ACTEN: A Computer Program to Calculate the Reaction Rate, the Rate of Energy Deposited and the Power Multiplication in a Fusion Blanket Using the Reaction Q Values

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December 1978

UWFDM-276

FUSION TECHNOLOGY INSTITUTE

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1. Introduction

The 'ACTEN' code evaluates the reaction rate of a given type of reaction, e.g. (n,γ), throughout a fusion blanket. As an option, it evaluates the rate of energy deposited in the blanket utilizing the scalar and angular neutron fluxes which are previously evaluated by the one-dimensional transport code ANISN.[1] In this respect, the 'ACTEN' code is considered a complimentary code to evaluate the necessary neutronic design parameters of the fusion blanket which has an external D-T neutron source. Among these design parameters are the displacement per atom, dpa, the helium production, the fissile fuel production, the heating rate and the blanket power multiplication.

The 'ACTEN' code uses a group-dependent cross-section library. The Q-value and decay energy of each neutron reaction with each element used in the blanket are needed when evaluating the heating rate. In this respect, the gamma energy is assumed to be deposited locally and no gamma rays are leaked from the system. This is particularly a good assumption in a blanket utilizing heavy elements located in zones adjacent to each other. Using the Q-value and the decay heat information eliminates the evaluation of the γ-ray flux for which neutron-gamma production cross-sections are needed for each element in the blanket.

The 'ACTEN' code uses neutron energy groups up to 25. It can be modified for larger numbers of energy groups.

2. Main Input to 'ACTEN'

The main input to 'ACTEN' is:

2.1. The Cross Section Library

The cross section library to 'ACTEN' is read from unit 4. The library is structured in a group dependent form. For each element the cross sections for difficult reactions are stored in a matrix form shown in Figure (1).

Each reaction (e.g. (n,2n)) is stored in a row (position) for the 25-neutron group. The matrix for each element is stored on the data file in an ordered record. The order of the elements should be known to specify the starting record of an element where the reaction cross-section matrix is stored. The matrix is stored column by column. For each matrix there are 28 positions available and each position is occupied by a certain cross section type. This matrix is of the form suitable for use as an "activity cross-section table" in the present one, two, or three-dimensional transport codes.[1-3]

2.2. The Neutron Scalar Flux

The neutron scalar flux is read from unit 9. 'ACTEN' reads the flux in a group-wise sense. The scalar flux is in the form given by the 'ANISN' code. Since the blanket is divided into zones, and each zone is divided into intervals, the scalar flux is read as follows:

```
      DØ 100 I = 1, NG
100   READ(9) (F(I,J),J = 1, MESH)
```

where

NG = the number of neutron energy groups

MESH = the number of intervals (meshes) in the system

F(I,J) = the matrix reserved for the scalar flux.

The number of energy groups and intervals in the system should be specified to the code. The number of the incident neutrons on the blanket for which F(I,J) was evaluated by 'ANISN' should also be given to 'ACTEN'. The code allows for normalizing the flux to any specified value.

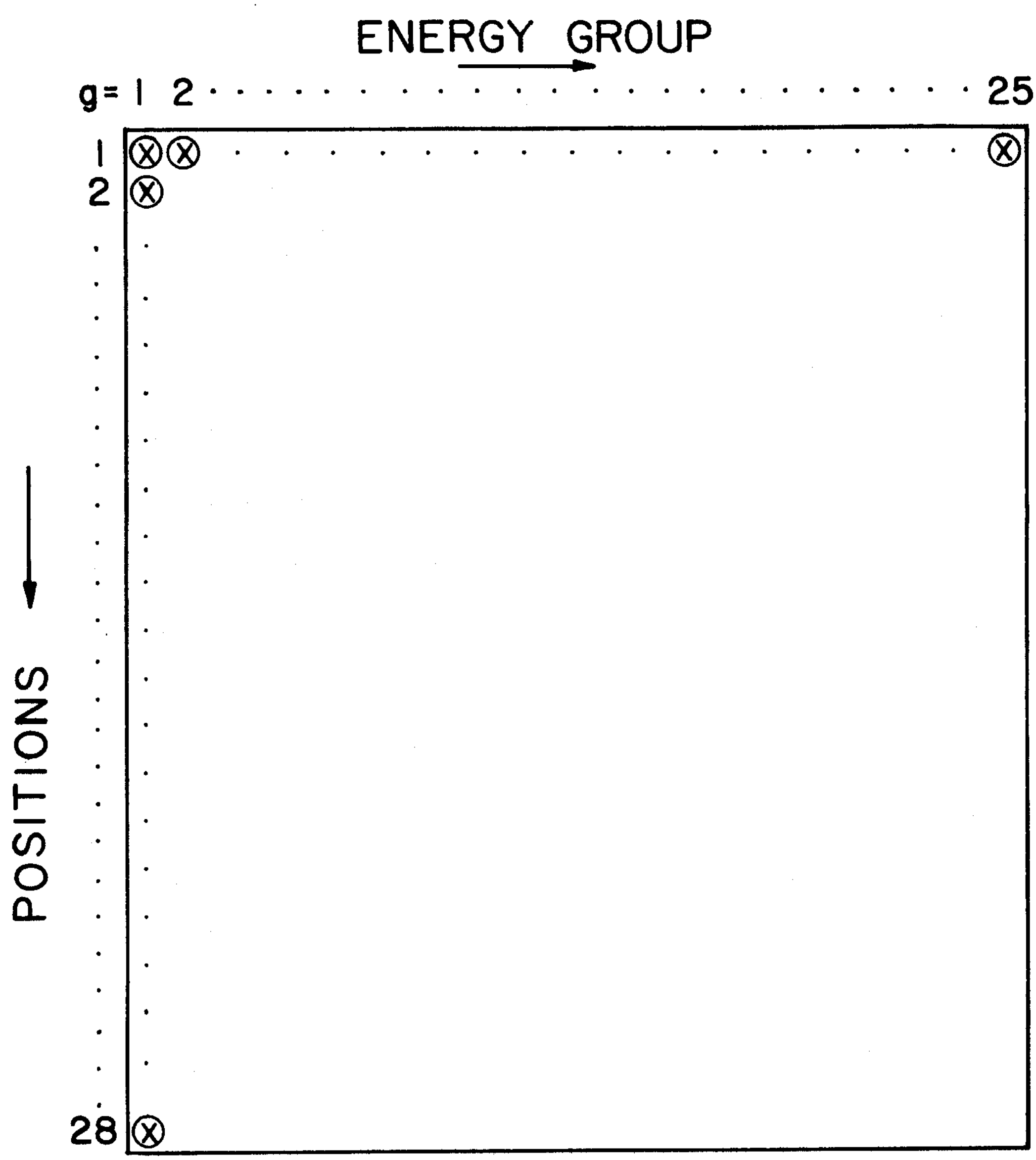

FIGURE 1. THE REACTION CROSS SECTION MATRIX.
(ACTIVITY - CROSS SECTION TABLE)

The scalar flux is used to evaluate the reaction rate or heat deposited by intervals or by zones (option to the code) for each element.

In the case of evaluating the heat deposition, the angular flux is used to evaluate the rate of energy deposition for that particular element by zones or by subzones.

2.3. The Neutron Angular Flux

The angular flux is ready from unit 18. It is read by the subroutine "ENERGD". The angular flux on unit 18 should be in the format provided by the 'ANISN' code. In this format, it is evaluated at the boundary interface and for each energy group it is read first for the first angular direction and all interval boundaries, then for the 2nd angular direction and all interval boundaries, etc. This is repeated for each energy group. The number of spacial interval boundaries, ME, is MESH+1. The array AF(J,K) is reserved for the angular flux for each energy group.

2.4. Blanket Description

The number of zones in the system NZT, the number of intervals (meshes), MESH, the first and last interval of each zone, the number of elements in each zone and their I.D. number in the cross section library and the atomic densities x 10^{-24} should be given to the code. This information specifies the different zones in the blanket and its constituents.

In the case of evaluating the rate of heat deposited in the blanket by subzones, the number of subzones in each zone and the first and last interval of each subzone should be given as input to 'ACTEN'.

