

Serco Assurance

NEW FEATURES

A Guide to the New Features of MCBEND Version 10A

ANSWERS/MCBEND/REPORT/005

serco

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Issue	Date	Description
1	Feb 2005	Original issue for MCBEND version 10A

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1 Introduction

MCBEND Version 10A is now available from the ANSWERS Software Service. This new version incorporates a range of new and enhanced features. This report provides an introduction to their use and is directed at existing MCBEND code users. Further information for all the features introduced here can be found in the MCBEND User Guide for version 10A [1].

The new features of MCBEND Version 10A (as described in section 2) comprise:

1. FG - Window Part
2. FG - OVERLAP Part
3. FG - Zone Complement
4. FG - OR Operator
5. FG - CONTAINED and CONFINED
6. Unified Source
7. Automatic Splitting Meshes for Neutrons
8. New Material Specification Module
9. Point Energy Adjoint
10. Covariance Module
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12. Response Library in the DICE Group Scheme
13. Material Data Translator
14. Improved Particle Flow Output
15. New Datasets (paths)
16. Geometrical Sensitivity Improvements
17. Syntax Improvements
18. RTZMESH Hole
19. USER and COIL Holes

2 Guide to New Features

2.1 FG - WINDOW PART

The current PART option in MCBEND requires that the body containing the part include no other structures within it. The 'E' material option can be used in some cases to model system where such overlapping is necessary, but it is not always clear how to implement it correctly. If there was a mismatch between the components this was not always easy for the code or user to determine.

The new WINDOW PART is designed to overcome these limitation by allowing the subsidiary PART to be partially obscured by zones in its parent PARTs, and by

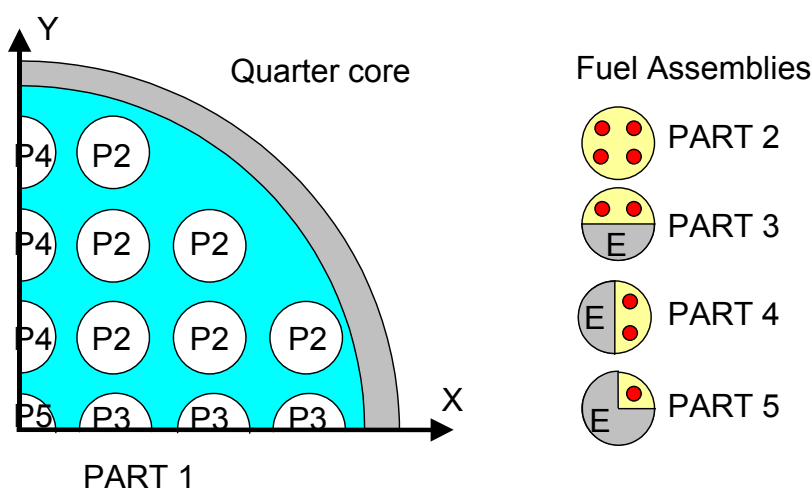
removing the need for the 'E' material improve the ability of the code to check for errors. The input to define a WINDOW PART is made when the PART is referenced – i.e. in its parent PART.

An example input would be of the form:

```
BOX W2 0.0 0.0 0.0 100.0 200.0 200.0
```

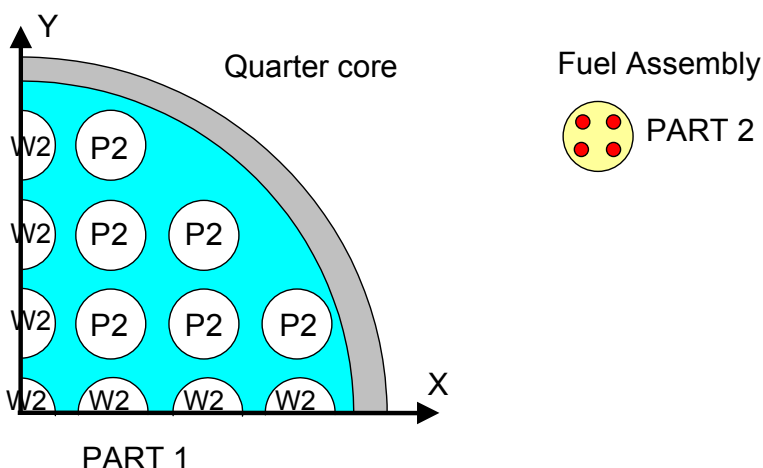
In this case PART 2 will be inserted into the BOX as a WINDOW PART (W2 instead of the usual P2), thus allowing any other zones in this PART (or parent PARTs) to obscure some of its contents.

