Material for exercises on WIMSD-5B

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CASES TO BE ANALYSED

5 INPUT cases are given for the analysis. The first 3 simpler cases are recommended to the beginners, the 2 last cases should be used by participants familiar with the WIMS code. All cases are taken from the set of benchmarks prepared for analysis under Co-ordinated Research Programme on WIMS Library Update Project. They all refer to critical experiments carried out in variuous laboratories. Their short characteristics is given in the table below. Their more detailed description can be found in the CRP materials on WLUP www pages.

Table

No	File name	fuel	moderator	Methods used
1.	extrx.win	Uranium metal	H_2O	Pin cell, DSN, S-12
2.	exbapl.win	Uranium oxide	H_2O	Pin cell, DSN, S-12
3.	exjaeri.win	UO_2/PuO_2	H_2O	Pin cell, DSN, S-12
4.	exd2o.win	Uranium oxide	D_2O	Cluster (or PIJ), DSN, S-12
5.	exth.win	UO_2/ThO_2	D_2O	Cluster (or PIJ), DSN, S-12

The basic exercise consists in calculation of at least one chosen case with 69-group and 172-group libraries and comparison of results.

Recommended extensions for more experienced participants:

- Calculation in reduced number of library groups (6 -20).
- Change of the method of fewgroup solution to PERSEUS in the first 3 cases, to PERSEUS or PIJ in the last 2 cases.

INPUT DESCRIPTION

4.1. General Structure of WIMSD-5 Input

(i) The WIMS input is in a general free format. Each item consists of a keyword and, usually, of consecutive digital entries divided by one or more spaces. The input routines of the code read 4 alphabetic characters and, if these are recognized as a keyword, the digital entries following the keyword are read and interpreted. The exception is a card with a star '∗'on it: the text after the star is interpreted as a comment extending up to the end of that card. The keyword must not contain spaces. There are occasional exceptions to the above rules where a keyword has to be followed by a formatted set of data. The exceptions relate to more advanced options of the code and they are noted specifically in the following description:.

(ii) A new keyword usually starts on a new line but the data prescribed to it may be continued on the next card(s). (Keywords may continue on the same line but this is usually harder for the user to read.)

(iii) Repeated data items are permitted in two forms:

CODEWORD n @ k l m

gives n times the value of k followed by l, m etc., e.g.:

SUPPRESS 13 @ 1 0 1

gives the output of chain 14 only,

CODEWORD 4 (1 2)

is equivalent to

CODEWORD 1 2 1 2 1 2 1 2

(iv) The WIMSD-5 input is divided into 3 sections read consecutively in 3 different parts of the code. The sections are divided by keywords. The first section known as the Prelude Data serves for fixing the problem dimensions. It is read in subroutine PRELUDE and it ends with a keyword:

PREOUT or ENDP

The second section contains the main data describing the case. It is read in subroutine DATAG of CHAIN 1 and, in the first lattice calculation, starts with a keyword:

INITIATE

and ends with a keyword:

BEGINC

The third section contains the Edit Data. It is read in subroutine DATAR of CHAIN 13 and it too ends with the keyword:

BEGINC.

(v) Multiple cases may be executed in the same run only if the Prelude Data remains unchanged. All that is required is a set of those Main Data items which are to be changed, followed by BEGINC, and a set of Edit Data items which are to be changed, also followed by BEGINC. If no items in any section are changed then BEGINC is sufficient. Thus a sequence

BEGINC
BEGINC

placed after the last BEGINC of the previous calculation causes a repetition of the previous case. This is widely used for burnup calculations where a double BEGINC is placed to execute the next burnup step with the same calculational parameters, but starting with the depleted isotope number densities.

4.2. List of Input Data

In this section, a full input description for WIMSD-5 is given, based on the input description of WIMSD-4 distributed previously by NEA Data Bank.

	Section 1 Prelude Data	
HOMOGENOUS		
PINCELL		
CLUSTER		
(The above 3 codewords are recommended instead of codeword CELL		
CELL		**i**=4 Homogeneous,
		i=5 Pin cell, no energy condensation,
		i=6 Pin cell, with energy condensation,
		i=7 Cluster.
NPLATE	**i**	if **i** positive: a slab geometry to be divided into **i** unit cells for resonance shielding and multigroup calculations,
		if **i** negative: a spherical geometry; in that case, only DSN is available and all geometry is input as for cylindrical geometry except that the annulus radii must be $r = \sqrt{4 \bullet R^3 / 3}$ so that $\pi \bullet r^2$ is the required spherical volume.
SEQUENCE	**i**	choice of the main transport routine:
		i = 1 - DSN,
		i = 2 - PERSEUS,
		for **i** = 1, 2 - in "CELL 7" a negative sign causes the unsmearing process to be omitted. (Do not use in Burnup calculations).
		i = 4 - PIJ - PERSEUS,
		i = 5 - PRIZE - PERSEUS.
		To change sequence option during a WIMS run, see SWITCH data.
		The SEQUENCE card can normally be replaced by one of the 4 cards specified below:
DSN		DSN chosen.