To specify the thickness or radius of each interval, array (R(I),I=1,KK) should be read by the code where KK = MESH+1. The geometry of the blanket (slab, sphere or cylinder) should also be specified.

2.5. The Reaction Cross Section Table

This is similar to the activity table used for the 'ANISN' code. Array (IDA(I),I=1,NTE) is reserved for the elements for which reaction rates are required. The variable NTE is the total reaction to be evaluated. Array (NA(I),I=1,NTE) is reserved for the positions of these reactions in the cross section matrices. For example, if the nth entry of IDA(n) is 50 and the nth entry of NA(n) is 3, then 'ACTEN' will evaluate the reaction rate of the particular reaction stored in the 3rd position of the cross section matrix of the 50th element in the cross section library.

Arrays QVAL(I) and DECHT(I) are the corresponding values of the Q-value for that reaction and its decay energy, respectively. The values of QVAL(I) and DECHT(I) should be read by 'ACTEN' code in MeV.

3. The Method Used to Calculate the Energy Deposition Rate

Neutron transport through the blanket can encounter different types of reactions with the different nuclides in each spacial zone. If we consider a segment of the blanket, which may consist of one or more intervals, a loss or gain in the kinetic energy of neutrons in that segment takes place because of the endothermic or exothermic reactions occurring where the kinetic energy is converted into mass or vice versa, respectively. The residual nuclei for some reactions may be left in an excited state and decay by gamma ray or charged particle emission. Neutrons are leaked out of that segment through the surface. To estimate the energy deposited in that segment, a simple energy balance is carried out. The net total neutron energy, L_{nE} transported out of the segment is:

$$L_{nE}(\bar{r}_s) = \int_s \int_0^\infty E_n \bar{J}_n (\bar{r}_s, E_n) \cdot \bar{n} \, dEds \; , \qquad (1)$$

and the net total gamma energy, $L_{n\gamma}$, transported out of the system is

$$L_{n\gamma}(\bar{r}_s) = \int_s \int_o^\infty E_\gamma\, \bar{J}_\gamma(\bar{r}_s,E_\gamma) \cdot \bar{n}\, dEds \qquad (2)$$

where

$\bar{J}_n(\bar{r}_s,E_n) \equiv$ net neutron current of energy E_n at position $\bar{r}$ on the surface of the segment s.

$\bar{J}_\gamma(\bar{r}_s,E_\gamma) =$ net gamma ray current of energy E_γ at the segment surface, s.

$\bar{n} \equiv$ a unit vector in the direction of the normal to that surface.

For a reaction i in element j inside the segment, the gain or loss of the kinetic energy, E^n_{ij}, due to mass-energy (or energy-mass) transformation is given by:

$$E^n_{ij} = R_{ij}\, Q_{ij} \qquad (3)$$

where R_{ij} is the reaction rate for reaction type i in element j integrated over the volume of the segment, V, and Q_{ij} is the Q-value for that reaction. If the residual nuclei decays through channel i' with a decay energy $E_{Di'j}$, then the total energy deposited in the segment using the Q-values, T^Q_t, is given by

$$T^Q_t = - L_{nE} - L_{\gamma E} + \sum_j \sum_i R_{ij}\, Q_{ij} + \sum_j \sum_{i'} R_{i'j}\, E_{Di'j} + E_{ns} + E_{\gamma s} \qquad (4)$$

where E_{ns} and $E_{\gamma s}$ are the energies of the neutron and gamma external sources (if any). In the third term of Eq. (4), the summations over all the possible reactions i for all the elements j are performed. The subscript i' in the fourth term is restricted for those reactions in which decay of the residual nucleus occurs. The inclusion of this term needs justification. If we assume that the energy deposited in the segment due to radioactive decay is considered only for nuclei with half-lives greater than an arbitrary cutoff T_c and that the transmutation of the residual nucleus is ignored, i.e., it decays before it undergoes any other nuclear reaction, then the contribution to the total heating rate in the segment from radioactive decay can be considered a time-independent process for a steady-state system operating for periods much longer than T_c. However, for afterheat calculations, more detailed treatment of the time dependence is needed. Equation (4) is used as the basis for evaluating the heating rate in different spatial segments in the blanket. The angular neutron flux is used to evaluate $\bar{J}_n(\bar{r},E_n)$ in Eq. (1) and the angular gamma flux is used to evaluate $\bar{J}_\gamma(\bar{r},E_\gamma)$ in Eq. (2). Evaluation of these fluxes requires the gamma-ray production cross sections for the elements present in each spatial segment.

Evaluation of the total heating rate can also be performed using the neutron and gamma ray kerma factors[4-6] for each element. If we define $H_{nt}(\bar{r})$ and $H_{\gamma t}(\bar{r})$ as the total neutron and gamma ray heating rate at $\bar{r}$, respectively, then we have

$$H_{nt}(\bar{r}) = \int_v \phi_n(\bar{r},E_n) \sum_j \sum_i N_j(\bar{r})\, K_{ij}\,(E_n)\, dE_n \quad (\text{eV/cm}^3\cdot\text{sec}) \qquad (5)$$

and

$$H_{\gamma t}(\bar{r}) = \int_v \phi_\gamma\,(\bar{r},E_\gamma) \sum_j N_j(\bar{r})\, K_\gamma^j\, dE_\gamma \quad (\text{eV/cm}^3\cdot\text{sec}) \qquad (6)$$

where

$\phi_n(\bar{r},E_n)$ = scalar neutron flux at position $\bar{r}$ and neutron energy E_n

$\phi_\gamma(\bar{r},E_\gamma)$ = scalar gamma ray flux at position $\bar{r}$ and gamma ray energy E_γ

$N_j(\bar{r})$ = nuclide density of element j at $\bar{r}$

K_{ij} = microscopic neutron kerma factor for element j and reaction i

$$= \sigma_{ij} E_{ij} \tag{7}$$

K_γ^j = microscopic gamma ray kerma factor for element j

$$= \sigma_{pe}^j E_\gamma + \sigma_{pp}^j (E_\gamma - 1.02) + \sigma_{ca}^j E_\gamma \tag{8}$$

E_{ij} = energy deposited per reaction i in element j (eV)

σ_{ij} = microscopic cross section of element j for reaction i at neutron energy E_n (cm^2/atom)

σ_{pe}^j = photoelectric microscopic cross section for element j (cm^2/atom)

σ_{pp}^j = pair production microscopic cross section for element j (cm^2/atom)

σ_{ca}^j = Compton microscopic absorption cross section for element j.

Therefore, the total energy deposited in the segment using kerma factors, T_t^K, is given by

$$T_t^K = \int_V (H_{nt}(\bar{r}) + H_{\gamma t}(\bar{r}))\, d\bar{r} \text{ eV/sec} \tag{9}$$

and we have

$$T_t^Q = T_t^K . \tag{10}$$

If we define $S_{E\gamma}$ as the total energy of the gamma ray produced in the segment from neutron-induced reactions, i.e.,

$$S_{E\gamma} = \sum_j \int_V N_j(\bar{r})\ \phi_n(\bar{r},E_n)\ \sigma_p^j\ (E_n,E_\gamma)\ E_\gamma\ dE_n\ dE_\gamma\ d\bar{r} \tag{11}$$

where

$\sigma_p^j(E_n,E_\gamma)$ = photon production cross-section in element j for gamma ray of energy E_γ by neutron of energy E_n,

then we have

$$\int_V H_{\gamma t}(\bar{r})d\bar{r} = S_{E\gamma} + E_{s\gamma} - L_{\gamma E} \tag{12}$$

$$\int_V H_{nt}(\bar{r})d\bar{r} = T_t^Q - (S_{E\gamma} + E_{s\gamma} - L_{\gamma E})\ . \tag{13}$$

The neutron angular flux, the gamma ray angular flux and the photon production cross section are used to evaluate the gamma ray heating rate from Eq. (12). Consequently, evaluation of the total heat deposition rate from Eq. (4) can be used to estimate the neutron heating rate from Eq. (13). In this respect, evaluation of the total heating rate using kerma factors (Eqs. 5, 6 and 9) can be entirely avoided if we use Eqs. 4, 11, 12 and 13. Details on using kerma factors in Eq. (9) can be found in Refs. 4, 5 and 6.

