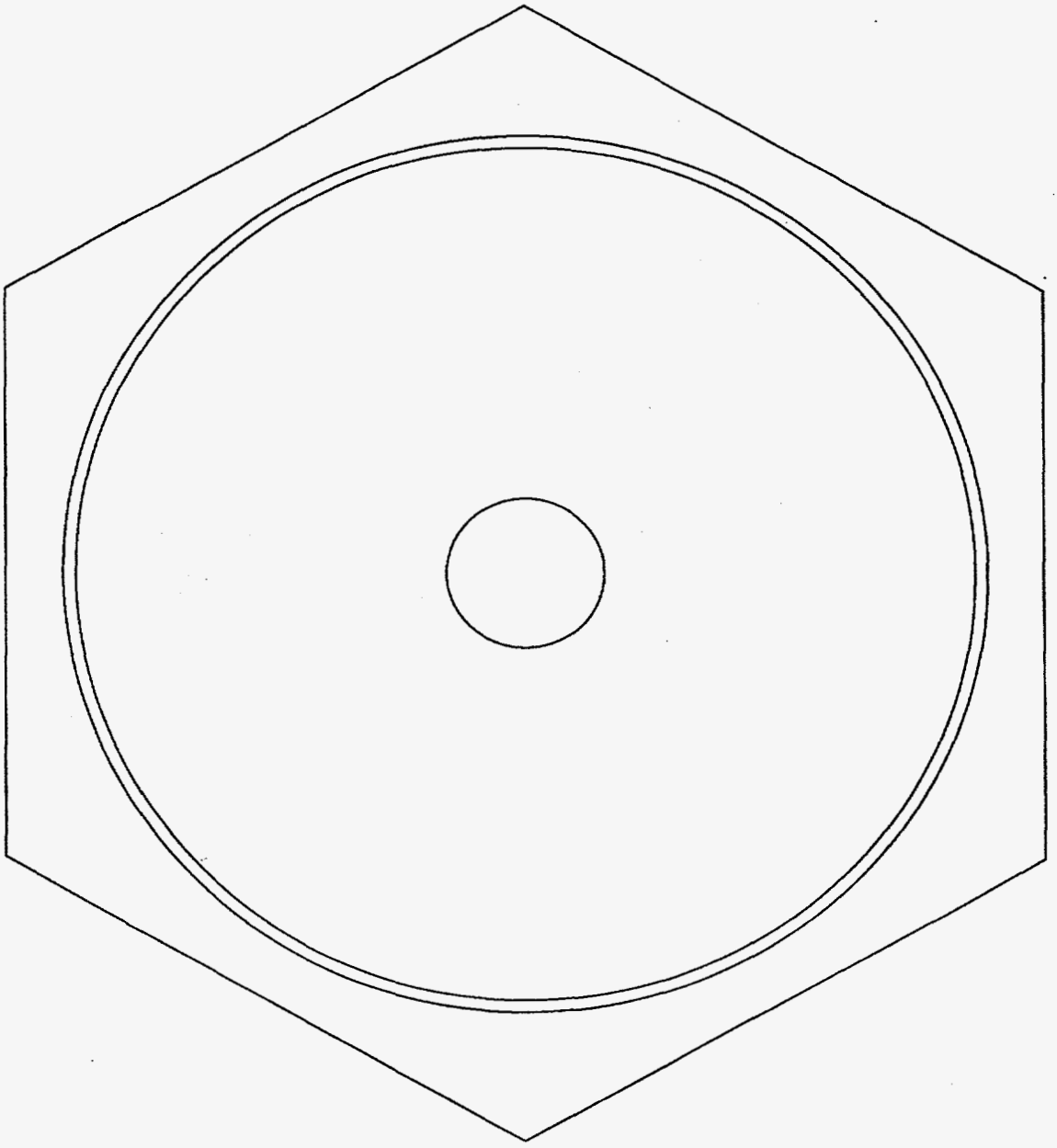
Central Zr Rod O.D.	=	0.457 cm
Fuel Pellet O.D.	=	3.482 cm
Fuel Rod O.D.	=	3.548 cm
Fuel Rod Pitch	=	3.886 cm

```
*
*
*                          Example 6
*
*  TRIGA LEU Multicell Case Using 23 Main Transport Groups
*        All 4 Unit Cells are Identical in this Example
*   The 23 Group Flux Spectrum is Used to Obtain 7 Group
*     Reaction Rate Edits and Cell-Averaged Microscopic
*              ISOTXS Cross Section Data
*
*
*                  *****PRELUDE INPUT DATA******
*
CELL 6
SEQUENCE 2
NGROUP 23 7 7
NMESH 60 60
NCELLS 4
NREGION 16 0 17
NREACT 11
NMATERIAL 4 1 5
PREOUT
INITIATE
*                   *****MAIN INPUT DATA******
*
* LEU 2X2 Standard 8.5wt% U No Er 35.6g U-235/Rod
CELL 1 1
*
* This CELL card is not to be confused with CELL card in PRELUDE input
*
ANNULUS 1 0.2286 1
ANNULUS 2 1.74117 2
ANNULUS 3 1.79197 3
SQUARE  4 1.9431  4
MESH 2 7 1 5
PCELL 1 (.0 .5 .5 .0)
CELL 2 1
ANNULUS 1 0.2286 1
ANNULUS 2 1.74117 2
ANNULUS 3 1.79197 3
SQUARE  4 1.9431  4
MESH 2 7 1 5
PCELL 2 (.5 .0 .0 .5)
CELL 3 1
ANNULUS 1 0.2286 1
ANNULUS 2 1.74117 2
ANNULUS 3 1.79197 3
SQUARE  4 1.9431  4
MESH 2 7 1 5
PCELL 3 (.5 .0 .0 .5)
CELL 4 1
ANNULUS 1 0.2286 1
ANNULUS 2 1.74117 2
ANNULUS 3 1.79197 3
SQUARE  4 1.9431  4
MESH 2 7 1 5
PCELL 4 (.0 .5 .5 .0)
MATERIAL  1 -1 300 2 91 .042909
MATERIAL  2 -1 300 1 235.1 2.5577E-4 238.1 1.01015E-3 2191 .056574 $
2091 0.035470 3239.1 1.E-18
MATERIAL  3 -1 300 2 56 0.060414 52 0.017384 58 0.0081033          $
1212 0.00031716
MATERIAL  4 -1 300 3 2001 0.0666913 16 0.0333456
FEWGROUPS 5 6 14 15 21 25 26 27 30 33 34 35 38 45 47 52 55 58 59 $
60 63 66 69
BEGINC
```

```
*                    *****EDIT INPUT DATA******
*
PARTITION 6 14 34 47 55 60 69
REACTION 235.1 300 238.1 300 2191 300 91 300 2091 300 $
16 300 2001 300 56 300 52 300 58 300 1212 300
THERMAL  15
ISOXS  0 1 1 0 0 1 0 0 0
REGION 1 16
HUSE
WIMS TRGA
HSETID
2x2 Array LEU WIMS 23 Group Intermediate & 7 Group GA
ISOTOPES 235 238 2191 2091 2001 91 16 56 52 58 1212
ISONAMES
U235  U238  H-ZR  ZR-H  HYDR  ZR    O-16  FE    CR    NI    C-12
EDITCELLS 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
BUCKLING 1.E-15  1.E-15
VECTOR 2 3 11 15 17 20 23
BEGINC
```