PERSEUS		PERSEUS chosen.
PIJ		PIJ chosen.
PRIZE		PRIZE chosen.
NGROUP	**i j ig nt icar**	**i** - the number of groups in the main transport solution,
		j - the number of reaction edit groups,
		ig - number of groups for additional condensation, equal to the number of entries on the VECTOR card, **ig**≤10,
		nt - logical unit for condensed output in LAMS format, **nt**=0 - the condensed cross sections are not determined, **nt**=8 - besides the LAMS format, the CITATION format cross sections are written on file 19, **nt**≠8 - only the LAMS format cross sections are written on file **nt**.
		icar - if **icar** = 1 the macroscopic fission cross sections will be calculated in the second condensation; in the presence of isotopes with ID = 3001, 1010, 6016, 4135, 4149 (or other for isotopes specified on the ELEM card) and second condensation to 2 groups also a library on unit 14 will be created.
		Remark: if **icar** is not equal 1, it should be zero or blank.
		Items ig, nt and icar may be omitted.
NMESH	**i j**	**i** - the number of mesh points applied in the main transport routine; in case of PRIZE calculations **i** must be increased by the number of PRIZE regions, for multicell cases, I is the sum over all cells.
		j - the number of edit mesh points (default = **i** + 3 times number of annuli containing rods). If the SWITCH option is used to change to PIJ, the number of edit meshes will be increased automatically to the number of PIJ meshes.
NREGION	**i j k igr**	**i** - the number of slabs or annuli,
		j - the number of annuli containing rods (default = 0),
		k - the number of edit regions (default = **i** + 3•**j**),
		If the PRIZE option is chosen **k** must be present on the card and calculated as described in the PRIZE option description.
		igr - number of regions for the second condensation (default zero).
		For multicell cases, i is the maximum in any one cell type and j is the sum over all cell types. k is also the total for all cells, so the default is likely to be too small.
NMATERIAL	**i j k**	**i** - the total number of materials,

		j - the number of materials undergoing burnup,
		k - the number of materials used in PERSEUS, if
		k = 0 (or blank) the code supplies an adequate default value, - an explicit value for **k** could be useful for saving space in multicell jobs.
NRODS	**i j k l m n nn**	Data required only for PIJ or for DSN/PERSEUS calculations with more than 5 rod-subs in any type:
		i - number of rods in the cluster (**i**≥1),
		j - cluster symmetry factor
		j > 0 for j fold rotational symmetry,
		j < 0 for -**j**/2 fold rotational and **j** fold reflectional symmetry, with θ=0 being a reflection plane,
		k - number of lines in PIJ mesh (50 or 100 mostly used depending on the case, consult printout of CHAIN 8 with exact and numerical volumes in particular cases),
		l- number of angles in PIJ mesh (best chosen to be co-prime with problem symmetry)
		m - number of rod types,
		n- maximum number of rod-subs in any type,
		nn - maximum number of sectors in any rod-sub.
		(The last 3 default to 5,5,2 if none is input).
NREACT	**i**	**i**- number of nuclide reaction rate edits.
NCELLS	**i**	**i** - number of cell types in multicell calculations.
POISON	**i**	**i** - number of regions in a subsidiary burnable poison pin cell calculation. (Default 7 or 2 + n of the NRODS data).
NTHERMAL	**i**	**i** - the maximum number of temperatures at which thermal library data is tabulated for nuclides in the WIMSE-type file output (see SAVE option). The default value of 7 is adequate unless the following identifiers have been used: 1012(8), 2012(14), 4016, 5016, 6016, 4235, 6235, 4238, 5238, 6238 (all 9).
NISOTOPES	**i**	**i** - the number of nuclides used (default = number of nuclides in the library).
TILT		This allocates sufficient data storage space to calculate heat flux tilt across cluster fuel pins. No main data required.

PRIME	**i dd/mm/yy**	Card required with **i** = 0 if the job is writing WIMSE-type output to a new tape. A non-zero value of **i** may be specified if the user wishes to save only the output from his first **i** WIMS runs. An expiry date in the form dd/mm/yy is optional but should be used as a safeguard against overwriting if the card is not removed for subsequent jobs.
	i	**i -** the number of previous sets of WIMS output to be skipped before the present run writes its output. For the first run with a new tape, **i**=0 is required. For subsequent runs the code automatically skips to the end of the previous output if this card is not supplied. If used this must be the first PRELUDE (Section 1) data card.
SAVE	**i j k l m n**	Option to write WIMSE-type files [26].
		i = -1 - no action taken except execution of the PROLOG subroutine.
		i = 0 - WIMSE-type files 1-5 will be computed and printed if required.
		i = 1 - Files 0-6 will be output to tape with or without the CALEB edit card.
		j = 0/1 - the full WIMS input data for the job will not/will be printed before execution commences.
		k - the length of a File 6 record (default = 100).
		l - the maximum length of output tape written in previous jobs which will permit the job to commence (default = 2000 feet).
		m - if non-zero, extensive printout will be obtained from the datablock input routine.
		n = 1 - a call to subroutine PROLOG is suppressed.
		n = 0 (or blank) - the call to PROLOG is executed (PROLOG is a subroutine which automatically supplies most of the PRELUDE data including the CELL option and all options from Keyword NGROUP to NTHERM inclusive. The user is still required to supply those cards which define a route of calculation - SEQUENCE, TILT, STORE, LIBRARY, PREOUT - and also NPLATE and NISOTOPES if required. The Keyword LINES in the Main Data (Section 2) should be used to complete the NRODS specification. All user-supplied PRELUDE data will overwrite PROLOG data so that existing data decks require no modification).
		The SAVE card must be followed by a card containing a 20 character run identifier (cf. ref.25). Execution will be terminated if File 6 output is requested without a coolant card in Section 2 and Xe-135, U-235, Pu-239 reaction edits requested in Section 3.