In the 'ACTEN' code Eq. (4) is used in evaluating the heating rate. Since no external sources of neutrons and gamma rays are present in the fusion blanket, the last two terms in Eq. (4) are not included in the code. Further, since the energy of the gamma ray is assumed to be deposited locally, the gamma ray leakage term, $L_{\gamma E}$, is not considered. This eliminates the need for evaluating the gamma flux using the photon production cross section which is not available for all elements in the present version of the ENDF/IV library, particularly for the fissile elements.

4. The Different Subroutines of the 'ACTEN' Code

The 'ACTEN' code consists of the main program, subroutine 'ENERGD', subroutine 'VAF1DR' and subroutine 'VAF1DI'. The purpose of each routine of the 'ACTEN' code is described below:

4.1. The Main Program

This routine performs the following:

- Reads the different options for the code, the interval dimensions, the dimensions of different zones and their constituents and densities.
- Reads the reaction cross section table (array NA(I) and array IDA(I)).
- Reads the Q-value for each reaction in that table and the decay energy, if any.
- Reads the zone description, i.e., number of subzones in each zone and first and last interval of each subzone.
- Reads the scalar neutron flux (unit 9) calculated by the 'ANISN' code and normalizes it to the normalization factor given to the code.
- Reads the cross section library (unit 4).
- Evaluates the reaction rate for the elements given in the reaction cross section table by interval or by zone.
- Evaluates the energy deposited in each subzone.
- Writes the output.

4.2. Subroutine 'ENERGD'

This subroutine, called by the main program if the option JHEAT $\neq$ 0, performs the following:

- Reads the angular quadrature used in evaluating the flux and their weights.
- Reads the energy boundary used in the multi-group calculation and in constructing the cross section library.
- Reads the angular flux (unit 18).
- Evaluates the net energy leaked from the front (outer) and the back (inner) boundaries of each interval using the angular flux.
- Evaluates the energy deposited in each interval due to neutron transport by subtracting the energy leaked from the outer boundary from the energy leaked from the inner boundary. (If this order is reversed, the result is the net neutron energy leaked from that interval).

4.3. Subroutine VAF1DR

This subroutine is called by the main program to read the dimensions of the interval boundaries (real array). This subroutine reads in 'ANISN' format. It is a simplified version of the subroutine 'FIDO' used in the 'ANISN' code. This subroutine performs interpolation, exponentiation, or repetition for the entries of each record read in 'ANISN' format (see Ref. 1).

4.4. Subroutine VAF1DI

This subroutine is called by the main program to read the array DIA(I) which is an integer array in the code. It reads in 'ANISN' format and is a simplified version of the subroutine 'FIDO' of the 'ANISN' code. It is the same as 'VF1DR' subroutine but it reads integer arrays only.

5. Input Description

On the following, a description of each card in the input is given.

Card No. 1 (4I6)

Item	Cols.	Name	Description
1	1-6	NETOT	# of elements in cross section library.
2	7-12	IP	# of positions in cross section tables, matrix (28), see sec. 2.1.
3	13-18	NG	# of energy groups (25).
4	19-24	MESH	# of intervals used in evaluating the flux. It should be the same # as in the 'ANISN' code.

Card No. 2 (10I6)

Item	Cols.	Name	Description
1	1-6	NZT	# of zones in the blanket.
2	7-12	NTE	Length of the reaction cross section table, see section 2.5.
3	13-18	IINTR	0 ≡ do not evaluate the reaction rate by interval when NHEAT=0, evaluate by zones. 1 ≡ evaluate the reaction rate by interval if NHEAT=0. If NHEAT=1, IINTR should = 0.
4	19-24	NHEAT	0 = evaluate the reaction rate only by interval if IINTR=1 or by zones if IINTR=1. 1 = evaluate the energy deposition by subzones.
5	25-30	JHEAT	0 = evaluate the energy deposition by subzones from the Q-value of the reaction for elements given in the reaction cross section table. 1 = evaluate the total energy deposition by subzones from the Q-values of the reaction and from energy deposited due to neutron transport (from leakage at the interval boundaries).

Item	Cols.	Name	Description
6	31-36	IFLUX	0 = the results in output are per incident neutron on the blanket. 1 = normalize the number of neutrons incident on the blanket (n/sec) to the value given by FACT1
7	37-42	IWAT	0 = print the energy deposited in "MeV/sec" units. 1 = print the energy deposited in "watts" unit.
8	43-48	IDEC	0 = ignore the decay energy for each reaction in the energy balance equation (Eq. (4)). Do not read DECHT(I) array. 1 = include the decay energy for each reaction in the energy balance equation, read DECHT(I) array.
9	49-54	IWT	0 = do not print the energy deposited due to the Q-value term (3rd term in Eq. 4). This term is evaluated by subzone for each element. 1 = print it.
10	55-60	IGM	1 = the blanket is planar. 2 = the blanket is cylindrical. 3 = the blanket is spherical.

Note: if NHEAT=1, then IINTR=0.
If NHEAT=0, then JHEAT, IWAT, IDEC, and IWT=0.

Card No. 3 (1E12.5)

Item	Cols.	Name	Description
1	1-12	FXNT	The source value (n/sec) incident on the blanket to which the scalar and angular flux were evaluated by 'ANISN' code.

Card No. 4 (1E12.5)

Item	Cols.	Name	Description
1	1-12	FACT1	The source value (n/sec) incident on the blanket to which the fluxes are normalized.

The following cards (in 'ANISN' format):

(R(I),I=1,MESH+1) — The radius of each spatial interval.

Note: These cards should be followed by a card with T in the 3rd column.

The following cards:

The following cards consist of several groups of cards. Each group describes each zone in the blanket. The number of these groups are the number of zones NZT. Each group consists of four cards.

Card No. 1 (1I6)

Item	Col.	Name	Description
1	1-6	NEZZ(I)	# of elements in zone I.

Card No. 2 (12I6)

Item	Col.	Name	Description
1	1-6	NT(I,1)	The first interval in zone I.
2	7-12	NT(I,2)	The last interval in zone I.

Note: These intervals are the starting and ending intervals for zone I as they are in the 'ANISN' output.

Card No. 3 (12I6)

(IDZ(I,J),J=1,NEZZ(I)) — The I.D. number in the cross section library (unit 4) for the elements present in zone I.

Card No. 4 (6E12.5)

(DENZ(I,J),J=1,NEZZ(I)) — The atomic densities x 10^{-24} of the elements present in zone I.

Following these groups of cards are:

(IDA(I),I=1,NTE) This array is written in 'ANISN' format. — The I.D. number in the cross section library for the required elements introduced in the cross section table, see section 2.5.

Note: This array should be terminated with a card where 'T' is punched in the 3rd column.

(NA(I),I=1,NTE) — Array specifies the positions of activities (reaction type) for the elements introduced in the cross section table. See Section 2.5.

The following cards (6E12.5):

(QVAL(I),I=1,NTE) — Array specifies the Q-value for each reaction of NA(I) in MeV. This array is to be given as input if NHEAT=1.

The following cards (6E12.5):

(DECHT(I),I=1,NTE)	Array specifies the decay energy of each reaction. It is given as input if IDEC=1 and NHEAT=1.

The following card (12I6):

(NSUB(I),I=1,NZT)	Array specifies the number of subzones in each zone. This array is introduced if NHEAT=1.

The following cards are introduced if NHEAT=1 and consist of NZT groups of cards (NZT = number of zones in the blanket). Each group describes the subzones of each zone and consists of the following cards (12I6):

(NXX(I,J,K),K=1,2),J=1,KM)	Array specifies the first and last interval (K=1,2) of each subzone J in zone I. KM is the number of subzones in zone I.

The following card (1I6):

Item	Col.	Name	Description
1	1-6	N	# of quadratures in Sn approximation. Introduced if NHEAT=1.

The following card (6E12.5):

(D(I),I=1,N)	The cosines of the angles. Introduced if NHEAT=1.

The following card (6E12.5):

(W(I),I=1,N)	Weights of the angles. Introduced if NHEAT=1.