As an example of moving from using material 'E' to the WINDOW PART, consider modelling a quarter core using normal parts:



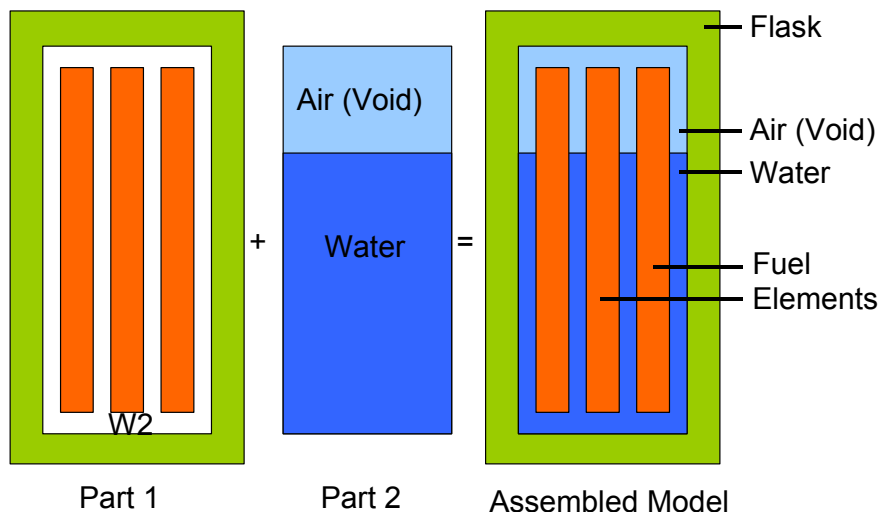
In this case it is necessary to define four PARTs to handle the visible portions of the fuel assemblies, three of which require material 'E'. These additional PARTs are an overhead and each is a possible source of error.

The WINDOW PART removes the requirement to create additional PARTs and thus simplifies both the model and its subsequent checking. Using the WINDOW PART the model becomes:



Now there is a single subsidiary PART for the fuel assembly that can be used in all locations within the quarter core.

Another example could be to model water levels in a flask. The usual solution in these cases is either to use the GENERAL PART or to use a PLATE HOLE. The WINDOW PART provides an alternative that will prove to be a better option in some cases:



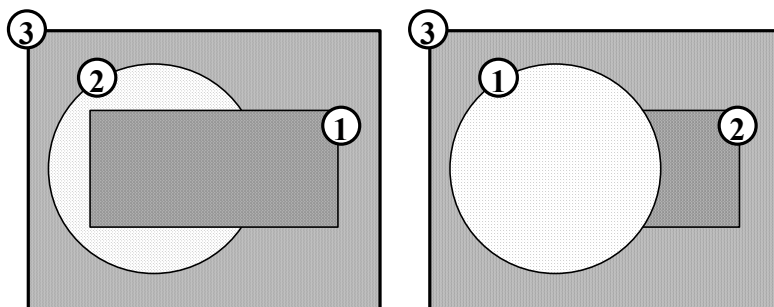
In this example the Fuel Elements in the parent PART obscure the Air and Water in the subsidiary PART.

See Chapter 9 Geometry Modelling, Section 4.2 for further details.

2.2 FG – OVERLAP PART

This is a new structure in the same category as a NEST or CLUSTER. Each body in an overlap part is overlapped by all bodies earlier in the list of definitions. Bodies are defined in a specific order. The last body defined thus becomes the part container. The surfaces of the internal bodies may touch one another and may overlap.

Some examples (in two dimensions) are sketched below:



Each example contains three bodies – the container being body 3. The bodies are identical, but they are defined with the sequence indicated above, resulting in

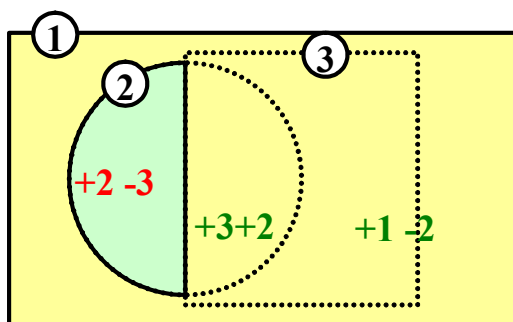
different zones. This illustrates the significance of sequence number when defining bodies.