		If **k** > 64 and a reaction edit is requested for ID 1000, fast and thermal cell averaged 1/v reaction rates in (sec/cm) will be stored in positions 63 and 64 of File 6.
STORE	**i j k l**	When all data items are greater than 100, the 'pseudo-tape' option of the code (ex-WIMS3) will be used and all execution will be in-core. Typical values for a 28 group library are 50000, 10000, 10000, 1000. The required value of **i** for the Winfrith '1986' 69 group library is 184000.
		i - the storage allocated for library data,
		j - the storage for dataset 3,
		k - the storage for dataset 6.
		Datasets 3 and 6 are scratch discfiles if this option is not used (ex WIMSD2).
		l - the storage allocated for data transfers.
		The code prints the required library storage and indicates the required values of **j** and **k** by comments of the form: "3>mmmm" and "6>mmmm" in the output.
LIBRARY		Used only with 'pseudo-tape' option (invoked by the STORE card)).
		A map of library data storage is produced - indispensable if library modifications are to be specified at run time.
PREOUT or ENDP		The last card ending Section 1.
	Section 2 - Main Data	
INITIATE		The first card of a complete set of Main Data.
	Geometry data	
ANNULUS	**j r m**	**j** - the annulus number, counting from the centre,
		r - the outer radius in cm,
		m - the material number for all parts of the annulus not occupied by rods.
		Note that of intermediate annuli as are usually required for PIJ calculations are not refined in the input, the code autmatically supplies appropriate data by linear interpolation in r. For multicell cases, annuli starting at 1 are specified for each cell type.
SLAB	**j r m**	**j** - the slab number, counting from the centre, **r** - the distance from the centre to the slab outer edge in cm,
		m - the material number.
		Note that symmetry is assumed about the centre line.
SQUARE	**j r m**	**j** - the outermost annulus of the problem,
		r - 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 - 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**√2, segments will be correctly masked off by the square boundary. Rods of spectrum type 4 materials may be located at corners of the square and will not count as rods in the averaging procedures at the level of multigroup calculations. The problem will be suitably homogenized and cylindricalized for DSN or PERSEUS but will be calculated explicitly by PIJ if the number of PIJ annuli is **j**.
CRAIG		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 minimise the differences between the fuel positions and the midpoints of the annuli.
POLYGON	**j n m r**	**j** - the "annulus" number,
		m - the number of sides of the polygon,
		n - the material number,
		r - the "radius" to the midpoint of a side.
		This option merely generates appropriate ANNULUS data and has no influence on the calculation flow.
ARRAY	**N (m n r θ)**	All rods of type **N** have their positions given by one ARRAY card. Up to 12 sets of the four numbers (**m n r θ**) are allowed, with **m** being an option on the coordinates used:
		m = 1: a ring with radius **r** of **n** rods, one with angular coordinate **θ** in radians,
		m = 2: (**r,θ**) specify (x,y) coordinates of one rod,
		m = 3: a ring of **n** rods with separation **r**, one with angular coordinate **θ**,
		m = 4: a hollow square of **n** rods, with separation **r, θ** is the angular coordinate of the first corner of the square,
		m = 6: a hollow hexagon of **n** rods, with separation **r**, **θ** is the angular coordinate of the first corner of the hexagon.
		If the cell boundary is square, non-fuel rods may be placed at the corners (cf. SQUARE option). They will be smeared for DSN or PERSEUS.
RODSUB	**N k r (m θ)**	**N** - the rod type (see ARRAY card),
		k - the rod subdivision number counting from the rod centre,
		r - the outer radius,

		(**m** θ) - pairs of numbers giving material number and angle at the end of each sector. For DSN and PERSEUS only one **m** needs to be specified.
PLOT	**r s**	After the Main Data has been read, the geometry is "plotted" on the line-printer.
		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. Default values are: **r** = outer annulus radius, **s** = 0.7 (for improved readability).
	Composition data	
MATERIAL	**m d t n list**	**m** - the material number,
		d - the density in g/cm^3 ,
		t - the temperature in °K,
		n - the spectrum type: 1 - fuel, 2 - can, 3 - coolant, 4 - moderator,
		A negative **n** causes the material to be excluded from the resonance treatment and the SPECTROX spectrum calculation. This means that the representative cell will not include materials with negative **n**, although these materials will get the multigroup spectrum calculated for the material with $\lvert \mathbf{n} \rvert$, **list** - pairs of nuclide identifier and weight per cent (the code renormalises these to total 100%).
	m -1 t n list	**m t n** - defined as above, list consists of pairs of nuclide identifier and number density in atoms/(b.cm). If the material has been specified in a previous lattice calculation, any nuclide not specified in **list** will retain its existing number density.
	-m d t n list	The material number may be specified negative,
		d is redundant, **t** and **n** are defined as above, **list** consists of pairs of nuclide identifier and a constant by which the number density of a nuclide in an existing material will be multiplied.
	m=M	If only two numbers are specified, material **m** will be given the same temperature, spectrum type and composition as material **M** (which must be specified previously). Note that subsequent redefinition of **M** does not affect **m** (used in burnup calculations with several burnable zones).
TEMPERATURE	**list**	**list** - string of temperature increments, one for each material as defined by MATERIAL data.