The following cards (6E12.5):

(E(I),I=1,NG+1)	The energy boundaries used in the multigroup calculations in eV. Introduced if NHEAT=1.

6. The Source Program of the 'ACTEN' Code

The source, in FORTRAN language, of the main program and the subroutines of the 'ACTEN' code are given in Appendix A.

7. A Sample for the Input

The example given in Appendix B is for the case of evaluating the heating rate in the blanket of the fission-fusion laser driven hybrid. A schematic diagram of the blanket is given in Fig. (2). The number of zones and subzones is shown in that figure along with the constituents of each zone and the interval radius. The blanket is in spherical geometry. It is designed to produce a uniform U-233 atom from Th(n,γ) reaction throughout the fuel zone. For more details of this design see Refs. (8), (10) and (13)-(16).

As it is taken from the cross section library used, the I.D. number of each element is shown in Table (1). For a particular element (e.g., 53; Li-6), the different possible reactions are introduced in array NA(I). The entry identifying this element (e.g., 53) is repeated in array IDA(I) as many times as the number of reactions considered. The associated Q-value for each reaction and the decay energy are given in array QVAL(I) and DECHT(I), respectively. The Q-values used are obtained from the working library, MACK-LIB of the Nuclear Engineering Department of the University of Wisconsin. Q-values for different reactions and different incident particles can be obtained from Ref. (9). The information about the energy of different channels of decay are obtained from Ref. (12). The multi-group cross sections (25 neutron group) are obtained from DLC-2D library(7) which is generated from ENDF/B-III with the 'SUPERTOG'(11) code using 1/E weighting spectrums for the GAM-II 100-group structure.

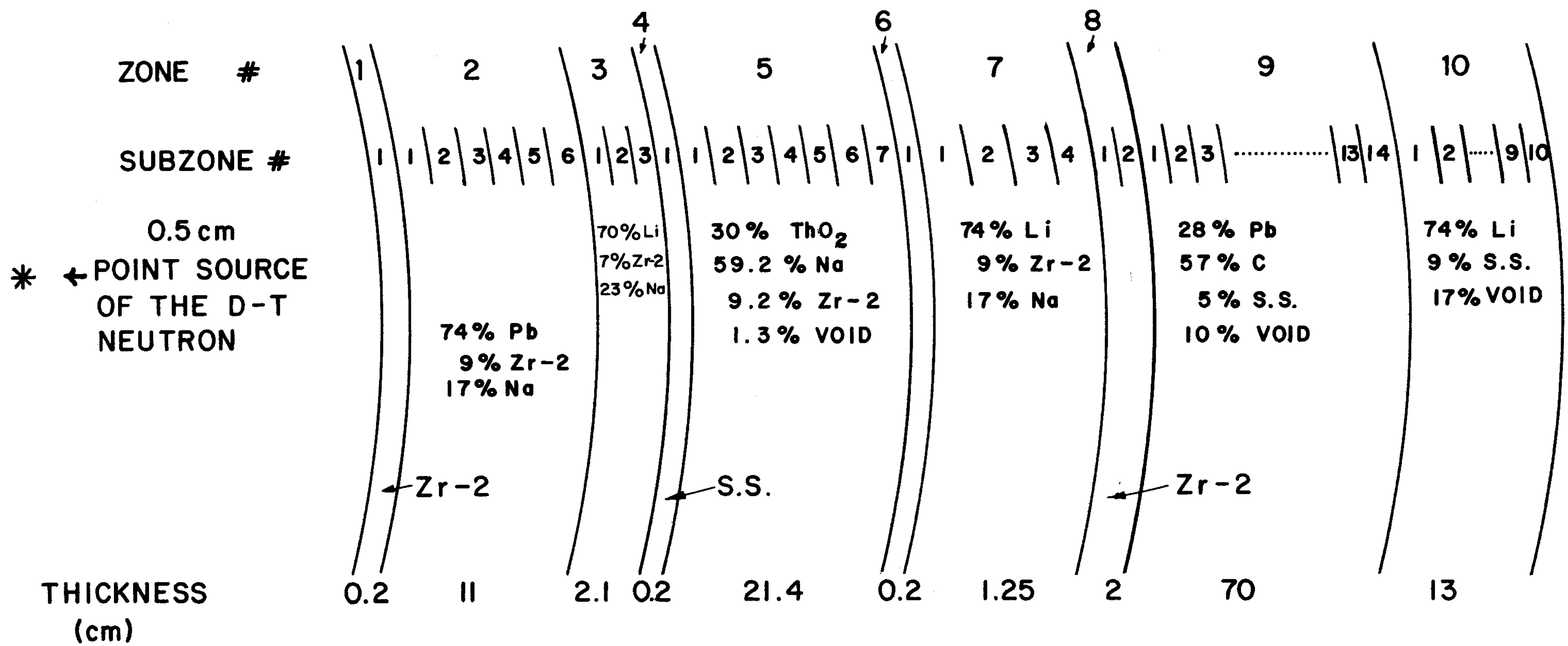

FIGURE 2 BLANKET CONFIGURATION

Table (1)

I.D.#	Element
53	Li-6
54	Li-7
56	C
57	Na
58	Cr
59	Ni
60	Fe
61	Pb
63	Th

Part of the reaction cross section table, which specifies the elements (array IDA(I)), the position of the reaction in the cross section library (array NA(I)), the type of this reaction and its Q-value is given in Table (2). The sample of the input for the mentioned blanket is given in Appendix B.

8. The Output

The output given in Appendix C is as follows: First, the options used are written. A description of the blanket follows the options. The reaction cross section table is printed where the elements in the blanket, the position of each reaction for that element and its Q-value are given. The decay energy for each reaction was ignored in evaluating the heating rate in this example. A description of the subzones of each zone and the first (INT1) and last (INT2) interval of each subzone are printed next.

A summary of the energy deposited by subzones is printed next. The first column specifies the zone. The sequence number of each subzone in that zone is given in column 2. Its thickness is given in column 3. The 4th column specifies the volume of each subzone. The term $\sum_j \sum_i R_{ij} Q_{ij}$ in Eq. (4) is evaluated for each subzone. This term /cm^3 sec and its integrated value for each subzone are given in columns 5 and 6, and they are denoted Q(MeV/3.) and Q(MeV), respectively. The rate of the energy deposited due to neutron transport/cm^3 and the integrated value for each subzone are given in columns 7 and 8. They are denoted SRC(MeV/cm^3) and SRC(MeV), respectively. They correspond to the term ($-L_{nE}$) in Eq. (4). The total value for the rate of energy deposited in each subzone (the term T_t^Q in Eq. (4)) is given next per cm^3 (column 9) and its integrated value is given in the last column. The value of $\sum_j \sum_i R_{ij} Q_{ij}$ (denoted Q-value) and

Table (2)

Element IDA(I)	Name	Position of the Reaction NA(I)	Type of Reaction	Q-Value (MeV)
53	Li-6	3	(n,n') 2nd excited	-3.562
53	Li-6	2	(n,2n)α	-3.696
53	Li-6	4	(n,n') to continum	-1.471
53	Li-6	5	(n,γ)	7.252
53	Li-6	6	(n,ρ)	-2.733
53	Li-6	7	(n,α)T	4.786
54	Li-7	2	(n,2n)	-7.252
54	Li-7	3	(n,2n)α	-8.723
54	Li-7	4	(n,n') 1st excited	-0.478
54	Li-7	5	(n,n') to cont. (n,n')T	-2.466
54	Li-7	6	(n,γ)	2.032
54	Li-7	7	(n,d)	-7.760
:	:	:	:	:

the value of $-L_{nE}$ (denoted source) are printed next for each zone. A summary of the total rate of energy deposited in each zone is printed next along with the volume of this zone. The rate of energy deposited per cm^3 in each subzone is given in the last column.

The total energy rate deposited in the entire blanket is given next. The power multiplication defined as the total power in the blanket divided by the total power incident on the blanket is printed as the last line in the output.

9. Conclusions

The 'ACTEN' code was developed to evaluate

(1) The reaction rate throughout the fusion blanket for any particular reaction in a specified element(s).