Example 7

TRIGA LEU Fuel In Hexagonal Geometry

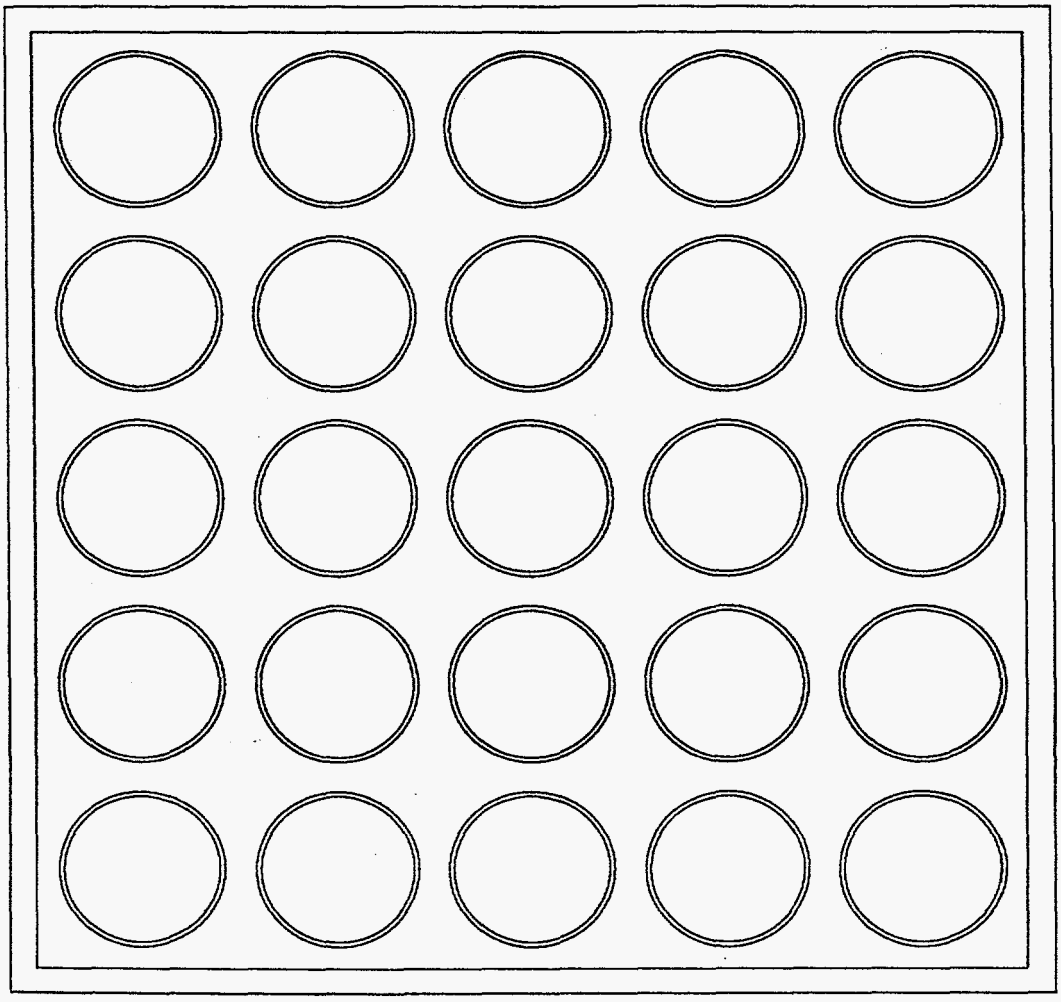


Central Zr Rod O.D.	=	0.635 cm
Fuel Pellet O.D.	=	3.632 cm
Fuel Rod O.D.	=	3.734 cm
Fuel Rod Hexagonal Pitch	=	4.250 cm

```
*
*                          Example 7
*
*            TRIGA LEU Fuel in Hexagonal Geometry
*               Using 69 Main Transport Groups
* Collapsed to 7 Reaction Rate and Microscopic ISOTXS Groups
*
*
*                 *****PRELUDE INPUT DATA******
*
CELL 6
SEQUENCE 2
NGROUP 69 7 7
NMESH 15 15
NREGION  4 1 5
NREACT  15
NMATERIAL 4 1 5
PREOUT
INITIATE
*                  *****MAIN INPUT DATA******
*
* LEU 20-30 TRIGA fuel 69 Main Transport Groups & 7 Group GA Edits
BELL 1.1608
ANNULUS 1 0.3175 1
ANNULUS 2 1.8161  2
ANNULUS 3 1.8669  3
*
*   The following card describes the outer hexagonal cell boundary
POLYGON 4 6 4 2.125
*
MATERIAL  1 -1 300 2 91 .042909
MATERIAL  2 -1 300 1 235.1 1.07552E-3 238.1 4.2935E-3 2191 0.04989 $
2091 0.032319 166.1 7.8705E-5  167.1 5.3435E-5 3239.1 1.E-18        $
234.1 8.2035E-6 236.1 1.3556E-5 1212 1.42659E-3
MATERIAL  3 -1 300 2 56 0.060414 52 0.017384 58 .0081033 $
1212 0.000317
MATERIAL  4 -1 300 3 2001 0.0666913 16 0.0333456
FEWGROUPS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 $
 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 $
 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 $
 64 65 66 67 68 69
MESH 2 9 1 3
BEGINC
*                  *****EDIT INPUT DATA******
*
PARTITION 6 14 34 47 55 60 69
REACTION 234 300 235 300 236 300 238 300 2191 300 58 300 1212 300 $
 2091 300 91 300 166 300 167 300 16 300 2001 300 56 300 52 300
THERMAL  42
ISOXS  0 1 1 0 0 1 1 0 0
REGION 1 4
HUSE
WIMS TRGA
HSETID
* LEU 20-30 fuel 69 Group Int. & 7 Group GA
ISOTOPES 234 235 236 238 2191 2091 91 166 167 16 2001 56 52 58
ISONAMES
U234  U235  U236  U238  H-ZR  ZR-H  ZR    ER66  ER67  O-16  HYDR  FE
CR    NI
EDITCELLS 1 1 1 1
*       *****CELL AVERAGED MICROSCOPIC CROSS SECTION EDIT ******
*
BUCKLING 1.E-15  1.E-15
VECTOR    6 14 34 47 55 60 69
BEGINC
```

Example 8

TRIGA Multicell 5 x 5 Array with Aluminum Shroud



Fuel Pellet O.D.	=	1.295 cm
Fuel Rod O.D.	=	1.377 cm
Fuel Rod Pitch	=	1.633 cm
Shroud Thickness	=	0.157 cm
Fuel Cluster Pitch	=	8.890 cm