The zones in an overlap part are automatically defined as the difference between the current body and all previously specified bodies (or the inside of the first body). Since there is an inherent one-to-one correspondence between bodies and zones in an overlap part, it is not necessary to number the bodies and zones independently.

See Chapter 9 Geometry Modelling, Section 3.3 for further details.

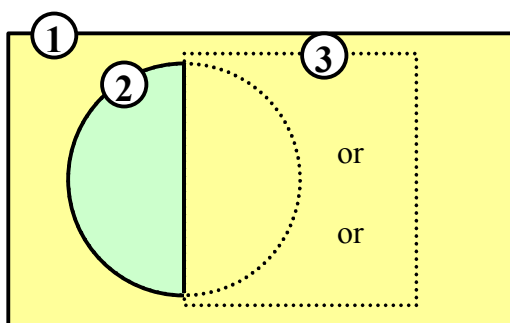
2.3 FG - ZONE COMPLEMENT

This new option of FG allows complete zones to be excluded from the definitions of other zones. This is designed to simplify the specifications of zones comprising many bodies, typically the interstitial volume that remains after all material zones are defined. For example consider the following system comprising three bodies:



If we define zone 1 to be $+2 -3$, the remaining area must normally be defined as two distinct zones ($+3+2$ and $+1-2$). It would be convenient to say that the remaining area is 'everywhere that is NOT zone 1'. The NOT (or \sim) operator allows us to do this.

An example of using the NOT operator on the above example would give:

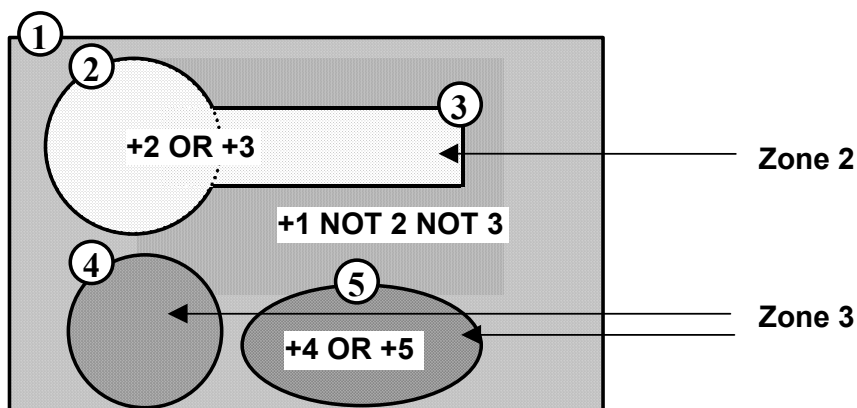


So, as above, zone 1 is defined as $+2 -3$, but now we can define the remaining area as $+1 \text{ NOT } 1$ (or as $+1 \sim 1$, or even $\sim 1 +1$). Note that the number after the NOT (or the \sim) refers to a previously defined zone.

See Chapter 9 Geometry Modelling, Section 3.4 for further details.

2.4 FG – OR OPERATOR

The OR operator allows a zone to be defined as the *union* of two or more bodies. The example below illustrates its use:



Within the code, the OR operator effectively generates two (or more) distinct zones with common properties: content, region number, sequence number etc. It is a form of legitimate multiple definition. A zone defined with the OR operator cannot contain a *body hole*, a *subsidiary part* or a *window part*. (There is no single, identifiable body to act as a container for these contents.)

See Chapter 9 Geometry Modelling, Section 3.4 for further details.

2.5 FG – CONTAINED AND CONFINED

When included in a general part, the CONTAINED qualifier declares that all inner bodies are intended to be within the confines of the container body. The code checks analytically that this condition is met.

When included in a general part, the CONFINED qualifier declares that all zones are to be restricted to be within the container body. If the container body has sequence number n: all zone definitions are automatically extended by the characters '+n'. Consequently the zones cannot contain a *subsidiary part*, although they can contain a *window part*.

See Chapter 9 Geometry Modelling, Section 3.4 for further details.

2.6 UNIFIED SOURCE

A new Unified Source specification input unit has been provided which combines the capabilities of both the Simple and Complex source input units. The function of the Unified Source module is to select the starting parameters of each new source particle: its position, energy, direction and weight.

The input data supplied by the user define the distribution of source in the problem from which these parameters may be sampled. The data divides into the following broad categories.