DENSITY	**list**	**list** - string of constants by which existing material densities are multiplied. (The code will fill out a truncated list with 1s).
ENRICHMENT	**m d e s**	**m** - material number,
		d - density [g/cm],
		e - enrichment (wt % of total heavy atoms, of U-235 if uranium fuel, or of total plutonium if plutonium enriched fuel. In the latter case the input ratio of U-235/U-238 will be unaltered).
		s - the stoichiometric ratio (eg., 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.
	list	In a RECYCLE calculation, **list** specifies the relative amounts of U-235, Pu-239, Pu-241, Pu-242, Am-241 in the external enrichment for RECYCLE option 1.
RESTART		Use of this keyword requests 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.
COOLANT	**n d**	**n** - the material number used for evaluating coolant density and temperature for File 6.
		d - the historic coolant density for File 6 (defaulted to the initial density of material **n** if no value is supplied). This card is mandatory if File 6 output has been requested (SAVE data of section 1).
DTDR	**d**	The temperature of all materials with spectrum type 1 (fuel) will be overwritten by **T + d•rq**, where **T** is the temperature of the "coolant" material and **rq** is the rating taken from the second item on the POWERC card. The subsequent changes in rating will have no effect on fuel temperature unless another DTDR card is supplied.
ELEMENTS	**list**	**list** - up to 5 identification numbers from the library defining nuclides used for unit 14 generation under **icar** = 1 option, denoting H, B-10, O, Xe-135, and Sm-149. Default numbers are: 3001, 1010, 6016, 4135, 4149. The list may be truncated at any point.
	Resonance treatment	(all items optional).
BELL	**a**	**a** - the Bell factor (default = 1.16).
DANCOFF	**(g h n)$_l$**	list of triads **(g h n)$_l$** with the following meaning: **g** - the infinite lattice Dancoff factor,

		h - the average Dancoff factor including the outermost ring of rods (**h>g**). **n** - the library resonance group number
		g and **h** apply to all library groups ($\mathbf{n_{l-1}}$+1) to $\mathbf{n_l}$ with $\mathbf{n_0}$=14. If **n** is absent single values of **g** and **h** apply to all library resonance groups.
REGULAR	**a n**	**a** - usually 1. By specifying **a** ≠ 1 a correction is introduced to take into account the irregularities of the lattice,
		n - can be blank or 6, the latter denotes a hexagonal geometry.
		This option is recommended for accurate calculations of regular lattices, especially for tight pitches, but should not be used with DANCOFF.
PIJDANCOFF	**g**	Automatic computation of cluster Dancoff and Bell factors. The job must be set 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 (Section 3) is required for this option and the computed factors are printed and saved for the next lattice calculations.
LAMBDA	**l list**	**l** - can value for the PIJDANCOFF option (default **l**=0.3923 - appropriate for Zircaloy cans), **list** - can 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.
RESXSECS	**r m list**	To input resonance cross sections:
		r - nuclide resonance identification, eg: 2235,
		m - type of cross sections: 1 is absorption, 2 is fission,
		list - inner cross sections for each resonance group for each type in turn, followed by a similar set of outer cross sections.
		The input cross sections replace those from the output of CHAIN 3, appearing in the first and third column under the title "MICROSCOPIC CROSS SECTIONS".
NORESONANCE		The infinite dilution cross sections will be used the resonance shielding calculations being bypassed.
LATTICE	**n**	**n** = $^{-1}$ - cancels a previous request for that option. **n** = 0 (or blank) - the Dancoff factor calculated for inner fuel pins is used for both inner and outer pins of the cluster.

SEGEV	**n**	**n** = $^{-1}$ - cancels a previous request for that option. **n** = 0 (or blank) - the Segev interpolation is used in resonance integral interpolation.
	Cross sections and flux solution	
FEWGROUPS	**list**	**list** - the division of library groups into main transport routine groups.
		The length of the **list** is the first number on the NGROUP card of Section 1. The last number is the number of library groups.
		This may be omitted if no condensation is required.
MESH	**list**	**list** - the number of mesh intervals of equal volume in each of the annuli.
		The length of the **list** is the first number of the NREGION card of Section 1.
		The sum of entries on this card should be equal to the first entry on the NMESH card unless the PRIZE option is applied.
DBSQUARED	**i list**	Leakage term DB^2 added to Σ_a in few groups:
		i = -1 - list of g values of B^2 , where g is the number of main transport groups. The term $B^2/(3\Sigma_{tr})$ is added to Σ_a for each material.
		i = 1 - list of g values of B^2 and g values of D. DB^2 is added to Σ_a for each material.
		i = 2 - list of 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|, ie., to -11, 11 or 12, the DB^2 terms 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 cancelled.
CARDS		Cross sections in DSN format are output to unit 7 by CHAIN 5.
HPS	**n**	This option has 2 independent effects:
		n - omitted - burnup calculations to be carried out in a k-infinity spectrum.
		n > 0 - if **n** > 1000, **m**=**n**-1000,

		macroscopic cross sections in DSN format, ie., as produced by CARDS option, are read for **m** first materials and over-ride the respective material data from the input. Data to be punched after the Main Data BEGINC card includes: Cross sections in DSN format for materials 1 to n-1000.
		The material code per mesh point in BINPUT format if the DSN option is being used. Note that a void is material I + 1 where I is specified on the NMATERIAL card. The material code should follow the DSN Σ's when a condensed group structure is used (because they are read in Chain 5), and precede them otherwise (because they are read in Chain 6 when there is no group condensation).
		If PIJ and/or PERSEUS are used Σ's are read in the same way but only if a condensed group structure is used. No material code is required.
FREE		A free (black) boundary condition ($\Phi \rightarrow 0$ at some extrapolation length). Note that group dependent albedoes can be input to a collision probability calculation by use of the PCELL option, even in single cell cases.
TOLERANCE	**a**	**a** - convergence tolerance of the main transport routine, default value = 0.0001.
OMEGA	**a**	**a** - acceleration parameter for the collision probability solution routine, default value = 1.25.
S	**n**	**n** - order of DSN calculation (SEQUENCE 1), default value = 4.
NPIJAN	**j t i**	**j** - number of annuli (including a square outer region) to be treated by PIJ, all outer annuli to be 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 (consult printout of CHAIN 13 in more sophisticated cases).
		t - maximum number of mean free paths for which neutrons will be tracked, default value = 10, recommended value = 7 to save computing time.
		i - if nonzero track renormalisation will be suppressed. The renormalisation is used to correct for inaccurate volume integration.
LINES	**i j k**	**i** - number of lines in PIJ integration mesh,
		j - number of angles in PIJ integration mesh,
		k - maximum number of boundary reflections which are tracked in a square PIJ calculation, (default = 2).