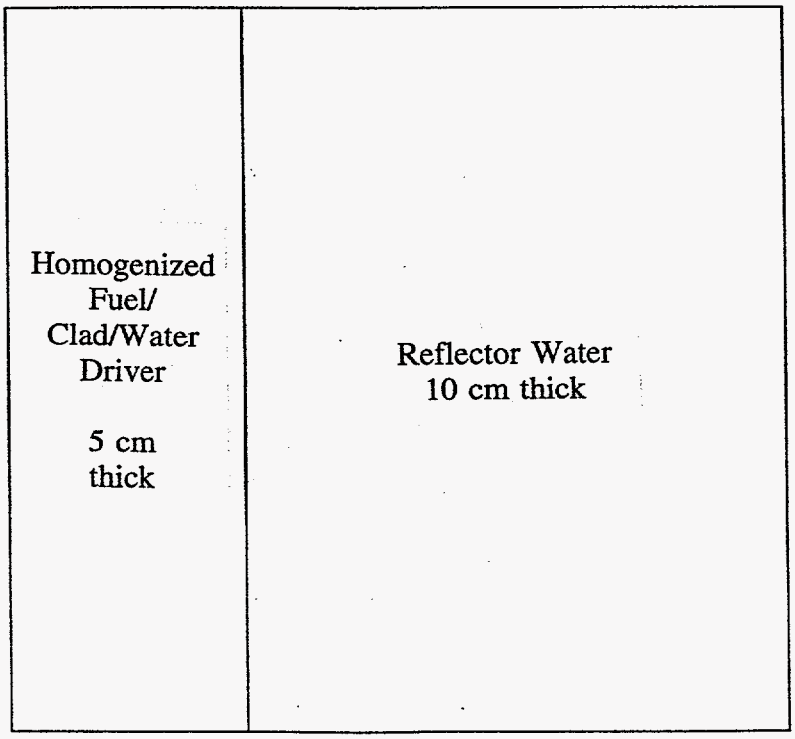
```
*
*                        Example 8
*
*  TRIGA Multicell 5X5 Array with Aluminum Shroud
*           Using 69 Main Transport Groups
*         Collapsing to 7 Reaction Rate and
*       Cell-Averaged Microscopic ISOTXS Groups
*
*
*                  *****PRELUDE INPUT DATA******
CELL 6
SEQUENCE 2
NGROUP 69 7 7
NMESH 45 45
NREGION 14 0 15
NMATERIAL 14 0 15
NCELLS 6
NREACT 17
PREOUT
INITIATE
*                   *****MAIN INPUT DATA******
*
*WIMS-MULTICELL OPTION FOR TRIGA LEU SSR 14MW FUEL BUNDLE *
*
* central pin cell model
*
CELL 1 1
ANNULUS 1 0.6477 1
ANNULUS 2 0.68834 2
ANNULUS 3 0.9214 3
MESH 6 1 3
PCELL 1 (0. 1. 0. 0. 0. 0.)
*
* 8 pin cells surrounding central pin
*
CELL 2 8
ANNULUS 1 0.6477 6
ANNULUS 2 0.68834 7
ANNULUS 3 0.9214 8
MESH 6 1 3
PCELL 2 (0.125 0.5 0.375 0.0 0.0 0.0 )
*
* 12 outer pin cells without corner pins
*
CELL 3 12
ANNULUS 1 0.6477 9
ANNULUS 2 0.68834 10
ANNULUS 3 0.9214 11
MESH 6 1 3
PCELL 3  (0.0 0.25  0.333 0.25 0.167 0.0 )
*
* outer shroud and water sides
*
CELL 4 12
ANNULUS 1 0.4337 4
MESH 2
PCELL 4  (0.0 0.0 0.4093  0.5302 0.0 0.0605 )
CSPECTRUM 3
*
* corner pins
*
CELL 5 4
ANNULUS 1 0.6477 12
ANNULUS 2 0.68834 13
ANNULUS 3 0.9214 14
MESH 6 1 3
```

```
PCELL 5 (0.0 0.0 0.5 0.0 0.0 0.5 )
*
* outer shroud and water corners
*
CELL 6 4
ANNULUS 1 0.6465 5
MESH 3
PCELL 6 ( 0. 0. 0. 0.0907 0.4093 0.5)
CSPECTRUM 5
MATERIAL 5 -1 300 3 2001 0.0376806 16 0.0188403 27 .0262035
MATERIAL 4 -1 300 3 2001 0.0376806 16 0.0188403 27 .0262035
MATERIAL 3 -1 300 3 2001 0.0666913 16 0.0333456
MATERIAL 1 -1 300 1 235.1 0.0018652 238.1 7.4693E-3 2191 0.044700 $
2091 0.029111 166.1 1.2915E-04 167.1 8.8211E-05 1212 .0016535       $
234.1 1.4263E-5 236.1 2.3569E-5
MATERIAL 2 -1 300 2 56 0.039435 52 0.018876 58 0.026095 $
55  .0006536 29 0.00059663 12 0.00015944
MATERIAL 6 -1 300 1 235.1 0.0018652 238.1 7.4693E-3 2191 0.044700 $
2091 0.029111 166.1 1.2915E-04 167.1 8.8211E-05 1212 .0016535       $
234.1 1.4263E-5 236.1 2.3569E-5
MATERIAL 7 -1 300 2 56 0.039435 52 0.018876 58 0.026095 $
55  .0006536 29 0.00059663 12 0.00015944
MATERIAL 8 -1 300 3 2001 0.061266913 16 0.0333456
MATERIAL 9 -1 300 1 235.1 0.0018652 238.1 7.4693E-3 2191 0.044700 $
2091 0.029111 166.1 1.2915E-04 167.1 8.8211E-05 1212 .0016535       $
234.1 1.4263E-5 236.1 2.3569E-5
MATERIAL 10 -1 300 2 56 0.039435 52 0.018876 58 0.026095 $
55  .0006536 29 0.00059663 1212 0.00015944
MATERIAL 11 -1 300 3 2001 0.0666913 16 0.0333456
MATERIAL 12 -1 300 1 235.1 0.0018652 238.1 7.4693E-3 2191 0.044700 $
2091 0.029111 166.1 1.2915E-04 167.1 8.8211E-05 1212 .0016535       $
234.1 1.4263E-5 236.1 2.3569E-5
MATERIAL 13 -1 300 2 56 0.039435 52 0.018876 58 0.026095 $
55  .0006536 29 0.00059663 1212 0.00015944
MATERIAL 14 -1 300 3 2001 0.0666913 16 0.0333456
FEWGROUPS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 $
 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 $
 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 $
 64 65 66 67 68 69
BEGINC
*                  *****EDIT INPUT DATA******
*
PARTITION 6 14 34 47 55 60 69
REACTION 235.1 300 238.1 300 2191 300 2091 300 166.1 300 167.1 300 $
16 300 2001 300 56 300 52 300 58 300 234.1 300 236.1 300 29 300    $
1212 300 55 300 27 300
THERMAL  42
ISOXS  0 1 1 0 0 1 0 0 0
REGION 1 14
HUSE
WIMS SSR
HSETID
SSR 5x5 Array LEU WIMS 69 Group Intermediate & 7 Group GA
ISOTOPES 234 235 236 238 2191 2091 166 167 16 2001 56 52 58
ISONAMES
U234  U235  U236  U238  H-ZR  ZR-H  ER66  ER67  O-16  HYDR  FE    CR
NI
EDITCELLS 1 1 1 1 1 1 1 1 1 1 1 1 1
BUCKLING 1.E-15  1.E-15
VECTOR    6 14 34 47 55 60 69
BEGINC
```

```
*
*                    Example 9
*
*     H2O Reflector Model Using Homogeneous Cell Option
*        20 Group Microscopic Cross Sections Edited
*
*
CELL 4
SEQUENCE 1
NGROUPS 69 2 20
NREACT 3
PREOUT
INITIATE
*Homogeneous Cell U-235 & HinH2O at 300K
FEWGROUPS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $
21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 $
41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 $
61 62 63 64 65 66 67 68 69
MATERIAL 1 -1 300 1 235.1 1.00E-10 2001 .06677753 16 .0333888
BEGINC
PARTITION 45 69
REACTION 235.1 300 2001 300 16 300
THERMAL 42
NOBUCKLING
ISOXS  0 1 1 0 0 1 1 0 0
REGION 1 1
HUSE
WIMS HOMO
HSETID
Homogeneous H2O Cell with inf dilute U-235
ISOTOPES 2001 16
ISONAMES
2001  O-16
EDITCELLS 1
NOBUCKLING
VECTOR 1 2 3 4 5 6 7 8 9 10 15 27 42 60 61 62 63 65 67 69
BEGINC
```