2.6.1 Preface

This section includes items such as seeds for the random number generator. It may often be omitted.

2.6.2 Geometry

This section defines the shapes and positions of the sources using a set of geometrical volumes or surfaces: cylinders, cuboids, discs etc. Source bodies may be subdivided into smaller volumes (or areas) within which the source can be assumed constant.

The source geometry has close links with the Fractal Geometry (FG) module that is used for defining the distributions of materials in the problem. The source geometry can therefore be defined by reference to Fractal Geometry PARTS, BODIES and/or ZONES.

2.6.3 Energy

This section defines the group schemes used for specifying the variation of source intensity with energy. Note that libraries of fission and activation product spectra are not yet available in the Unified Source module.

2.6.4 Angles

In most cases, source particles are emitted isotropically from a selected point. This section is required exceptionally to specify an angular quadrature in which anisotropic sources may be defined.

2.6.5 Intensity

The above sections essentially divide space, energy and direction into a set of *cells* within which the source can be considered constant. This section defines the source intensity within each cell.

2.6.6 Weighting

It is often fruitful to bias the sampling of source parameters to give preference to those that are more likely to contribute to the scored results. This (optional) section assigns a relative importance to each source cell. Note that the energy group schemes do not need to be compatible to use automatic source weighting.

2.6.7 Examples

An example input that references previously defined FG zones could be:

```
BEGIN UNIFIED SOURCE DATA
  GEOMETRY                                ! specify the source geometry:
  FGZONE 3 IN PART 1                       ! the source bodies refer to
  FGZONE 4 IN PART 1                       ! the FG zones/parts
  FGZONE 5 IN PART 1
  FGZONE 6 IN PART 1
  ENERGY                                  ! specify the energy data:
  SOURCE GROUPS                           ! using a histogram...
```

```

14.6 5.0 1.0 0.1 0.0674      ! then the energy boundaries
SPECTRA                      ! and the source spectrum
0.1 3*100.0
INTENSITY                    ! and the source intensity
BODY 1                       ! for each body listed above
COMPONENT 100.0
BODY 2
COMPONENT 80.0
BODY 3
COMPONENT 60.0
BODY 4
COMPONENT 30.0
WEIGHTING AUTOMATIC         ! use automatic source weighting
END

```

The example shows FG zones 3 to 6 of PART 1 being identified as source bodies (BODY 1, 2, 3 and 4 further down the input unit). After the source bodies are identified the energy boundaries and spectra are defined (in this example a single histogram is defined). Then, for each source body defined, the source intensity is entered. Finally automatic source weighting is specified to enable the code to concentrate on the more important source regions.

This second example makes use of more of the features in the Unified Source. The example begins by using the PREFACE section to provide seeds to the random number generator. In the GEOMETRY section the bodies are explicitly defined and include source body subdivisions. To assist in specifying the subdivisions the **I**, **F** and **P** operators are available to allow the user to specify the Intervals between boundaries, Fractions of the total width between boundaries, or the boundary Positions explicitly. The ENERGY data comprises a line spectrum

```

BEGIN UNIFIED SOURCE DATA
  Preface seeds 12345 54321      ! define the RNG seeds
  Geometry
  +ZHEMI One 10.0 10.0 10.0 4.5 ! define the first body 'One'
  R 2.5 P                        ! and its subdivisions
  THETA 4*90.0 I DEGREES
  -ZHEMI Two 10.0 10.0 10.0 4.5 ! and then body 'Two'
  R 2.5 P
  THETA 45 90 135 180 225 270 P DEGREES
  ENERGY                      ! Specify the energy data
  LINES 6.0                    ! for a line spectrum
  SPECTRA 1.0
  INTENSITY                    ! and the source intensities
  BODY one S 1                 ! for the subdivisions in each body
  COMPONENT R 0.0 1.0
  COMPONENT THETA 1.0 2.0 0.0 3.0
  Body two S 1
  COMPONENT R 0.0 1.0
  COMPONENT THETA 1.0 3.0 2.5 4.0 0.0 5.0 3.0
END