(2) The rate of energy deposited (by subzones) in the blanket (in MeV/sec or in watts). This evaluation is based on a single energy balance equation utilizing the Q-value and decay energy for each reaction.

(3) The power multiplication in the blanket. The rate of energy deposited from gamma-rays is assumed to be deposited locally in this code.

10. Appendices

10.1. Appendix A

The source program of the 'ACTEN' code and other subroutines.

```
===== (ACTEN*PROG)  FOR(11)  =====

C                   ***   A C T E N  ***
C
C             PROGRAM TO EVALUATE THE FOLLOWING...
C          * REACTION RATE FOR ANY PARTICULAR MATERIAL USING A DATA LIBRARY
C         OF 'ANISN' GROUPE DEPENDENT. THE REACTIN RATE IS EVALUATED BY ZONE
C           OR BY INTERVAL
C
C          * HEAT DEPOSITED IN THE BLANKET BY ZONE,SUBZONE OR BY INTERVAL
C         USING THE REACTION Q- VALUE METHOD AND ASSUMING LOCAL DEPOSITION
C           OF GAMMA ENERGY
C
C           THIS PROGRAM USES THE SCALER FLUX AND ANGULAR FLUX CALCULATED
C           FROM 'ANISN' CODE
C
C           UNITS..
C
C          N4 =X'S LIBRARY 25-GROUP NEUTRON ONLY
C           N9 =SCALER FLUX
C           N18 =ANGULAR FLUX
C
      DIMENSION C30(15),C31(15)
      DIMENSION VOLJ(15,100),VOLZ(15)
      DIMENSION ED(200),                EDJ(15,100),EDZ(15)
      DIMENSION DECHT(200)
      DIMENSION IDA(200),NA(200),X(28,25),IDZ(15,10),DENZ(15,10),
     *      NEZZ(15),NT(15,2),XNFA(200),F(25,200)
      DIMENSION R(201),V(200)
      DIMENSION ACT(200)
      DIMENSION QVAL(200)
      DIMENSION NSUB(15),NXX(15,100,2)
      DIMENSION ID(20),HTEL(15,100,10),HTEL1(15,100,10),HT(15,100),
     *   HT1(15,100),H(15)
      COMMON NG,MESH,R,V,ED,IGM
      READ(N5,100)NETOT,IP,NG,MESH
      DATA N5,N6,N4,N9/5,6,4,9/
      XMEV=1.0E+06
      CFF=1.6021E-19
      N18=18
C       READING THE OPTIONS
C
C       IWAT =0/1 ENERGY DEPOSITED IN MEV/IN WATTS
C       IFLUX =0/1 ONE NEUTRON/N NEUTRON ..NORMALIZATION FACTOR
C       NHEAT = 0/1 EVALUATE REACTION RATES ONLY/EVALUATE HEATING RATE
C       JHEAT =0/1 HEAT DEPOSITED FOR Q-VALUE ONLY/Q-VALUE + SOURCE
C       IDEC =0/1 NO DECAY HEAT IS INCLUDED/INCLUDED
C       IINTR =0/1 ACTIVITY BY INTERVAL/ZONE
C     IWT =0/1 DO NOT WRITE HEAT DEPOSITED FOR EACH ELEMENT
      READ(N5,100)NZT,NTE,IINTR,NHEAT,JHEAT,IFLUX,IWAT,IDEC,IWT
     *,IGM
      WRITE(N6,158) IINTR,NHEAT,JHEAT,IFLUX,IWAT,IDEC,IWT,IGM
  158 FORMAT(///,5X,'***OPTIONS***',//,2X,'IINTR ='I6,
     *2X,'NHEAT =',I6,
     *2X,'JHEAT =',I6,
     *2X,'IFLUX =',I6,
     *2X,'IWAT =',I6,
     *2X,'IDEC =',I6,2X,'IWT =',I6,2X,'IGM =',I6,///)
      READ(N5,101)FXNT
```

```
      FACT1=1.0
      IF(IFLUX .EQ.1)READ(N5,101)FACT1
      PY=3.141592654
      JJ=MESH+1
C
C       READING INTERVALS RADIOUS
C
      CALL VAFIDR(R,JJ)
      DO 31 I=1,MESH
      IF(IGM.EQ.1)V(I)=R(I+1)-R(I)
      IF(IGM.EQ.2)V(I)=PY*((R(I+1)**2.0)-(R(I)**2.0))
      IF(IGM.EQ.3)V(I)=((4.0/3.0)*PY)*((R(I+1)**3.0)-(R(I)**
     *3.0))
   31 CONTINUE
  100 FORMAT(12I6)
      WRITE(N6,300)
  300 FORMAT(1H1,//,30X,'****** DESCRIPTION ******',////)
C
C       READING MATERIAL BY ZONFIDZ(NZ) THEN THE DENSITY DENZ(NZ)
C       AND THE STARTING AND ENDING INTERVAL OF EACH ZONE NT(NZ,J),J=1,2
      DO 8 I=1,NZT
      WRITE(N6,301)I
  301 FORMAT(2X,'ZONE NUMBER',6X,'=',I6)
      READ(N5,100)NEZZ(I)
      NEZ=NEZZ(I)
      READ(N5,100)(NT(I,J),J=1,2)
      WRITE(N6,302)(NT(I,J),J=1,2)
  302 FORMAT(2X,'EXTENDED FROM INT.',2X,I6,2X,'TO',2X,I6)
      READ(N5,100)(IDZ(I,J),J=1,NEZ)
      WRITE(N6,303)(IDZ(I,J),J=1,NEZ)
  303 FORMAT(2X,'INCLUDES ELEMENTS',2X,20I6)
      READ(N5,101)(DENZ(I,J),J=1,NEZ)
      WRITE(N6,304)(DENZ(I,J),J=1,NEZ)
  304 FORMAT(2X,'THEIR DENSITIES ARE',1P20E12.4)
    8 CONTINUE
  101 FORMAT(6E12.5)
C
C       READING MATERIAN # FOR ACTIVITY IDA(I),I=1,NTE)
C
      CALL VAFIDI(IDA,NTE)
C
C       READING THE POSITION FOR ACTIVIT FOR EACH MAT. NA(I),I=1,NTE
C       READING THE Q- VALUE FOR EACH REACTION IF NHEAT.EQ.1
C       READING THE DECAY ENERGY FOR EACH REACTION IN MEV IF IDEC .EQ.1
C       NA(I) = POSITION OF ACTIVITY IN THE X'S TABLE
C       QVAL(I) = Q-VALUE FOR THIS REACTION
C       DECHT(I) = DECAY HEAT FOR THIS REACTION
C
      READ(N5,100)(NA(I),I=1,NTE)
      IF(NHEAT.EQ.1) READ(N5,101)(QVAL(I),I=1,NTE)
      IF(IDEC.EQ.1)READ(N5,101)(DECHT(I),I=1,NTE)
      IF(IDEC.EQ.0) GO TO 2222
      GO TO 2223
 2222 DO 2224 III=1,NTE
 2224 DECHT(III)=0.0
 2223 CONTINUE
      WRITE(N6,305)
```

```
  305 FORMAT(1H1,///,20X,'ELEM.',2X,'POSITION',5X,'Q VALUE',2X,'DECAY EN
     *RGY',///)
      DO 881 I=1,NTE
  881 WRITE(N6,306)IDA(I),NA(I),QVAL(I),DECHT(I)
  306 FORMAT(18X,I6,4X,I6,2X,1P2E12.4)