Example 10

SUPERCELL MODEL FOR H2O CROSS SECTIONS

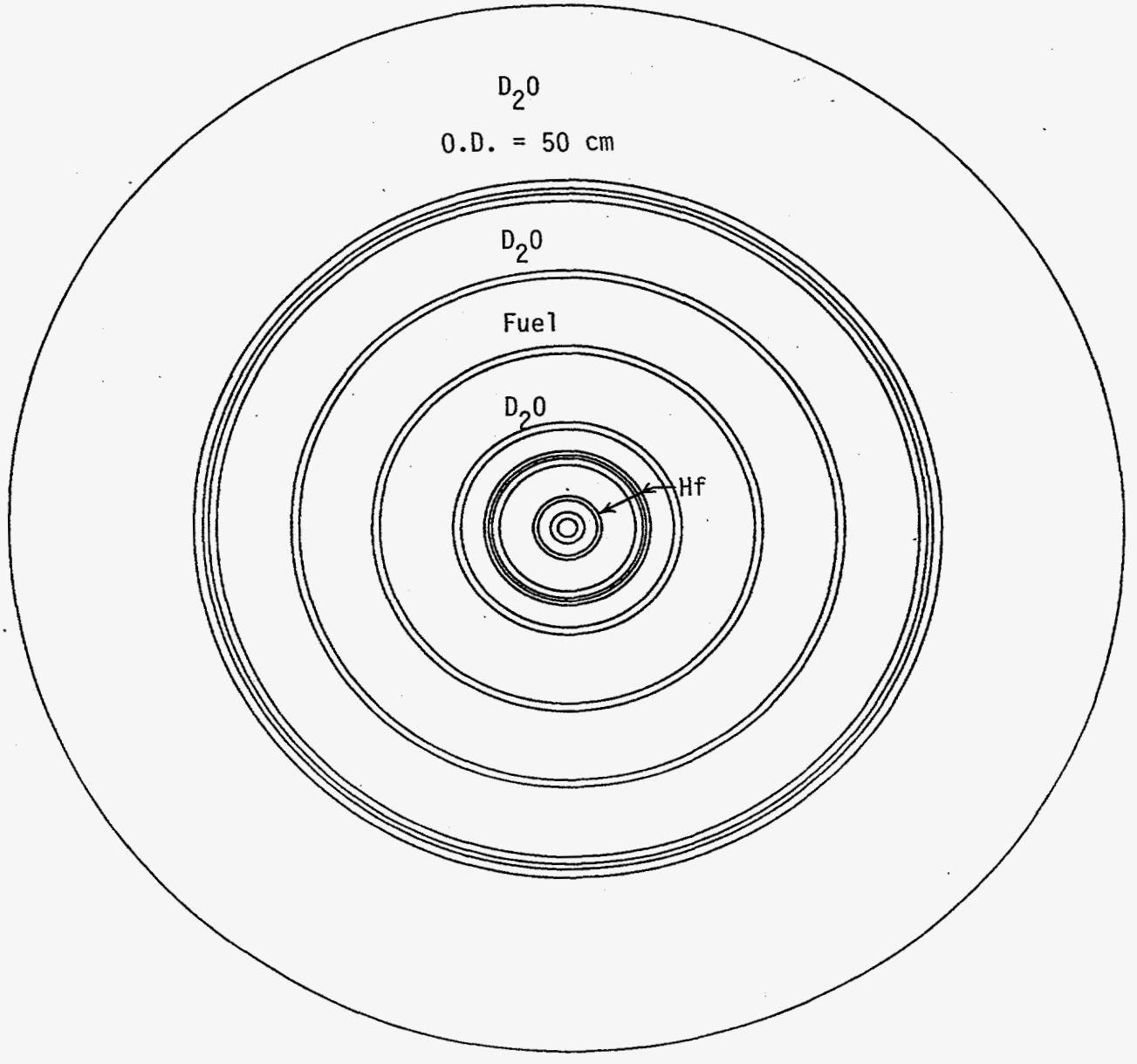


```
*
*                          Example 10
*
*        Supercell Model for Water Reflector Cross Sections
*
CELL 8
SEQUENCE 1
NGROUPS 23 2 4
NMESH 44 25
NREGION 8 0 3
NMATERIAL 5 0 5
NCELL 3
PREOUT
INITIATE
*WIMS Supercell Option for Water Reflector Xs Data  *
FEWGROUPS 5 6 14 15 21 25 26 27 30 33 34 35 38 45 47 52 55 58 59 $
60 63 66 69
*
* Supercell (homogeneous fuel slab, vessel and reflector)
*
CELL 1 1 1 1
CSPECTRUM -1
SLAB 1 5.0 4
SLAB 2 5.05 2
SLAB 3 15.0  5
MESH 12 1 10
*
* Homongenized fuel with resonance treatment included
*
CELL 2 1 1 0
CSPECTRUM 2
SLAB 1 0.0254 1
SLAB 2 0.0634 2
SLAB 3 0.2250 3
MESH 3 3 3
*
* Improved reflector spectrum
*
CELL 3 1 1 1
CSPECTRUM 3 1
SLAB 1 3.0  4
SLAB 2 8.0  5
MESH 4 8
*
NEWXS 1 -1 2
NEWXS 2 -1 2
NEWXS 3 -1 2
NEWXS 4  1 2 1 2 3
NEWXS 5 -1 3
*
MATERIAL 1 -1 300 1 235.1 1.7326E-3 238.1 6.8625E-3 27 4.0160E-2  $
 29 5.7473E-3
MATERIAL 2 -1 300 2 27 6.0238E-2
MATERIAL 3 -1 300 3 2001 6.6691E-2 16 3.3346E-2
MATERIAL 4 -1 300 1 235.4 1.E-18
MATERIAL 5 -1 300 3 2001 6.6691E-2 16 3.3346E-2
BEGINC
THERMAL 15
PARTITION 45 69
LEAKAGE
ISOXS  0 1 1 0 0 1
REGION 1 3
HUSE
WIMS  REFLT
HSETID
Reflector cross-sections for Hydrogen and Oxygen
```

```
ISOTOPES 2001 16
ISONAMES
HRFL  ORFL
EDITCELLS 0 0 0 0 1
VECTOR 1 3 8 23
BEGINC
```