	Burnup	
POWERC	**i rq rtau indb rmaxt indg list**	**i** - the units of rating 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.
		rtau - the timestep between criticality calculations and flux renormalisation to the input power level (days).
		indb - the number of such timesteps between full lattice calculations.
		rmaxt - if positive is the maximum fractional nuclide density change per integration step (default= 0.05), if negative is a constant integration step length in days.
		indg - the group used to normalise the flux level in the **i** = 5 option (default = 1). In options **i**=4 and **i**=5 list contains a trigger for each material which is 1 if the material is to be included in the flux normalisation and 0 otherwise. If no values are specified in the list, all are assumed to be 1.
ODDS	**i j**	**i** $\neq$ 0 - 2-group microscopic effective absorption and fission cross sections are printed for all burnable nuclides. Group 1 contains the first $\lvert$**i**$\rvert$ main transport groups, group 2 the remainder. If $\lvert$**i**$\rvert$ equals the number of main transport groups, 1-group data will be obtained.
		j $\neq$ 0 - multigroup fluxes will be read for the fuel, coolant, moderator and can from the input and will substitute the spectra calculated for a representative cell. The reading is carried out in CHAIN 5 and, thus, the fluxes must be given after the first BEGINC in the format 6E12.5 (see SPV option).
BUCKLING	**list**	**list** consists of B^2_r , B^2_z , B'^2_r , B'^2_z where B^2_r , B^2_z enable a k_{eff} spectrum to be used for burnup. If B'^2_r , B'^2_z are specified a critical spectrum will be used with bucklings $B^2_r + \lambda\bullet B'^2_r$ and $B^2_z+\lambda\bullet B'^2_z$ with λ chosen to give k_{eff} = 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		Without this card Ariadne diffusion coefficients 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 burnup will be evaluated as MWd/te of current heavy atoms. The fuel mass is recalculated at every burnup step.
		b - an irradiation increment for File 6 output and is required only if a file output job is restarted from a non-zero irradiation.
		list - remaining percentage weights of each burnup 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 list**	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 module.
		i - number of regions in the pin cell calculation (including poison, can, coolant, and paste regions) **i** ≤ Section 1 POISON data value,
		j - number of regions in the poison pin itself.
		list defines the geometry of the poison cell, and contains I-1 sets of
		- region number
		- region radius
		- material number
		- volume fraction (= 1.0)
		followed by data for the paste region containing
		- region number
		- region radius
		- up to 3 pairs of material number and volume fraction (totalling 1.0).
NONEQUILIBRIUM	**n**	**n** = $^{-1}$ - cancels a previous request for that option. **n** = 0 (or blank) - all isotopes are treated as not in equilibrium. The option requires a sufficiently short time step (≤ 1 day), but is not recommended except for short xenon transient calculations.
EQUILIBRIUM	**n**	**n** = $^{-1}$ - cancels a previous request for that option. **n** = 0 (or blank) - a modified equation is solved for isotopes in equilibrium (Xe-135) [32].

	Fuel cycle calculations	
CYCLE	**i k_m X δX rtau indnb w j**	To perform automatic fuel cycle calculations **i** =1 or 2 (see definition of **X**).
		k_m - the irradiation averaged value of k_{eff} at which burnup will terminate.
		X ±δX - the required initial k_{eff} 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** defined by averaging k_{eff} .
		j = 1, **k_m** 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.
		It must be noted that several assumptions are made in the CYCLE options concerning the nuclide identifiers. These must be checked if the Winfrith 1986 library is not used.
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 k_{eff} 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 Pu-241 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 refuelling.
		f - the fractional efficiency of plutonium extraction.
		(The assumed Pu-241 half life is 14.4 years).

DIFFERENTIAL	**list**	**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).
	Multicell calculations	
CELL	**i n**	In a multicell calculation all ANNULUS, MESH and ARRAY data refer to the immediately preceding CELL card, but MATERIAL and RODSUB data apply globally.
		i - cell type,
		n - number of cells of this type, default =1.
		To minimise round-off error it may be advisable to number cell types in order of increasing **n** values.
CSPECTRUM	**m (or blank)**	If this card is supplied with any value **m** $\neq$ **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**.
PCELL	**i Pij** for all **j**	**i** - cell type,
		Pij - 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.
	Sequence changes	
SWITCH	**i j k l**	This option may be used for changing the SEQUENCE option in a burnup run:
		i - new SEQUENCE data (eg. 1= DSN, 2= PERSEUS),
		j - new number of annuli (replaces first item on the NREGION card),
		k - new number of meshes (replaces first item on the NMESH card),
		j and **k** may be zero or blank if the new values equal to the old ones. If **j** changes the number of annuli, the SWITCH card must be followed by a complete new set of ANNULUS and MESH cards.
	Library Data	
REPLACE	**i_1 i_2 list**	The following library modification options are available only when the in-core option is used (see STORE data of Section 1). The required information on storage locations is obtained with the LIBRARY option. The library tape itself is not affected.