      IF(NHEAT.EQ.0) GO TO 400
C
C          READING THE # OF SUBZONE FOR EACH ZONE NSUB(NZ) AND THE START
C          AND ENDING INTERVAL FOR EACH SUBZONE NXX(NZ,J,K),K=1,2)
      READ(N5,100)(NSUB(I),I=1,NZT)
      JX=0
      DO 401 I=1,NZT
      KM=NSUB(I)
      JX=JX+KM
      READ(N5,100)((NXX(I,J,K),K=1,2),J=1,KM)
  401 CONTINUE
      WRITE(N6,402)
  402 FORMAT(1H1,///,3X,'ZONE',2X,'SUBZONE',1X,'SEQ.',1X,'INT1',1X,
     *'INT2')
      NNN=0
      DO 403 I=1,NZT
      KM=NSUB(I)
      DO 403 J=1,KM
      NNN=NNN+1
      WRITE(N6,100)I,J,NNN,(NXX(I,J,K),K=1,2)
  403 CONTINUE
  400 CONTINUE
   96 FORMAT(6E12.5)
C
C         REDING THE SCALAR FLUX AND NORMALIZE IT TO 1 NEUTRON
C         AND THEN NORMALIZE IT TO FACT1 IF IFLUX=1
C
      DO 16 III=1,NG
   16 READ(N9)(F(III,J),J=1,MESH)
  161 FORMAT(6E12.5)
      DO 17 III=1,NG
      DO 17 J=1,MESH
   17 F(III,J)=(F(III,J)/FXNT)*FACT1
      LM=1
      ID(LM)=IDA(LM)
      IF(NHEAT.EQ.0) GO TO 408
      DO 409 NZ=1,NZT
      DO 409 J=1,100
      DO 409 LMI=1,10
      HTEL(NZ,J,LMI)=0.0
      HTEL1(NZ,J,LMI)=0.0
  409 CONTINUE
  408 CONTINUE
C
C         DO LOOP 1 TAKES EACH ELEM. FROM THE ACTIVITY TABLE AND EVALUATE
C          THE Q-VALUE HEAT DEPOSITED FROM IT IF NHEAT.EQ.1 OR ONLY THE
C          ACTIVITY IF NHEAT.EQ.0
C
      DO 1 NE=1,NTE
      DO 901 NZ=1,NZT
      C30(NZ)=0.0
  901 C31(NZ)=0.0
```

```
      NEL=IDA(NE)
      IF(NE.GE.2) GO TO 2
    4 IF(NE.EQ.1) GO TO 55
      REWIND N4
   55 DO 5 II=1,NEL
C
C        READING THE X´S LIBRARY
C
    5 READ(N4)((X(I,J),I=1,IP),J=1,NG)
      GO TO 3
    2 K=NE-1
      IF(IDA(K).EQ.IDA(NE)) GO TO 3
      LM=LM+1
      ID(LM)=NEL
      GO TO 4
    3 CONTINUE
      ICC=0
      IF(NHEAT.EQ.0)XNFA(NE)=0.0
      KKKK=NA(NE)
      IF((NHEAT.EQ.0).AND.(IINTR.EQ.0))WRITE(N6,103)NEL,KKKK
C
C        CHECKING IF THE ELEMENT IS IN THE ZONE NZ
C
      DO 6 NZ=1,NZT
      N1=NT(NZ,1)
      N2=NT(NZ,2)
      IF(NHEAT.EQ.1)KMM=NSUB(NZ)
      KK=NEZZ(NZ)
      DO 9 IT=1,KK
      IF(NEL.EQ.IDZ(NZ,IT)) GO TO 10
    9 CONTINUE
      GO TO 6
   10 ICC=ICC+1
      ICT=0
      IF(NHEAT.EQ.0) GO TO 404
      J=0
  405 J=J+1
      N1=NXX(NZ,J,1)
      N2=NXX(NZ,J,2)
  404 CONTINUE
      C=0.0
      C1=0.0
      IF((IINTR.EQ.1).AND.(ICC.EQ.1)
     *.AND.(NHEAT.EQ.0))WRITE(N6,805)NEL,NA(NE)
  805 FORMAT(1H1,///,15X,´ACTIVITY BY INTERVAL FOR ELM.´,I6,2X,´POSITION
     *´,I6,///,2X,´ZONE´,2X,´INT´,4X,´THIC(CM)´,2X,´VOLUME´,4X,´ACTIVITY
     */CM3. ´,2X,´ACTIVITY BY INT.          ´)
C
C        DO 12 EVALUATE THE ACTIVITY BY INTERVAL IF IINTR.EQ.1 OR BY ZONE
C        IF NHEAT.EQ.1
C
      DO 12 INT=N1,N2
      ICT=ICT+1
      CC=0.0
      KKK=NA(NE)
      DO 13 IGG=1,NG
   13 CC=CC+F(IGG,INT)*X(KKK,IGG)
```

```
      ACT(ICT)=DENZ(NZ,IT)*CC
      C1=C1+V(INT)
      CCKK=R(INT+1)-R(INT)
      CCKC=ACT(ICT)*V(INT)
      IF((IINTR.EQ.1).AND.(NHEAT.EQ.0))WRITE(N6,806)NZ,ICT,CCKK,V(INT),A
  806 FORMAT(I6,I4,1P3E12.4,5X,1PE12.4)
   12 C=C+DENZ(NZ,IT)*CC*V(INT)
      CKKC=C/C1
      IF((IINTR.EQ.1).AND.(NHEAT.EQ.1))C30(NZ)=C
      IF((IINTR.EQ.1).AND.(NHEAT.EQ.0))C31(NZ)=CKKC
  893 FORMAT( /,3X,'FOR ZONE',2X,I6,2X,'ACTIVITY                   =',1PE12.4,
     *2X,'WITH AVERAGE VALUE          PER CM3',1PE12.4)
      IF(NHEAT.EQ.0) GO TO 406
C
C        EVALUE THE ENERGY DESODITED FOT THIS REACTION OF THE ELEM. LM
C        LM = THE INTERNAL # OF THE ELEM. I .LM 1 MEANS THE FIRST ELEM.
C        APPEARS IN YHE ACTIVITY TABLE
C
      VVV=C*DECHT(NE)
      VV=C*QVAL(NE)
      HTEL(NZ,J,LM)=HTEL(NZ,J,LM)+VV+VVV
      HTEL1(NZ,J,LM)=HTEL1(NZ,J,LM)+VV/C1+VVV/C1
      IF(J.EQ.KMM) GO TO 6
      GO TO 405
  406 IF((IINTR.EQ.0).AND.(NHEAT.EQ.0))WRITE(N6,102)NZ,C
      XNFA(NE)=XNFA(NE)+C
    6 CONTINUE
      IF(IINTR.EQ.0) GO TO 896
      DO 900 I=1,NZT
  900 WRITE(N6,893)I,C30(I),C31(I)
  896 CONTINUE
      IF(ICC.EQ.0) WRITE(N6,105)NEL
  105 FORMAT(30X,'****ELEMENT',I6,2X,'NOT FOUND IN ZONES')
      IF(NHEAT.EQ.0) WRITE(N6,104)XNFA(NE)
    1 CONTINUE
  103 FORMAT(//,2X,'ELEMENT=',I6,2X,'POSITION=',I6)
  102 FORMAT(16X,'ACTIVITY IN ZONE',I6,'=',1PE12.4)
  104 FORMAT(/,16X,'TOTAL ACTIVITY=',1PE12.4,/,'************************
     ******************************************************************
     ****************')
      IF(NHEAT.EQ.0) GO TO 407
      IF(JHEAT.EQ.0) GO TO 475
C
C        EVALUATE THE ENERGY DEPOSITED IN EACH INTERVAL FROM THE SOURCE
C        EDJ(NZ,J) = ENERGY DEPOSITED FROM THE SOURCE IN SUBZONE J OF
C        THE ZONE NZ
C        EDZ(NZ) = ENERGY DEPOSITED FROM SOURCE IN ZONE NZ
C        TOTEN = ENERGY DEPOSITED IN THE BLANKET FROM THE SOURCE
C
      CALL ENERGD
      TOTVOL=0.0
      TOTEN=0.0
      DO 460 NZ=1,NZT
      EDZ(NZ)=0.0