Example 11

Supercell Model For ORNL's Advanced Neutron Source Design



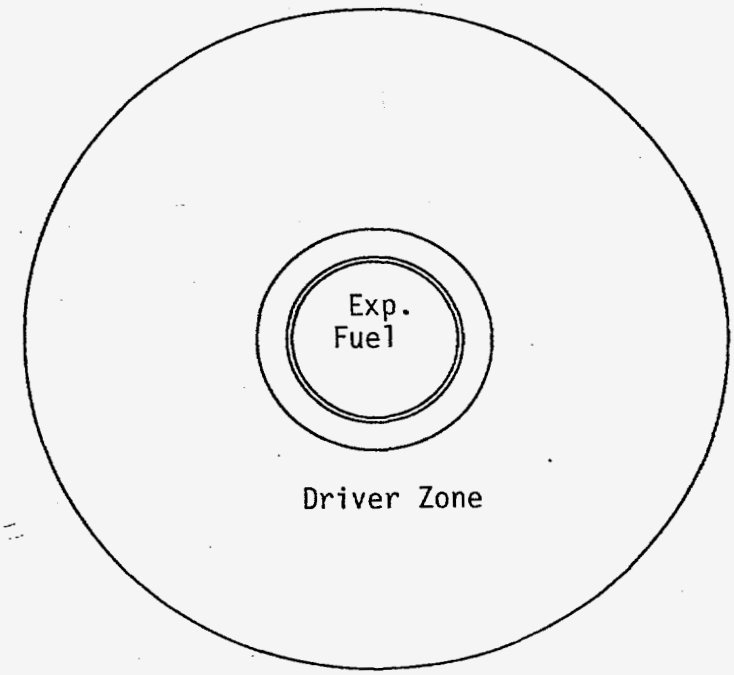
```
*
*                              Example 11
*
*          Supercell Model for ORNL's Advanced Neutron Source Design
*                              Using LEU Fuel
*
CELL 8
SEQUENCE 1
NGROUP 30 15 15
NMESH 263 181
NREGION 19 0 20
NMATERIAL 13 0 13
NCELL 5
PREOUT
INITIATE
*Supercell for ANS lower FE, Hf rods in, Hf resonance *
S 16
TOLERANCE 0.000001
FEWGROUPS 3 5 6 8 10 13 15 16 18 20 22 24 26 27 29 34 37  $
 40 42 45 47 50 52 54 56 60 61 64 66 69
*
* Supercell geometry
*
CELL 1 1 0 1
CSPECTRUM -1
ANNULUS  1 0.87037  1
ANNULUS  2 1.52037  2
ANNULUS  3 2.64537  1
ANNULUS  4 3.04537  8
ANNULUS  5 6.05463  1
ANNULUS  6 6.70463  4
ANNULUS  7 7.00463  3
ANNULUS  8 7.40463  9
ANNULUS  9 9.50000  3
ANNULUS 10 10.2000  4
ANNULUS 11 16.8000 11
ANNULUS 12 17.5000 12
ANNULUS 13 24.1000 13
ANNULUS 14 24.8000 12
ANNULUS 15 31.4000 11
ANNULUS 16 32.1000 12
ANNULUS 17 32.6000 11
ANNULUS 18 33.4000 12
ANNULUS 19 50.0000 10
MESH 2 1 2 60 3 1 2 60 3 1 5 1 10 1 5 1 2 1 20
*
* Homogenized fuel with resonance treatment included
*
CELL 2 1 1 0
CSPECTRUM 2
DANCOFF  0.086105 0.086105
SLAB 1 3.1750E-02  5
SLAB 2 6.3500E-02  6
SLAB 3 1.2700E-01  7
SLAB 4 0.635      11
MESH 6 1 2 2
*
* Inner Hf with resonance treatment
*
CELL 3 1 0 1 8  0.80
CSPECTRUM 3 1
BELL 1.197
ANNULUS  1 0.87037  1
ANNULUS  2 1.52037  2
ANNULUS  3 2.64537  1
ANNULUS  4 3.04537  8
```

```
ANNULUS  5 6.05463  1
ANNULUS  6 9.0     13
MESH 3 2 3 10 4 5
*
* Outer Hf with resonance treatment
*
CELL 4 1 0 1 9  0.80
CSPECTRUM 4 1
BELL 1.197
ANNULUS  1 6.05463  3
ANNULUS  2 6.70463  4
ANNULUS  3 7.00463  3
ANNULUS  4 7.40463  9
ANNULUS  5 9.50000  3
ANNULUS  6 10.2000  4
ANNULUS  7 13.00   13
MESH 5 2 3 10 3 2 5
*
* Outer region spectrum, heavy water & structure
*
CELL 5 1 1 1
CSPECTRUM 5 1
SLAB 1 5.0  13
SLAB 2 5.5  12
SLAB 3 10.0 11
SLAB 4 15.0 10
MESH 5 1 4 4
*
NEWXS  1 -1 3
NEWXS  2 -1 3
NEWXS  3 -1 4
NEWXS  4 -1 4
NEWXS  5 -1 2
NEWXS  6 -1 2
NEWXS  7 -1 2
NEWXS  8 -1 3
NEWXS  9 -1 4
NEWXS 10 -1 5
NEWXS 11 -1 5
NEWXS 12 -1 5
NEWXS 13  1 2 5 6 7
MATERIAL 1 -1 300 3 2001 1.66179E-4 4002 6.63099E-2 16 3.32357E-2
MATERIAL 2 -1 300 2 24 6.68713E-4 27 5.82195E-2 29 3.47224E-4 $
 52 6.25173E-5 55 4.43768E-5 56 3.53521E-4 63.1 7.60718E-5
MATERIAL 3 -1 300 3 2001 1.62364E-4 4002 6.47837E-2 16 3.24825E-2
MATERIAL 4 -1 300 2 24 6.68713E-4 27 5.82195E-2 29 3.47224E-4 $
 52 6.25173E-5 55 4.43768E-5 56 3.53521E-4 63.1 7.60718E-5
MATERIAL 5 -1 300 1 27 2.21272E-2 29 8.11631E-3  $
 234.1 2.45393E-5 235.1 2.45964E-3 236.1 1.1266E-5 238.1 9.67901E-3  $
 3239.1 1.0E-20 240.1 1.0E-20 241.1 1.0E-20 242.1 1.0E-20  $
 1241.1 1.0E-20 149 1.0E-20 135 1.0E-20 1149 1.0E-20 2135 1.0E-20
MATERIAL 6 -1 300 2 24 6.68713E-4 27 5.82195E-2 29 3.47224E-4 $
 52 6.25173E-5 55 4.43768E-5 56 3.53521E-4 63.1 7.60718E-5
MATERIAL 7 -1 300 3 2001 1.66044E-4 4002 6.62364E-2 16 3.31989E-2
MATERIAL 8 -1 300 1 178.1 4.47728E-2
MATERIAL 9 -1 300 1 178.1 4.47728E-2
MATERIAL 10 -1 300 3 2001 1.66179E-4 4002 6.63099E-2 16 3.32357E-2
MATERIAL 11 -1 300 3 2001 1.66179E-4 4002 6.63099E-2 16 3.32357E-2
MATERIAL 12 -1 300 2 24 6.68713E-4 27 5.82195E-2 29 3.47224E-4 $
 52 6.25173E-5 55 4.43768E-5 56 3.53521E-4 63.1 7.60718E-5
MATERIAL 13 -1 300 1 27 1.E-18
BEGINC
OPTION  3
BUCKLING  1.000E-15 1.000E-15
NOBUCKLING
PARTITION  5 10 13 15 18 20 24 26 27 37 45 50 54 61 69
```

```
THERMAL 10
LEAKAGE 5
ISOXS  0 1 1 0 0 1 0 0
REGION 1 19
HUSE
ANS ISOTXS
HSETID
ANS Cylindrical cell 30 fine gps, 15 Bd. Gps
ISOTOPES 178
ISONAMES
HFOR
EDITCELLS 0 0 0 0 0 0 0 1 0
*EDITCELLS 0 0 0 0 0 0 0 0 1
VECTOR 2 5 6 7 9 10 12 13 14 17 20 22 24 27 30
BEGINC
```

Example 12

Supercell Model For TRIGA Experimental Location

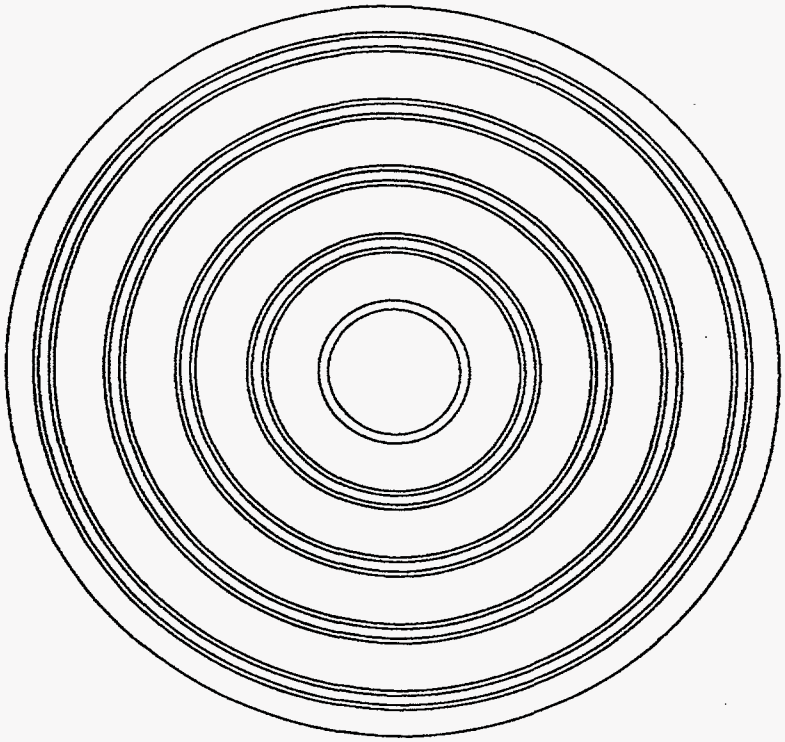


Central Fuel Pellet O.D.	=	1.295 cm
Central Fuel Rod O.D.	=	1.377 cm
Central Coolant Water O.D.	=	1.840 cm
Driver Zone O.D.	=	5.520 cm