```

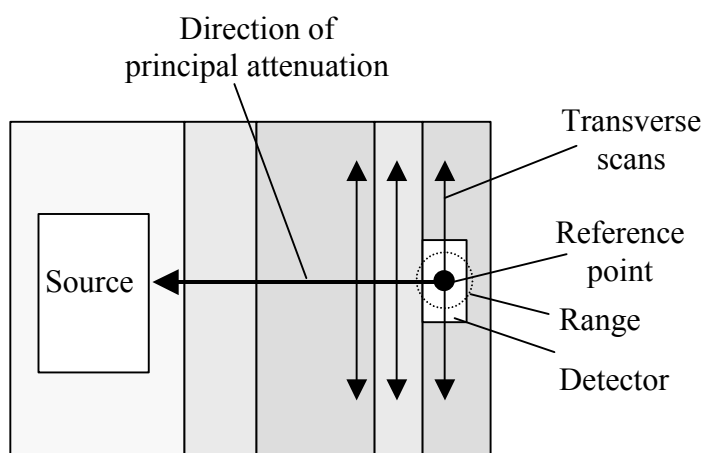
Refer to Chapter 10 Source Options, Section 2 in the MCBEND version 10A User Guide for detailed information on the Unified Source module.

2.7 AUTOMATIC SPLITTING MESHES FOR NEUTRONS

The requirement for the user to specify the location of the splitting mesh boundaries for a neutron case has been enhanced by an automatic system which, given information about the main axis of the problem, can generate a suitable set of splitting mesh boundaries.

Automatic meshing chooses importance mesh boundaries that are a function of the importance energy groups. They are placed according to the attenuation in a given group along specified scan lines.

A common number of meshes is used for each energy group. This keeps the importance map as a regular array with dimensions $NX*NY*NZ$ in all groups.



The reference point should ideally be within one of the detector zones identified as a **TARGET** for the **CALCULATE** option in the splitting map unit.

The direction of principal attenuation is a co-ordinate direction that approximates a line from source to detector. E.g. **-X**. A specific logic is used for placing importance boundaries along this axis.

Transverse scans orthogonal to the direction of principle are taken. (e.g. along the Y and Z axes) The average attenuation along these axes is used to place the mesh boundaries. They are generally more closely spaced near the vector from reference point to source and coarser at more remote positions.

Example:

```
BEGIN SPLITTING GEOMETRY
  R 10 AUTO           !Generate 10 radial intervals
  THETA 3            !Specify the azimuthal mesh manually
  0.0 120.0 240.0 360.0
  DEGREES           !in DEGREES
  Z AUTO            !Let the code choose the number and
                   !distribution of axial meshes
  AUTOMESH          !select the AUTOMESH route for the input data
  REFERENCE POINT   !define a reference point in/near target zone
  26.0 0.0 50.0
```

```
ATTENUATION -R      !Source is radially inwards from the detector
FULL 30             !30 Transverse (Z) scans will be taken through
                   !points along a radius through the detector.
RANGE 0.8           !Automatic meshing will begin 0.8cm from the
                   !reference point.

END
```

Note that the automatic splitting mesh is limited to neutron cases only.

2.8 NEW MATERIAL SPECIFICATION MODULE

The Materials Specification input unit has undergone a few minor revisions to simplify its use, for example removing the need to specify the number of mixtures and materials about to be defined. There is also the new keyphrase NUMBER DENSITY (or keyword NUMDEN) that can be used if the composition is defined by number density.

The library materials have also undergone minor revisions, principally the composition of Air. It is still the recommended advice that if a library material is to be used, then the composition of the material (listed in the user guide) is checked to ensure it is consistent with the composition required. In some cases (e.g. some concrete types) there is no universally agreed composition.

2.9 POINT ENERGY ADJOINT

This capability allows the running of an adjoint neutron calculation using the DICE point energy nuclear data instead of the more typical multigroup data. Additional nuclear data libraries are provided for these calculations, noting that only a simple one-group thermal treatment is currently available.

The option is activated by entering the keyword ADJOINT after NEUTRON in the ENERGY DATA input unit. It is also necessary to identify whether a one-group or no thermal treatment is used – a detailed treatment is not yet available. The relevant adjoint DICE nuclear data libraries (and thermal data if used) must then be identified to the code either through LaunchPad or a datasets file.

The Tabular Output unit provides special facilities for processing the output from adjoint point energy neutron calculations.

For further information, including a worked example, refer to Chapter 6 Advice and Examples, Section 6.7, Example E in the MCBEND version 10A User Guide.

2.10 COVARIANCE MODULE

This new module allows the user to estimate uncertainties in the calculated fluxes and/or responses due to uncertainties in the cross-section data for the *materials* present in the system being modelled. In the case of a response, it can also give the

uncertainty in the calculated result due to uncertainties in the *response function* (i.e. in detector cross-sections).