		$\mathbf{i_1}$ and $\mathbf{i_2}$ are the addresses of the first and last library locations to be modified.
		list is $\mathbf{i_1}$ -$\mathbf{i_2}$ +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	$\mathbf{i_1}$ $\mathbf{i_2}$ **list**	The list will be expanded or truncated to $\mathbf{i_1}$ - $\mathbf{i_2}$ + 1 values as above and will then be used to multiply the library data stored in addresses $\mathbf{i_1}$to $\mathbf{i_2}$ inclusive.
INCREASE	$\mathbf{i_1}$ $\mathbf{i_2}$ **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 $\mathbf{l_1}$ to $\mathbf{i_2}$.
		Note that only REAL data can be (easily) changed.
	Printout control	
TESTPRINTS		More extensive printout is produced, particularly in the resonance and transport calculations.
SUPPRESS	**list**	**list** contains up to 16 integers, $\mathbf{i_n}$.
		$\mathbf{i_n}$ = 0 - normal printout in CHAIN **n**,
		$\mathbf{i_n}$ = 1 - suppresses all printout $\mathbf{i_n}$ CHAIN **n** except for input data listings, some (not all!) error messages, but including FORTRAN error messages.
		Default values are 0 for **n** = 1-15 and 1 for **n** = 16.
		It may be useful in a failed job to know that the output of the last suppressed CHAIN to be executed can be found in dataset 4.
	End of data	
BEGINC	**n**	The final card of section 2. If **n** is omitted a normal lattice calculation proceeds. The only recommended alternative is **n** = 13 which causes execution to jump straight to Chain 13 and is used to generate more than one edit of a single lattice calculation (often used with the REGION option of Section 3).
	Section 2.1 PRIZE Geometry Data	
	PRIZE calculations	
		If SEQUENCE 5 (PRIZE r-2 collision probabilities) is chosen the data for PRIZE calculations must be read immediately after the first BEGINC. Each line must start with the **PRIZE** keyword and the data must be given in the order specified below:
PRIZE	**nnr nge 0.0**	**nnr** - number of regions in PRIZE calculations,

		nge - definition of geometry:
		nge < 0 - symmetry in the plane Z=0.0; only regions above Z=0.0 have to be specified;
		nge = 0 - infinite cylinder;
		nge = ± 1 - finite cylinder;
		nge = ± 2 - slab.
PRIZE	**za zb ra rb m**	A set of **nnr** cards specifying dimensions of the regions and materials filling up them. For each region (after the keyword PRIZE):
		za - bottom height (cm)
		zb - top height (cm) (for infinite cylinder za - 0, zb = 1.0).
		ra - inner radius (cm)
		rb - outer radius (cm) (for slabs, ra and rb are omitted).
		m - material
PRIZE	**nnrr nnth nnzz r1 r2**	**r1** and **r2** are inner and outer radii in cm for the r-mesh of the "line set" or tracks used for interpretation of collision probabilities; if **r2** = 0 the maximum radius of the system is taken.
		nnrr - number of points in the r-mesh,
		nnth - number of points in the θ-mesh,
		nnzz - number of points in the z-mesh.
		For a slab system only one line set card is read, and the values of **nnrr** and **nnzz** on it are redundant. For a cylindrical system the code computes the contribution of a line set to the integrals and looks for another line set card unless the last used value of **r2** was the maximum outer radius of the system.
		The number of mesh intervals on the NMESH card has to be equal to the number of meshes in the r direction increased by the number of PRIZE zones from the first PRIZE card.
		The number of edit regions (the third entry on the NREGION card) must be equal to the sum of PRIZE zones plus the number of regions in the r direction.
	Section 3 - Edit Data	
	Leakage calculations	
BUCKLING	$\mathbf{B^2_r}$ $\mathbf{B^2_z}$	$\mathbf{B^2_r}$ - is the radial buckling, [cm^{-2}] (or xy $\mathbf{B^2_z}$ - is the axial buckling,. [cm^{-2}] buckling in slabs)
NOBUCKLING		No search for critical buckling will be made.
THERMAL	**n**	**n** - the number of thermal groups in the fewgroup scheme for the two group leakage edit (default = (number of groups + 1)/2).
BEEONE	**i**	**i** = 1 - B_1 flux solution in the leakage edit, or B_0 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 = zero. Buckling values must be set.
DNB	**n D1 D2 D3 D4**	Zero values will be the default for any material not defined if BEEONE is requested.
		n - the material number,
		D1 to **D4** - number densities of those nuclides whose P_1 matrices are on the tape (usually H, D, O, C or U238).
		Note that non-zero D's should be specified only if all the principal nuclides in the material have P_1 matrices. This particularly applies to oxygen in UO_2 if there is not U238 P, data available.
DIFFUSION	**j k l**	Leakage flux calculations will be made by the following methods:
		j = 1 - Benoist,
		j = 2 - Transport,
		j = 3 - Ariadne (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 3-region cell. If **l** is not integral, it is taken to be an 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.
TESTTUBES		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.
NOCORRELATION		An earlier Benoist prescription without correlation terms will be used.