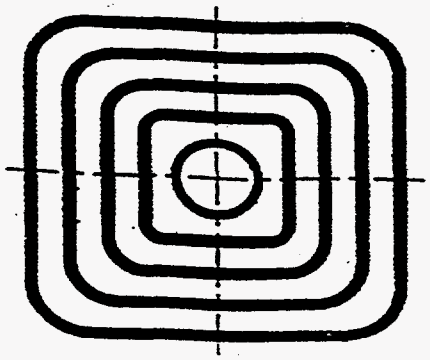
```
*                       Example 12
*
*      Supercell Model for a SSR TRIGA Experimental Location
*       13 Main Transport Groups and 8 Broad ISOTXS Groups
*
*
CELL 8
SEQUENCE 1
NGROUP 13 8 8
NMESH 21 15
NREGION 7 0 4
NMATERIAL 4 0 4
NCELL 2
PREOUT
INITIATE
*
*           Supercell option for a SSR experimental location
*            with material 4 as one central fuel pin cell
*
PRTOPT 1
CELL 1 1 0 1
CSPECTRUM -1
ANNULUS 1 0.6477 1
ANNULUS 2 0.6883 2
ANNULUS 3 0.9200 3
ANNULUS 4 2.76   4
MESH 3 1 2  9
*
CELL 2 1 0 0
CSPECTRUM 2
ANNULUS 1 0.6477 1
ANNULUS 2 0.6883 2
ANNULUS 3 0.9200 3
MESH 3 1 2
*
NEWXS 1 -1 2
NEWXS 2 -1 2
NEWXS 3 -1 2
NEWXS 4  1 2 1 2 3
*
MATERIAL 1 -1 680 1 235.1 0.00143 238.1 0.000105 2191 0.0543 2091 $
0.0339   166.1 0.0002035 167.1 0.000143
MATERIAL 2 -1 370 2 56 0.0394 52 0.01887 58 0.02619 55 0.000654  $
27 0.000532 29 0.000597 1212 0.000159
MATERIAL 3 -1 300 3 2001 6.66912E-2 16 3.33456E-2
MATERIAL 4 -1 300 1  235   1.E-18
FEWGROUPS 6 14 17 20 23 25 27 30 33 47 55 59 69
BEGINC
THERMAL  6
ISOXS  1 3 1
REGION 1 3 1 4
HUSE
WIMS SSR
HSETID
SSR Supercell model, 13-> 8-> 8 ISOTXS broad groups
ISOTOPES 2001 2191 1212 16 27 52 55 56 58 2091 166 167 235 238
ISONAMES
H-1   H-ZR  C-12  O-16  AL27  CR    MN55  FE    NI    ZR-H  ER66  ER67
U235  U238
EDITCELLS 1 1 1 0 0 0 0
NOBUCKLING
BUCKLING 1.E-15  1.E-15
VECTOR 1 2 8 9 10 11 12 13
BEGINC
```

Example 13

Supercell Model of Czech Republic IRT-2M Fuel Assembly



Actual Fuel Assembly Configuration[9, 10]



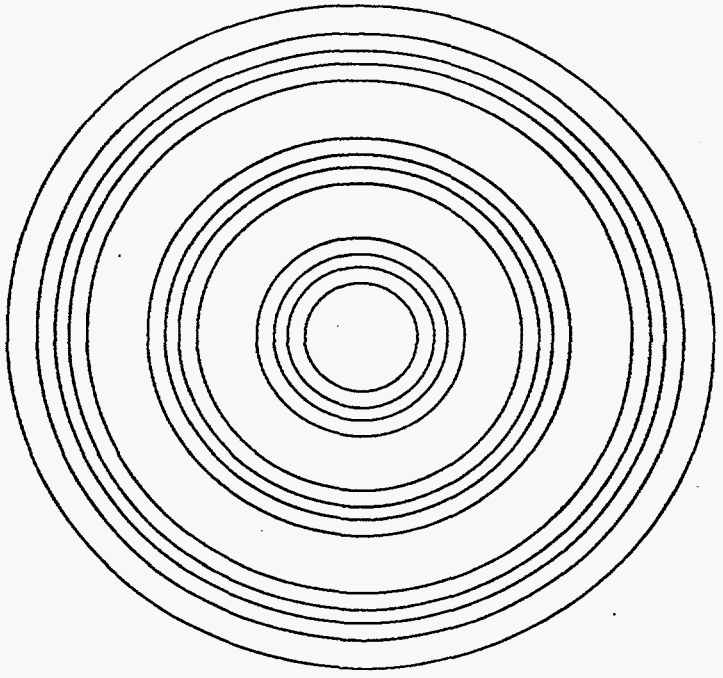
Four Fuel Tubes with Thickness = 2.00 mm
Fuel Meat Thickness = 1.00 mm
Coolant Channel Thickness = 4.50 mm
Fuel Enrichment = 36 wt.%
U235 Loading in Fuel Assembly = 230 g

```
*
*
*                          Example 13
*
* Supercell Model of Czech Republic IRT-2M Fuel Assembly
*     Using a 30 Group DSN Flux Spectrum Calculation
*     with 15 Group ISOTXS Microscopic Cross Sections
*
*
*                 *****PRELUDE INPUT DATA******
CELL 8
SEQUENCE 1
NGROUP 30 0 15
NMESH 52 37
NREGION 19 0 19
NMATERIAL 6 0 6
NCELL 3
PREOUT
INITIATE
*
*                  *****MAIN INPUT DATA******
*
*             *  Supercell Geometry Description  *
*  Plate Thickness = 2.0mm          Fuel Meat Thickness = 1.0mm
*
CELL 1 1 0 1
CSPECTRUM -1
ANNULUS 1 0.70   1
ANNULUS 2 0.80   2
ANNULUS 3 1.32921 3
ANNULUS 4 1.38151 4
ANNULUS 5 1.48565 5
ANNULUS 6 1.53751 4
ANNULUS 7 2.06420 3
ANNULUS 8 2.11724 4
ANNULUS 9 2.22290 5
ANNULUS 10 2.27554 4
ANNULUS 11 2.79759 3
ANNULUS 12 2.85104 4
ANNULUS 13 2.95756 5
ANNULUS 14 3.01065 4
ANNULUS 15 3.53039 3
ANNULUS 16 3.58408 4
ANNULUS 17 3.69116 5
ANNULUS 18 3.74455 4
ANNULUS 19 4.03396 3
MESH 4 1 3 1 2 1 3 1 2 1 3 1 2 1 3 1 2 1 2
PRTOPT 0
*
CELL 2 1 1 0
CSPECTRUM 2
SLAB 1 0.050 5
SLAB 2 0.100 4
SLAB 3 0.550 3
MESH 2 1 3
*
CELL 3 1 0 1
CSPECTRUM 3 1
ANNULUS 1 0.70   1
ANNULUS 2 0.80   2
ANNULUS 3 3.01   6
MESH 3 1 5
*
NEWXS 1 -1 3
NEWXS 2 -1 3
NEWXS 3 -1 2
```

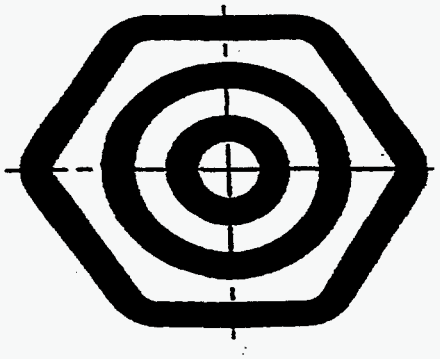
```
NEWXS 4 -1 2
NEWXS 5 -1 2
NEWXS 6  1 2 3 4 5
*
MATERIAL 1 -1 300 3  2001 6.63371E-2 16 3.31685E-2
MATERIAL 2 -1 300 2  27 6.02380E-2
MATERIAL 3 -1 300 3 2001 6.63371E-2 16 3.31685E-2
MATERIAL 4 -1 300 2  27 6.02380E-2
MATERIAL 5 -1 300 1 235.1 0.0015008 238.1 0.0026343 27 0.019284 $
  16 0.0082702
MATERIAL 6 -1 300 1 235 1.0E-18
FEWGROUPS 3 5 6 8 10 13 15 16 18 20 22 24 26 27 29 34 37 $
 40 42 45 47 50 52 54 56 60 61 64 66 69
BEGINC
THERMAL  6
ISOXS  0 1 1 0 0 1 1 0
HUSE
WIMS RRR
HSETID
CRF Super-cell problem e=36 wt%, 69->30->15 broad groups
* ISOTOPES 235 238 27 2001 16
ISOTOPES 2001 16
ISONAMES
HH2O  OH2O
* U235  U238  AL27  HH2O  OH2O
* EDITCELLS 1 1 1 1 1
EDITCELLS 1 0 0 0 0
NOBUCKLING
BUCKLING 1.E-15  1.E-15
VECTOR 2 5 6 7 9 10 12 13 14 17 20 22 24 27 30
BEGINC
```