The cross-section uncertainties are expressed in the form of covariances. The uncertainties in the calculated results are obtained by combining the covariances with sensitivities calculated in the same run.

The covariances applicable to the data in a MCBEND nuclear data library are stored in a separate material covariance data library. Covariances applicable to the data in a MCBEND response function library are stored in a separate detector covariance data library. Covariance data libraries are not available for all of the MCBEND libraries. With MCBEND version 10A a single library of material cross-section covariance data is provided for use with the JEF2.2 based DICE neutron data library. The library contains data for a limited set of nuclides, dictated by the availability of covariance data in the evaluated files. No detector covariance data libraries are available with MCBEND version 10A.

Further details of the covariance module, including the input requirements, can be found in Chapter 3 Input Data, Section 3.7.8 of the MCBEND version 10A User Guide.

2.11 DICE HIGH TEMPERATURE DATA

A new JEF2.2 DICE nuclear data library has been generated for MCBEND, containing data at a number of different temperatures for a selection of important nuclides. At the same time, the code has been modified so that this library can be used for calculations involving materials of differing temperatures within a given model.

Free atom data have been generated for the nuclides H, D, C, O, ^{50}Cr , ^{52}Cr , ^{53}Cr , ^{54}Cr , ^{54}Fe , ^{56}Fe , ^{57}Fe , ^{58}Fe , ^{58}Ni , ^{60}Ni , ^{61}Ni , ^{62}Ni , ^{64}Ni , ^{235}U and ^{238}U , at temperatures of 100°C, 200°C, 300°C, 400°C, 500°C and 600°C. Bound atom data have been produced for H in H₂O at temperatures of 100°C, 200°C and 300°C. All the data were taken from JEF2.2.

Within the DICE library and during the MCBEND calculation, each nuclide at each temperature is treated as a separate nuclide. The library names, DFNs and MOULD numbers for the nuclides at elevated temperatures are shown in Table B2.2 of Chapter 4 Input Appendices, Appendix B of the MCBEND version 10A user guide. These are used in the MCBEND input, as described below, to request the appropriate temperature dependent data.

Within the Material Specification Unit, the material compositions are defined in the usual way. The material temperatures are then defined by the keyword TEMPERATURE followed by the values in °C. For any material at an elevated temperature, the library nuclides to be used must be defined using the data introduced by the keyword USE, e.g.

```
USE J21H1 FOR H1 IN MATERIAL 3
```

USE DFN 6000773 FOR C IN MATERIAL 5
USE MOULD 245 FOR NI58 IN MATERIAL 7

It is the responsibility of the user to ensure that library nuclides at the appropriate temperature are specified for each material. The code does not check that the temperature of the specified library nuclide is the same as that of the material. For any nuclide not specified in the "USE" input, the data for 20°C will be used.

For a free atom nuclide, the material temperature is used for the free gas model of thermal neutron scattering, while the nuclide temperature determines the cross-sections used. For full consistency, these temperatures should be equal; this would restrict them to the values available in the library. If a material temperature is known to be at some intermediate value, there are several possible procedures open to the user:

- a) use the nearest library temperature for the material and for its nuclides;
- b) use the correct temperature for the material and the nearest library temperature for the nuclides;
- c) do two calculations, with the material and nuclide temperatures set to the library values either side of the correct value, and then interpolate between the results.

For a bound atom nuclide, the nuclide temperature controls both the thermal neutron scattering and the cross-sections. The material temperature has no effect on the treatment of such a nuclide. The treatment is therefore restricted to library temperatures, so intermediate values must be handled either by using the nearest library temperature or by interpolating between results of separate calculations.

2.12 RESPONSE LIBRARY IN THE DICE GROUP SCHEME

An additional response library is available that is based mainly on data from the JEF2.2 DICE library and is thus in 13193 energy groups. Where data were not available from the DICE library they have been taken from the existing MCBEND response library and expanded into the 13193 group scheme. This DICE response library is available directly from ANSWERS and will not be supplied unless specifically requested.

The existing MCBEND response library is based largely on IRDF-90 dosimetry data represented in 641 energy groups based on the SAND-IIA group scheme, and thus the cross-sections differ from those in the DICE response library. It is essential the user is aware of this difference between the two sets of data prior to requesting and using the DICE response library.

To use the DICE response library it is only necessary to attach the library to the RESPONSE channel either through LaunchPad or directly in a datasets file. No input changes are required.