	Burnup control	
ALPHA	**i j**	Pu-240 selfshielding can be varied continuously through burnup.
		i - the first (highest energy) main transport group occupied by the Pu-240 resonance at 1.06eV,
		j -the lowest such group (default: j=i)
SATURATE	**n**	**n** - the identification number of a single nuclide required to be in equilibrium throughout burnup.
	Reaction rate edit	
REACTION	**list**	**list** - pairs of numbers (**i, Ti**), the nuclide identification number and its temperature in Kelvin degrees, for each nuclide for which the reaction rate edit is required. There should no more than specified on the NREACT card. The value of the temperature is relevant only for those nuclides which have temperature dependent absorption or fission cross sections.
PARTITION	**list**	**list** - combination of library groups required in the edit. The length of the list is the second number on the NGROUP card and the last number in the **list** is the number of library groups.
LEAKAGE	**m**	The value of **m** determines which leakage spectrum is to be used for the **k** 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.
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-infinity reaction edit will be printed/suppressed.
	Additional edit data	

REGION	**n m**	The cell edit will be taken over regions **n** to **m** only. The total cell absorption of 1 is not renormalized. Often applied with the BEGINC 13 card to produce output averaged over chosen subsequent regions.
VECTOR	**list**	**list** - a partition vector for additional group condensation. The group numbers should refer to the transport group scheme from the FEWGROUP card: The last entry should be equal to the number of main transport groups equal to the first entry on the NGROUP card. The number of the entries should equal **ig** from the same card.
MOMOD	**list**	**list** - a partition vector for additional region condensation. The region numbers should refer to the edit regions of CHAIN 13. The number of entries must be equal to **igr** on the NREGION card.
		Special care is recommended when the condensation is done for a PIJ calculation.
OPTION	**i**	The WED edit contains: (i) Flux per unit volume and per mesh interval. (ii) Cross sections for each material times flux per unit volume. (iii) Cross sections for each material times flux per mesh interval. **i** = 0 - the full edit, **i** = 1 - items (i) and (iii), **i** = 2 - item (i), **i** = 3 - no output (default = 3).
SPU		The SPECTROX condensation spectra are punched (but only if a nuclide reaction edit has been requested).
PUNCH	**i j**	**i** = 1- card output in WDSN format (main transport group structure), **i** = 2 - card output in SCRAMBLE format, **i** = 3 - both, **i** = 0 - neither. All edit zones from **j** outwards are used to define the 'cell edge' for evaluating cell edge normalisation factors in all card edit options. If **j** is too large it will be reset by the code to the outermost zone number. This card is required for the ZADOC and GOG options.
ZADOC	**n**	**n** = -1 - A previous request for the ZADOC edit will be cancelled. **n** = 0 (or blank) - cross section data is printed and punched in the ZADOC format. Note that the fission cross sections are actually 'power cross sections' normalised to the initial fission cross sections. The VECTOR card must specify a 5-group partition for this option.

GOG	**n**	**n** = -1 - cancels a previous request for GOG data,
		n = 0 (or blank) - cell edge normalised GOG data is produced,
		n = 1 - cell averaged GOG data is produced.
CALEB	**n**	To generate File 6 output, the FEWGROUPS, THERMAL and PARTITION data should have a common thermal energy boundary. Unless a non zero value of **n** is required, this card can be omitted if the appropriate SAVE card is included in the first section of data. **n** = 0 (or blank) - At present up to 62 items of data for whole reactor calculations are stored in a data block of length **k** as defined by the SAVE data. **n** $\neq$ 0 - Power peaking factors will be stored in the data block starting at position **n** (default value 40). Note that REACTION data must be supplied for Xe-135, U-235, Pu-239 with all File 6 output options, and LEAKAGE data is required.
SIGPUNCH	**n**	**n** = -1 - cancels the previous request for the edit. **n** = 0 -(or blank) - Cross section data from the 'Few Group Regional and Cell Edit' (Chain 13) will be punched in the order: D, $\nu\Sigma_f$, Σ_a, $\nu\Sigma_f$, Σ_s.
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 Section 2.
MISCELLANEOUS	**n**	**n** = -1 - cancels a previous request for the output. **n** = 0 (or blank) - miscellaneous 2-group nuclide data is produced [25].
DOPPLER	**n T k**	**n** =1 - this card should be included in the edit data of a case in which the fuel temperature has 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_{inf}. The output is the X8 factor required in reactor codes [26].

BORON	**n c**	**n** = 0 - The boron concentration **c** (normally in ppm) will be inserted in File 6. This option should be used for File 6 output if a non-zero datum level of boron is required in the reactor calculation. **n** = 1 - To generate effective boron cross sections for printer and File 6 output a perturbed boron level **c** is defined. An appropriate MATERIAL card should appear in Section 2 data. **n** = 2 -This data should appear in the edit of a subsequent lattice calculation, identical to the first except for a MATERIAL card to return to the datum boron level. **c** - The boron concentration normally in the moderator and in parts/million. It is the user's responsibility to check that the MATERIAL data and the values of **c** are consistent. The BORON option is valid for reflector data using a REGION card to specify the moderator.
KRYPTON or HELIUM	**n c**	The two keywords are synonymous and the data is identical to that for the BORON option. The item **c** is normally the gas pressure in psi.
ENDCAP	**list**	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. This option does not work with a B_1 edit.
BEHADD	**list**	Behrens slots are specified by a **list** of 3N (≤30) numbers comprising: N values of hole volume ($n\pi r^2$ for n 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). 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 cancelled.
	End of data	

BEGINC		The last card of the Section 3.