Example 14

Supercell Model for Hungarian VVR-M2 Fuel Assembly



Annular Fuel
Assembly Model



Actual Fuel
Assembly Geometry [8]

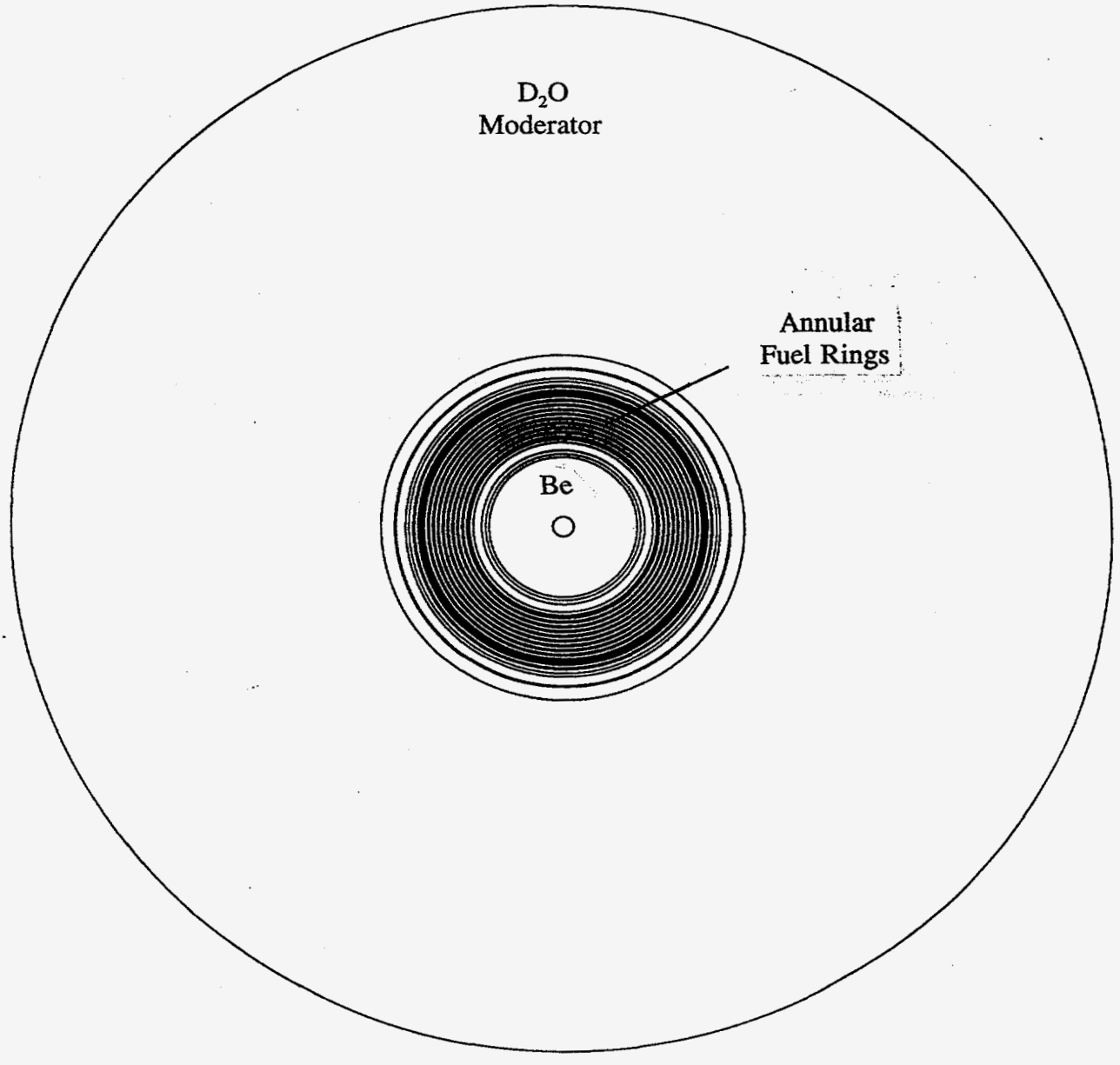
3 Fuel Tubes
Fuel Tube Thickness = 2.5 mm
Fuel Meat Thickness = 0.70 mm
Coolant Channel Thickness = 2.5 mm
Enrichment = 36 wt. % U235
Total U235 = 33.1 g

```
*
*                          Example 14
*
*    Supercell Model of Hungarian VVR-M2 Fuel Assembly
*     Using a 30 Group DSN Flux Spectrum Calculation
*     with 15 Group Reaction Rate Edits, 15 Group ISOTXS
* Microscopic Cross Sections and 3 Depletion Burnup Steps
*
*
*                  *****PRELUDE INPUT DATA******
CELL 8
SEQUENCE 1
NGROUP 30 15 15
NMESH 38 29
NREGION 13 0 13
NMATERIAL 4 0 4
NCELL 2
PREOUT
INITIATE
*
*                   *****MAIN INPUT DATA******
*
CELL 1 1 0 1
CSPECTRUM -1
ANNULUS 1 0.30 1
ANNULUS 2 0.39 2
ANNULUS 3 0.46 4
ANNULUS 4 0.55 2
ANNULUS 5 0.85 1
ANNULUS 6 0.94 2
ANNULUS 7 1.01 4
ANNULUS 8 1.10 2
ANNULUS 9 1.4176 1
ANNULUS 10 1.5121 2
ANNULUS 11 1.5856 4
ANNULUS 12 1.6801 2
ANNULUS 13 1.8376 3
*POLY 13 6 1 1.675
MESH 5 1 3 1 3 1 3 1 3 1 3 1 3
*
*CELL 2 1 1 1 4 0.28
CELL 2 1 1 0
*CSPECTRUM 2 1
CSPECTRUM 2
*DANCOFF 0.527  0.527
SLAB 1 0.035 4
SLAB 2 0.125 2
SLAB 3 0.275 1
SLAB 4 0.295 3
*SLAB 4 0.325 3
MESH 3 1 3 2
*
NEWXS 1 -1 2
NEWXS 2 -1 2
NEWXS 3 -1 2
NEWXS 4 -1 2
*
MATERIAL 1 -1 300 3  2001 6.63371E-2 16 3.31685E-2
MATERIAL 2 -1 300 2  27 6.02380E-2
MATERIAL 3 -1 300 3 2001 6.66912E-2 16 3.33456E-2
MATERIAL 4 -1 300 1 235.1 0.0012544 238.1 0.0022019 27 0.034412 $
 236.1 1.E-20 3239.1 1.E-20 240.1 1.E-20 241.1 1.E-20  $
 242.1 1.E-20 1241.1 1.E-20
FEWGROUPS 3 5 6 8 10 13 15 16 18 20 22 24 26 27 29 34 37 $
 40 42 45 47 50 52 54 56 60 61 64 66 69
POWERC 1 250.0 0.1 1 0.05
```

```
*
*                    *****EDIT INPUT DATA******
*
BEGINC
THERMAL  6
ISOXS  0 1 4 1 0 1 1 0
* ISOXS  0 1 1 0 0 1 1 0
REGION 1 13
HUSE
WIMS RRR
HSETID
RRR Super-cell problem, 69->30->15 broad groups
ISOTOPES 27 235 238
ISONAMES
AL27  U235  U238
*EDITCELLS 0 0 0 1
EDITCELLS 1 1 1 1
NOBUCKLING
BUCKLING 1.E-15  1.E-15
VECTOR 2 5 6 7 9 10 12 13 14 17 20 22 24 27 30
BEGINC
POWERC 1 250.0 1.0 1
BEGINC
BEGINC
BEGINC
BEGINC
POWERC 1 250.0 10.0 1
BEGINC
BEGINC
```