2.13 MATERIAL DATA TRANSLATOR

A Material Data translator has been written to convert MINNIE data into Material Specification data. The translator generates a file containing the converted data, provided that this file is defined in "datsets" using the channel name MATSP.

To make use of the converted data, the user must check and possibly modify the contents of the file produced by the translator (mainly the USE statements, and possibly the density of a mixture defined in terms of absolute number densities), then insert this text into the input file, and finally run the case.

Note that the output from the translator will not necessarily represent the best way of defining the compositions using the Material Specification input.

2.14 IMPROVED PARTICLE FLOW OUTPUT

A new option has been added to the Tabular Output unit to allow the user to print the particle INFLOWS data in a user defined format. The user can select not only the order of the subscripts for printing, but also select a subset of the data to be printed, e.g. a subset of the energy groups; a subset of meshes.

The detailed description and flowcharts for this new option can be found in Chapter 3 Input Data, Section 3.8.1: Tabular Output, Sheet 3 of the MCBEND version 10 A User Guide.

2.15 NEW DATSETS (PATHS)

The capability of the DATSETS method of identifying input, output and library files to MCBEND has been enhanced to allow the definition of PATHS. A PATHS file can now be set up which allows the user to assign paths to single character variables. These variables can then be referenced in the DATSETS file for the specific cases to be run. The advantage of this is that any change in location of input, output or libraries can be trivially handled by a corresponding change to the PATHS file. For example the PATHS file might be called P1.lis and contain:

```
I=/mctest/M2/IN
O=/mctest/M2/OUT
L=/answers/data_libraries/
```

And in the datsets file we have:

```
INPUT  $Itest01.dat
OUTPUT $Otest01.out
MATDB  $Lmcbend_matdb.dat
DICE   $Ldicedat1c.dat
```

When the code is run the command line instruction 'paths=P1.lis' is added (in the same way as for space=). Thus by simply changing the entry in the PATHS file the outputs from several runs can be directed to a different directory. Alternatively three

PATHS files could be set up to fully define the libraries and a correspondingly named output file directories for each nuclear data evaluation (JEF, JENDL, ENDF), thus allowing a set of calculations to be set up and run with the different output appearing in different directories.

2.16 GEOMETRICAL SENSITIVITY IMPROVEMENTS

Improvements have been made to the geometrical sensitivity module in MCBEND version 10A. The geometrical sensitivity module allows the sensitivity of fluxes and responses to a small change in the position of body or one of its boundaries within the model can be estimated using this option. The geometrical sensitivities are evaluated during the calculation by making differential changes to the position or size of selected bodies in the geometry model. For example:

If ϕ is a scored particle flux and R is the radius of a cylindrical component then

$$\text{Geometrical sensitivity} = \frac{d\phi}{dR}$$

Several distinct sensitivities may be defined, where each includes the effect of perturbing a single body.

At present, a given body can not be perturbed in more than one sensitivity. The data identifying perturbed bodies and the associated sensitivity numbers are appended to body definitions in the Material Geometry Unit. For example, the input: D/DX 3 requests a differential movement of the body along its X axis with the effect being attributed to sensitivity number 3. Other options for body displacements are: D/DY and D/DZ. The direction of displacement may be reversed by including a minus sign:

D/-DX, D/-DY and D/-DZ.

A body may also be perturbed by changing its parameters. The input D/DA or D/DB or D/DC refers, respectively to differential increases in the first, second or third body size parameter. At present the sensitivity option is restricted to BOX and ROD bodies. The parameters may be shrunk by including a minus sign: D/-DA, D/-DB, D/-DC.

Only one perturbation may be made to a given body – i.e. it cannot be displaced in two directions or moved and expanded.

The input syntax is detailed in Chapter 3 Input Data, Section 3.7.4 of the MCBEND version 10A User Guide.

2.17 SYNTAX IMPROVEMENTS

There are a range of syntax improvements, including an enhanced sequence of numbers and an enhanced group-repeat option. These can all be found in Chapter 2 Input Description, Section 2.2 of the MCBEND version 10A User Guide.