Energy boundaries for the libraries [eV]

ENDFB-VI 172-group library

```
 1.96403000E+07 1.73325000E+07 1.49182000E+07 1.38403000E+07 1.16183000E+07
 1.00000000E+07 8.18731000E+06 6.70320000E+06 6.06531000E+06 5.48812000E+06
 4.49329000E+06 3.67879000E+06 3.01194000E+06 2.46597000E+06 2.23130000E+06
 2.01897000E+06 1.65299000E+06 1.35335000E+06 1.22456000E+06 1.10803000E+06
 1.00259000E+06 9.07180000E+05 8.20850000E+05 6.08101000E+05 5.50232000E+05
 4.97871000E+05 4.50492000E+05 4.07622000E+05 3.01974000E+05 2.73237000E+05
 2.47235000E+05 1.83156000E+05 1.22773000E+05 1.11090000E+05 8.22975000E+04
 6.73795000E+04 5.51656016E+04 4.08676992E+04 3.69786016E+04 2.92830000E+04
 2.73944004E+04 2.47875000E+04 1.66155996E+04 1.50344004E+04 1.11377998E+04
 9.11882031E+03 7.46585986E+03 5.53083984E+03 5.00450977E+03 3.52662012E+03
 3.35462988E+03 2.24866992E+03 2.03468005E+03 1.50732996E+03 1.43381995E+03
 1.23409998E+03 1.01039001E+03 9.14242004E+02 7.48518005E+02 6.77286987E+02
 4.53998993E+02 3.71703003E+02 3.04325012E+02 2.03994995E+02 1.48625000E+02
 1.36742004E+02 9.16608963E+01 7.56735992E+01 6.79040985E+01 5.55951004E+01
 5.15779991E+01 4.82515984E+01 4.55173988E+01 4.01689987E+01 3.72664986E+01
 3.37201004E+01 3.05112991E+01 2.76077003E+01 2.49804993E+01 2.26033001E+01
 1.94547997E+01 1.59282999E+01 1.37096004E+01 1.12244997E+01 9.90555000E+00
 9.18980980E+00 8.31529045E+00 7.52398014E+00 6.16012001E+00 5.34642982E+00
 5.04347992E+00 4.12925005E+00 4.00000000E+00 3.38074994E+00 3.29999995E+00
 2.76792002E+00 2.72000003E+00 2.59999990E+00 2.54999995E+00 2.35999990E+00
 2.13000011E+00 2.09999990E+00 2.01999998E+00 1.92999995E+00 1.84000003E+00
 1.75500000E+00 1.66999996E+00 1.59000003E+00 1.50000000E+00 1.47500002E+00
 1.44498003E+00 1.37000000E+00 1.33749998E+00 1.29999995E+00 1.23500001E+00
 1.16999996E+00 1.14999998E+00 1.12535000E+00 1.11000001E+00 1.09700000E+00
 1.07099998E+00 1.04499996E+00 1.03499997E+00 1.01999998E+00 9.95999992E-01
 9.86000001E-01 9.72000003E-01 9.49999988E-01 9.30000007E-01 9.10000026E-01
 8.60000014E-01 8.50000024E-01 7.90000021E-01 7.79999971E-01 7.04999983E-01
 6.25000000E-01 5.40000021E-01 5.00000000E-01 4.85000014E-01 4.32999998E-01
 4.00000006E-01 3.91000003E-01 3.49999994E-01 3.19999993E-01 3.14500004E-01
 3.00000012E-01 2.80000001E-01 2.47999996E-01 2.19999999E-01 1.88999996E-01
 1.80000007E-01 1.59999996E-01 1.40000001E-01 1.34000003E-01 1.15000002E-01
 1.00001000E-01 9.49999988E-02 7.99999982E-02 7.69999996E-02 6.70000017E-02
 5.79999983E-02 5.00000007E-02 4.19999994E-02 3.50000001E-02 2.99999993E-02
 2.50000004E-02 1.99999996E-02 1.49999997E-02 9.99999978E-03 6.89999992E-03
 4.99999989E-03 3.00000003E-03 1.00000998E-05
```

69-group library

```
 1.00000000E+07 6.06550000E+06 3.67900000E+06 2.23100000E+06 1.35300000E+06
 8.21000000E+05 5.00000000E+05 3.02500000E+05 1.83000000E+05 1.11000000E+05
 6.73400000E+04 4.08500000E+04 2.47800000E+04 1.50300000E+04 9.11800000E+03
 5.53000000E+03 3.51910010E+03 2.23944995E+03 1.42510010E+03 9.06897949E+02
 3.67261963E+02 1.48727997E+02 7.55014038E+01 4.80520020E+01 2.76999969E+01
 1.59680004E+01 9.87699986E+00 4.00000000E+00 3.30000019E+00 2.60000038E+00
 2.10000038E+00 1.50000000E+00 1.30000019E+00 1.14999962E+00 1.12300014E+00
 1.09700012E+00 1.07100010E+00 1.04500008E+00 1.02000046E+00 9.95999992E-01
 9.72000003E-01 9.49999988E-01 9.10000026E-01 8.50000024E-01 7.79999971E-01
 6.25000000E-01 5.00000000E-01 3.99999976E-01 3.50000024E-01 3.19999993E-01
 3.00000012E-01 2.79999971E-01 2.50000000E-01 2.20000029E-01 1.80000007E-01
 1.39999986E-01 1.00000024E-01 7.99999833E-02 6.69999719E-02 5.79999983E-02
 5.00000007E-02 4.19999994E-02 3.50000001E-02 3.00000012E-02 2.49999985E-02
 1.99999996E-02 1.50000006E-02 1.00000016E-02 4.99999896E-03 0.00000000E+00
```