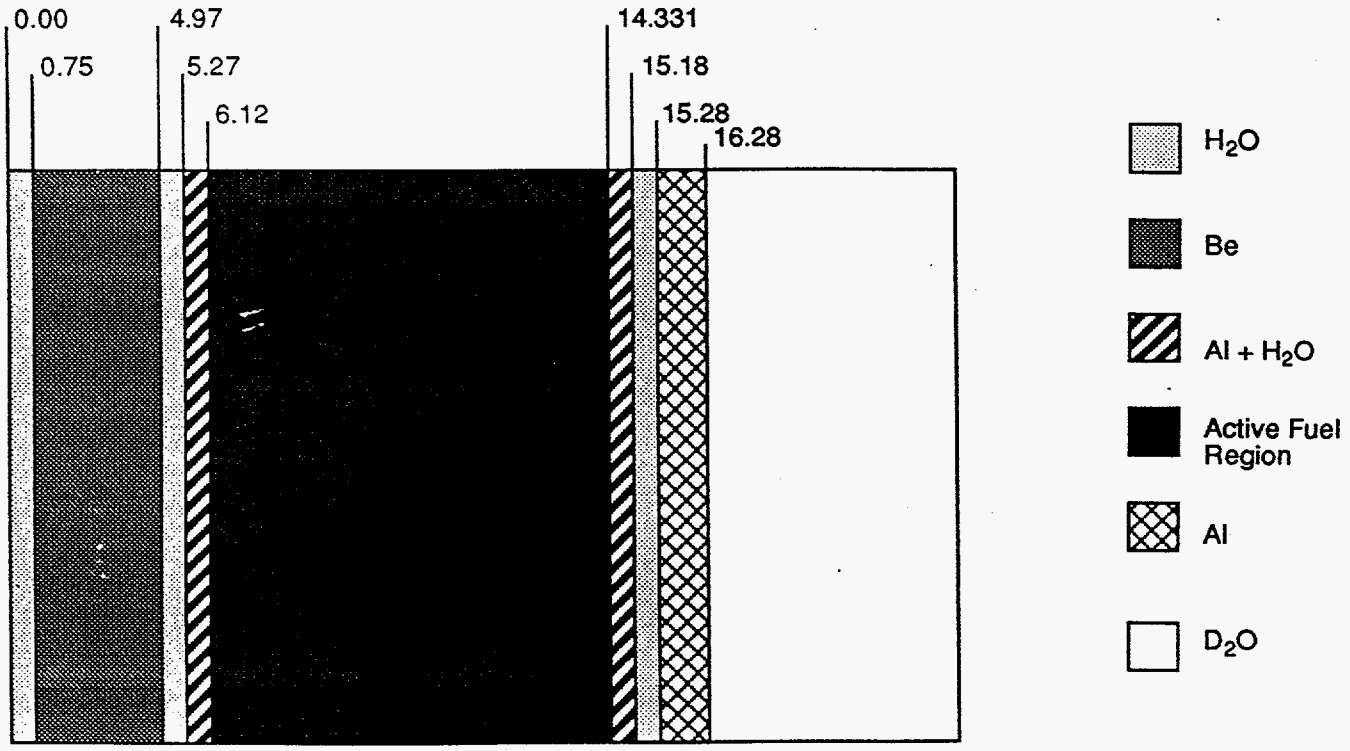
Example 15

Supercell Model of LEU Involute Plate Core Design



Example 15

Supercell Model of LEU Involute Plate Core Design



```
*
*                              Example 15
*
*           Supercell Model of LEU Involute Plate Core Design
*
CELL 8
SEQUENCE 1
NGROUP 30 15 15
NMESH 67 24
NREGION 10 0 10
NMATERIAL 13 0 1
NCELL 4
PREOUT
INITIATE
*Wims super-cell option for the LEU core
CELL 1 1 0 1
CSPECTRUM -1
ANNULUS  1  0.7500  1                                                  H2O  1
ANNULUS  2  3.9700  2                                                  Be   2
ANNULUS  3  4.9700  3                                                  AL   3
ANNULUS  4  5.2700  4                                                  H2O  4
ANNULUS  5  5.8700  5                                                  AL   5
ANNULUS  6  6.1200  6                                                  in sp 6
ANNULUS  7  14.331 13                                                  fuel mi
ANNULUS  8  14.581 10                                                  out sp
ANNULUS  9  15.581 11                                                  CPT 9
ANNULUS 10  30.000 12                                                  D2O 10
MESH  1  4  1  2  1  5  2  1  2  5
DANCOFF  0.4995 0.4995
*   fuel cell
CELL 2 1 1 0
* CELL 2 1 1 1
CSPECTRUM 2
SLAB 1 0.0255 7
SLAB 2 0.0555 8
SLAB 3 0.1955 9
MESH 3 2 3
* inner structure with Be reflector
CELL 3 1 1 1
CSPECTRUM 3 1
ANNULUS 1 0.75   1                                                     H2O
ANNULUS 2 3.97   2                                                     Be or
ANNULUS 3 4.97   3                                                     Al or
ANNULUS 4 5.27   1                                                     H2O
ANNULUS 5 5.87   4                                                     AL
ANNULUS 6 6.12   5                                                     sidepl
ANNULUS 7 10.226 13                                                    fuel m
MESH 2 8 2 2 2 2 5
* outer reflector of D2O
CELL 4 1 1 1
CSPECTRUM 4 1
SLAB 1 4.000 13
SLAB 2 20.0  12
MESH 4 8
* MESH 4 10
NEWXS  1 -1 3
NEWXS  2 -1 3
NEWXS  3 -1 3
NEWXS  4 -1 3
NEWXS  5 -1 3
NEWXS  6 -1 3
NEWXS  7 -1 2
NEWXS  8 -1 2
NEWXS  9 -1 2
NEWXS 10 -1 3
NEWXS 11 -1 3
```

```
NEWXS 12 -1 4
NEWXS 13  1 2 7 8 9
MATERIAL  1  -1  300.0  3  2001  6.646200E-02  16  3.32310E-02          H2O  1
MATERIAL  2  -1  300.0  3  9  1.23600E-01                               Be 2
MATERIAL  3  -1  300.0  2  27  6.0267E-2                               Al 3
MATERIAL  4  -1  300.0  3  2001  6.646200E-02  16  3.32310E-02          H2O 4
MATERIAL  5  -1  300.0  2  27  6.0267E-2                               Al 5
MATERIAL  6  -1  300.0  2  27  1.71090E-02  2001  4.7594E-2        $    sideplate m
          16  2.3797E-2
MATERIAL  7  -1  300.0  1  27  2.8071E-02  29  8.1171E-03      $        Meat
          235.1  2.4600E-03  238.1  9.7157E-03                  $
          3147 1.00E-20 1143 1.00E-20
MATERIAL  8  -1  300.0  2  27  6.0267E-02                              Al clad
MATERIAL  9  -1  300.0  3  2001  6.646200E-02  16  3.32310E-02          H2O
MATERIAL 10  -1  300.0  2  27  1.71090E-02  2001  4.7594E-2        $    sideplate m
          16  2.3797E-2
MATERIAL 11  -1  300.0  2  27  6.0267E-2                               Al 9
MATERIAL 12  -1  300.0  3  4002  6.629583E-02  16  3.32315E-02  $       D2O 10
                        2001  1.671649E-04
MATERIAL 13  -1  300.0  1 27 1.000E-10                                 fuel mix
FEWGROUPS  3  5  6  8 10 13 15 18 20 22 24 26 27 30 34 37          $
           38 40 42 45 47 50 52 54 56 58 61 64 66 69
BEGINC
THERMAL  6
ISOXS  0 1 1 0 0 1 1 0
REGION 10 10 1 10
* REGION 2 2 1 14
HUSE
WIMS
HSETID
LEU Super-cell problem D2O
ISOTOPES  2001 16 4002
* ISOTOPES  9
ISONAMES
RH    RO    RD
EDITCELLS 0 0 0 0 0 0 0 0 0 0 0 1 0
NOBUCKLING
BUCKLING 1.E-15  1.E-15
VECTOR  2 5 6 7 8 9 11 12 13 16 20 22 24 27 30
BEGINC
```