The group-repeat enhancement is an extension to the group repeat option that allows a different value to be used in each pass of the repetition. The syntax for this is:

$$N^* \{A \ B \ (C1 \ C2 \ C3 \ . \ . \ CN) \ D\}$$

N = number of repetitions
 A B D = values used in each repetition
 C1 = value used in first pass
 C2 = value used in second pass
 ...
 CN = value used in last pass

As an example of using this option consider a sequence of concentric ZROD bodies with increasing radius and different materials. The origin and height are common

```
5*(ZROD M (1 2 1 2 1) 0 0 0 (2.1 4.2 6.3 8.4 10.5) 5.3)
```

=

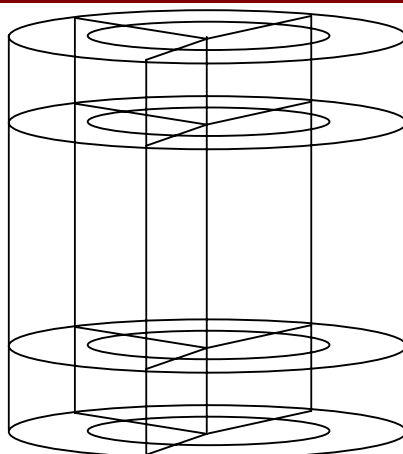
```
ZROD M 1 0 0 0 2.1 5.3
ZROD M 2 0 0 0 4.2 5.3
ZROD M 1 0 0 0 6.3 5.3
ZROD M 2 0 0 0 8.4 5.3
ZROD M 1 0 0 0 10.5 5.3
```

The number of items between each pair parentheses must match the value of the group repetition count. Parameters or formulae may be used for a given item but the colon sequence may not.

A semicolon may be used as a null value if a particular pass does not require an item.

2.18 RTZMESH HOLE

The RTZMESH hole allows the user to allocate materials within a defined RθZ mesh. The mesh system is surrounded on all sides by an enclosing material, and any material within the hole may be a subsidiary hole.



The user simply defines the R, θ and Z mesh boundaries in increasing order and then supplies a material map for the mesh system. An example of its use could be:

```

HOLE 1
RTZMESH
!      number of radii & the radii (all>0)
      3 0.1 0.2 0.3
!      number of azimuthal surfaces & the angles (first >=0)
      3 0.0 110.0 280.0
!      number of z regions & z+1 surfaces (NB no zeds is OK)
      2 2.0 5.0 7.0
!      Materials for first z region
      1 2 3
      4 5 6
      7 8 9
!      Materials for second z region
      11 12 13
      14 15 16
      17 18 19
!      Other material - beyond max radius, min & max z.
      10

```

The azimuthal zero is assumed to be along the direction of the x-axis. It is possible to have zero regions for the θ and z axes, in which case no surface data is entered and a single region is assumed. This does not apply to the R axis, there must always be at least one radial region with an appropriate radius entered.

2.19 USER AND COIL HOLES

The USER hole (see Chapter 9 Geometry Modelling, Section 13.20 of the MCBEND version 10A User Guide) uses a BASIC-like syntax to define a 'designer hole' for specific tasks. As a simple example a PLATE HOLE could be simulated using:

```

BEGIN HOLE GEOMETRY
HOLE 1 USER
If Z < 6 Then
  M = 1
ELSE
  M = 0

```

```
ENDIF  
END
```

The COIL hole (Chapter 9 Geometry Modelling, Section 13.2 of the MCBEND version 10A User Guide) allows the user to model one or more coiled pipes.

Both these holes use the new HOLE GEOMETRY input unit. Thus the user must contact ANSWERS to receive the additional details required to use them.

3 Summary

This report has introduced the main new features of MCBEND version 10A that provide a range of additional options to assist the shielding analyst and assessor:

- FG - Window Part
- FG - Zone Complement
- FG – CONTAINED and CONFINED
- Unified Source
- Automatic Splitting Meshes for Neutrons
- New Material Specification Module
- Point Energy Adjoint
- Covariance Module
- DICE High Temperature Data
- Response Library in the DICE Group Scheme
- Material Data Translator
- Improved Particle Flow Output
- New Datasets (paths)
- Geometrical Sensitivity Improvements
- Syntax Improvements
- RTZMESH Hole
- USER and COIL Holes

A major programme of pre-release testing has been completed which has not only exercised the new features of the code but also exercised a large set of older models to ensure that existing features have not been disturbed. This test programme has also included contributions from the user community through external beta code versions. Further details on the new features are contained within the user guide issued to accompany the release of MCBEND version 10A. Additional advice and information is available via the usual ANSWERS customer support channels.

4 References

- [1] The ANSWERS Software Service
MCBEND User Guide for Version 10A
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