      VOLZ(NZ)=0.0
      KMM=NSUB(NZ)
      DO 461 J=1,KMM
```

```
      N11=NXX(NZ,J,1)
      N12=NXX(NZ,J,2)
      EDJ(NZ,J)=0.0
      VOLJ(NZ,J)=0.0
      DO 462 INT=N11,N12
      VOLJ(NZ,J)=VOLJ(NZ,J)+V(INT)
  462 EDJ(NZ,J)=EDJ(NZ,J)+ED(INT)
      EDJ(NZ,J)=EDJ(NZ,J)/XMEV/FXNT
      EDJ(NZ,J)=EDJ(NZ,J)*FACT1
C
C        ENERGY DEPOSITED IN WATTS IF IWAT.EQ.1
C
      IF(IWAT.EQ.1)EDJ(NZ,J)=EDJ(NZ,J)*CFF*XMEV
      VOLZ(NZ)=VOLZ(NZ)+VOLJ(NZ,J)
  461 EDZ(NZ)=EDZ(NZ)+EDJ(NZ,J)
      TOTVOL=TOTVOL+VOLZ(NZ)
  460 TOTEN=TOTEN+EDZ(NZ)
  475 CONTINUE
      LMAX=LM
      TOT=0.0
C
C        EVALUATE THE ENERGY DEPOSITED FOR Q- VALUE  FOR ELEM LM
C        TOT = TOTAL ENERGY DEPOSITED IN THE BLANKET FROM Q- VALUE
C           HT(NZ,J) = ENERGY DEPOSITED IN ZONE NZ IN SUBZONE J FROM ALL
C        ELEMENTS( Q- VALUE ONLY )
C
      DO 412 NZ=1,NZT
      KMM=NSUB(NZ)
      H(NZ)=0.0
      DO 411 J=1,KMM
      C3=0.0
      C2=0.0
      DO 410 IIEL=1,LMAX
      C2=C2+HTEL(NZ,J,IIEL)
  410 C3=C3+HTEL1(NZ,J,IIEL)
      IF(IWAT.EQ.1)C2=C2*CFF*XMEV
      IF(IWAT.EQ.1)C3=C3*CFF*XMEV
      HT(NZ,J)=C2
      HT1(NZ,J)=C3
  411 H(NZ)=H(NZ)+HT(NZ,J)
  412 TOT=TOT+H(NZ)
C
C        ENERGY DEPOS. IN THE SUBZONE FROM ELM. NEL FOR Q-VALUE ONLY
C        IF IWT =1
C
      IF(IWT.EQ.0) GO TO 4133
      DO 413 LM=1,LMAX
      NEL=ID(LM)
      WRITE(N6,414)NEL
  414 FORMAT(1H1,///,20X,'ENERGY DEPOSITED FROM ELEMENT',I6,2X,'FOR Q VA
     *LUE ONLY',/////)
      IF(IWAT.EQ.0)WRITE(N6,415)
  415 FORMAT(3X,'ZONE',2X,'SUBZONE',2X,'MEV/CM3. ',4X,'MEV   ',///)
      IF(IWAT.EQ.1)WRITE(N6,934)
  934 FORMAT(3X,'ZONE',2X,'SUBZONE',2X,'WAT/CM3',4X,'WATTS',///)
      ZZ=0.0
      DO 416 NZ=1,NZT
```

```
      KMM=NSUB(NZ)
      DO 416 J=1,KMM
      IF(IWAT.EQ.1)HTEL(NZ,J,LM)=HTEL(NZ,J,LM)*CFF*XMEV
      IF(IWAT.EQ.1)HTEL1(NZ,J,LM)=HTEL1(NZ,J,LM)*CFF*XMEV
      ZZ=ZZ+HTEL(NZ,J,LM)
  416 WRITE(N6,417)NZ,J,HTEL1(NZ,J,LM),HTEL(NZ,J,LM)
      IF(IWAT.EQ.0)WRITE(N6,555)NEL,ZZ
      IF(IWAT.EQ.1)WRITE(N6,556)NEL,ZZ
  555 FORMAT(///,5X,'ENERGY DEPOSITED FROM ELEMENT',I6,2X,'IN THE BLANKE
     *T =',1PE12.4,2X,'MEV              ')
  556 FORMAT(///,5X,'ENERGY DEPOSITED FROM ELEMENT',I6,2X,'IN THE BLANKE
     *T =',1PE12.4,2X,'WATTS')
  413 CONTINUE
 4133 CONTINUE
      WRITE(N6,418)
  418 FORMAT(1H1,///,10X,'ENERGY DEPOSITED BY SUBZONE FOR Q VALUE&SOURCE
     *',///)
      IF(IWAT.EQ.0)WRITE(N6,715)
      IF(IWAT.EQ.1)WRITE(N6,943)
  715 FORMAT(2X,'ZONE',2X,'SUB',2X,'THK',2X,'VOL.SUB',2X,'Q(MEV/3. )',2X
     *,'Q(MEV   )',2X,'SRC(MEV/CM3)',2X,'SRC(MEV   )',2X,'TOT(MEV/CM3)',2X
     *,'TOT(MEV   )',///)
  943 FORMAT(2X,'ZONE',2X,'SUB',2X,'THK',2X,'VOL.SUB',2X,'Q(WAT/CM3)',2X
     *,'Q(WAT   )',2X,'SRC(WAT/CM3)',2X,'SRC(WAT)',5X,'TOT(WAT/CM3)',2X,
     *'TOT(WAT   )',///)
C
C        SUMMERY OF THE HEAT DEPOSITED IN EACH SUBZONE FOR Q+SOURCE
C
      DO 419 NZ=1,NZT
      KMM=NSUB(NZ)
      DO 419 J=1,KMM
      ED1=EDJ(NZ,J)/VOLJ(NZ,J)
      ED2=ED1+HT1(NZ,J)
      ED3=HT(NZ,J)+EDJ(NZ,J)
      N11=NXX(NZ,J,1)
      N12=NXX(NZ,J,2)
      N13=N12+1
      THIK=R(N13)-R(N11)
  419 WRITE(N6,777)NZ,J,THIK,VOLJ(NZ,J),HT1(NZ,J),HT(NZ,J),ED1,EDJ(NZ,J)
     *,ED2,ED3
  777 FORMAT(I5,I6,F6.3,1PE9.3,1PE12.4,1X,1PE9.3,1P4E12.4)
  417 FORMAT(I6,2X,I6,2X,1P4E12.4)
      WRITE(N6,422)
C
C        SUMMERY BY ZONE FOR THE ENERGY DEPOSITED FOR Q-VALUE ONLY
C
      DO 420 NZ=1,NZT
      IF(IWAT.EQ.0)WRITE(N6,421)NZ,H(NZ)
      IF(IWAT.EQ.1)WRITE(N6,971)NZ,H(NZ)
  420 CONTINUE
  421 FORMAT(5X,'ENERGY DEPOSITED IN ZONE',I6,2X,                'FOR Q VALU
     *E =',1PE12.4,2X,'MEV')
  971 FORMAT(5X,'ENERGY DEPOSITED IN ZONE',I6,2X,
     *'FOR Q VALUE =',1PE12.4,2X,'WATS')
  422 FORMAT(1H1,//////,10X)
      IF(IWAT.EQ.0)WRITE(N6,423)TOT
      IF(IWAT.EQ.1)WRITE(N6,972)TOT
```

```
      423 FORMAT(///,2X,'TOTAL ENERGY DEPOSITED IN THE BLANKET   FOR Q VALUE
     * =',1PE12.4,2X,'MEV',///)
      972 FORMAT(///,2X,'TOTAL ENERGY DEPOSITED IN THE BLANKET FOR Q VALUE
     * =',1PE12.4,2X,'WAT',///)
          IF(JHEAT.EQ.0) GO TO 407
C
C         ENERGY DEPOSITED FOR EACH ZONE FROM THE SOURCE
C
          DO 463 NZ=1,NZT
          IF(IWAT.EQ.1) WRITE(N6,973)NZ,EDZ(NZ)
          IF(IWAT.EQ.0)WRITE(N6,464)NZ,EDZ(NZ)
      463 CONTINUE
      464 FORMAT(5X,'ENERGY DEPOSITED IN ZONE',I6,2X,            'FOR SOURCE
     * =',1PE12.4,2X,'MEV')
      973 FORMAT(5X,'ENERGY DEPOSITED IN ZONE',I6,2X,'FOR SOURCE =',1PE12.4,
     *2X,'WAT')
          IF(IWAT.EQ.0)WRITE(N6,465)TOTEN
          IF(IWAT.EQ.1)WRITE(N6,974)TOTEN
      465 FORMAT(///,2X,'TOTAL ENERGY DEPOSITED IN THE BLANKET   FOR SOURCE
     * =',1PE12.4,2X,'MEV',///)
      974 FORMAT(///,2X,'TOTAL ENERGY DEPOSITED IN THE BLANKET FOR SOURCE ='
     *,1PE12.4,2X,'WAT',///)
          IF(IWAT.EQ.0)WRITE(N6,778)
          IF(IWAT.EQ.1)WRITE(N6,975)
      778 FORMAT(1H1,/////,45X,'*** SUMMERY BY ZONE ***',///,3X,'ZONE',2X,
     *'VOLUME(CM3)',2X,'TOTAL ENR. DEPOS(MEV  )',2X,'ENERGY DENSITY(MEV/
     *CM3. )',////)
      975 FORMAT(1H1,/////,45X,'***SUMMERY BY ZONE ***',///,3X,'ZONE',2X,
     *'VOLUME(CM3)',2X,'TOTAL ENR. DEPOS(WAT  )',2X,'ENERGY DENSITY(WAT/
     *CM3. )',////)
          DO 779 NZ=1,NZT
          C11=H(NZ)+EDZ(NZ)
          C12=C11/VOLZ(NZ)
          WRITE(N6,800)NZ,VOLZ(NZ),C11,C12
      779 CONTINUE
      800 FORMAT(I6,1PE12.4,5X,1PE12.4,15X,1PE12.4)
C
C         ETOT = ENERGY DEPOSITED IN THE BLANKET FROM SOURCE + Q VALUE
C         PM = ENERGY MULTIPLICATION
C
          ETOT=TOT+TOTEN
          PM=ETOT/(14.1*FACT1)
          IF(IWAT.EQ.1)PM=PM/CFF/XMEV
          WRITE(N6,466)ETOT,PM
      466 FORMAT(///,20X,'TOTAL ENERGY DEPOSITED IN THE BLANKET
     *     =',1PE12.4,/,20X,'POWER MULTIPLICATION',31X,'=',1PE12.4)
      407 END
```

```
C
C
C        SUBROUTINE ENERGD EVALUATE ENERGY DEPOSITION FROM SOURCE IN EV
C        FOR EACH MESH INTERVAL
C
C
      SUBROUTINE ENERGD
      DIMENSION D(10),W(10),E(26),R(201),F(25),AF(201,10),ELG(201)
      DIMENSION V(200)
      DIMENSION EK(201),ED(200)
      COMMON NG,MESH,R,V,ED,IGM
      DATA N4,N3,N5,N6/4,3,5,6/
      N18=18
      READ(N5,101)N
  101 FORMAT(12I6)
      READ(N5,100)(D(I),I=1,N)
      READ(N5,100)(W(I),I=1,N)
  100 FORMAT(6E12.5)
      NGG=NG+1
      READ(N5,100)(E(I),I=1,NGG)
      DO 1 I=1,NG
    1 F(I)=(E(I)+E(I+1))/2.0
      ME=MESH+1
      PY=3.141592654
      DO 16 INT=1,ME
   16 EK(INT)=0.0
      DO 15 IG=1,NG
C
C        READING THE ANGULAR FLUX
C
      READ(N18)((AF(J,K),J=1,ME),K=1,N)
      DO 144 INT=1,ME
      ELG(INT)=0.0
C
C        EVALUATING ENERGY LEAKAGE FOR INTERVAL INT
C
      DO 14 KK=1,N
      CCVV=W(KK)*D(KK)*AF(INT,KK)*F(IG)
      IF(IGM.EQ.1)CCVV=CCVV*1.0
      IF(IGM.EQ.2)CCVV=CCVV*2.0*PY*R(INT)
      IF(IGM.EQ.3)CCVV=CCVV*4.0*PY*(R(INT)**2.0)
      ELG(INT)=ELG(INT)+CCVV
   14 CONTINUE
  144 EK(INT)=EK(INT)+ELG(INT)
   15 CONTINUE
C
C       EVALUATING ENARGY DEPOSITED
C
      DO 6 INT=1,MESH
      ED(INT)=EK(INT)-EK(INT+1)
    6 CONTINUE
      RETURN
      END
```

```
      =====  (ACTEN*PROG)  VAFIDR(1)  =====

      SUBROUTINE VAFIDR(D,JJ)
C
C
C       SUBROUTINE VAFIDR READS A REAL ARRAY OF DIMENSION JJ
C
C
      DIMENSION IN(6),K(6),V(6),D(1)
      DATA LR,LT,LPL,LMI/1HR,1HT,1H+,1H-/
      DATA LB/1HI/
      N5=5
      N6=6
      J=0
    1 CONTINUE
      KL=K(6)
      IN1=IN(6)
      VL=V(6)
      READ(N5,10)(IN(I),K(I),V(I),I=1,6)
   10 FORMAT(6(I2,A1,E9.0))
      DO 27 I=1,6
      IF(K(I).NE.LPL.AND.K(I).NE.LMI) GO TO 27
C*********EXPONENTIATION
      L=IN(I)
      IF(L.EQ.0) GO TO 27
      E=10.0**L
      IF(K(I).EQ.LMI) GO TO 28
      V(I)=V(I)*E
      GO TO 27
   28 V(I)=V(I)/E
   27 CONTINUE
      DO 2 I=1,6
C       *********INTERPOLATION*******
      IF((I.EQ.1).AND.(KL.EQ.LB)) GO TO 704
  706 CONTINUE
      IF((K(I).EQ.LB).AND.(I.LT.6))GO TO 700
      GO TO 999
  700 J=J+1
      D(J)=V(I)
      KK=IN(I)
      C=(V(I+1)-V(I))/(KK+1)
      DO 701 IV=1,KK
      J=J+1
      D(J)=D(J-1)+C
  701 CONTINUE
      GO TO 2
  704 CONTINUE
      D(J)=VL
      CC=(V(I)-VL)/(KL+1)
      DO 705 IV=1,IN1
      J=J+1
      D(J)=D(J-1)+CC
  705 CONTINUE
      GO TO 706
C        ***********************************
  999 CONTINUE
      IF(K(I).EQ.LR) GO TO 7
      IF(K(I).EQ.LT) GO TO 9
      GO TO 14
```

```
C *****TERMINATION
    9 WRITE(N6,100) JJ
  100 FORMAT(1H0,10H          ,I7,13H ENTRIES READ)
      IF(J.EQ.JJ)RETURN
      WRITE(N6,200)J
  200 FORMAT(1X,13H ERROR***NOW ,I7,14H  ENTRIES READ)
      STOP
    7 L=IN(I)
      DO 18 II=1,L
      J=J+1
      D(J)=V(I)
   18 CONTINUE
      GO TO 2
C ****REGULAR INPUT
   14 IF(V(I).NE.0.0) GO TO 17
      IF(SIGN(1.0,V(I)).LT.0.0) GO TO 2
   17 J=J+1
      D(J)=V(I)
    2 CONTINUE
      GO TO 1
      END
```

```
      SUBROUTINE VAFIDI(M,JJ)
C
C
C       SUBROUTINE VAFIDI READS A INTEGER ARRAY OF DIMENSION JJ
C
C
      DIMENSION IN(6),K(6),N(6),M(1)
      DATA LR,LT,LPL,LMI/1HR,1HT,1H+,1H-/
      DATA LB/1HI/
      N5=5
      N6=6
      J=0
    1 CONTINUE
      KL=K(6)
      IN1=IN(6)
      NL=N(6)
      READ(N5,10)(IN(I),K(I),N(I),I=1,6)
   10 FORMAT(6(I2,A1,I9))
      DO 27 I=1,6
      IF(K(I).NE.LPL.AND.K(I).NE.LMI) GO TO 27
C*********EXPONENTIATION
      L=IN(I)
      IF(L.EQ.0) GO TO 27
      E=10.0**L
      IF(K(I).EQ.LMI) GO TO 28
      N(I)=N(I)*E
      GO TO 27
   28 N(I)=N(I)/E
   27 CONTINUE
      DO 2 I=1,6
C        *********INTERPOLATION*******
      IF((I.EQ.1).AND.(KL.EQ.LB)) GO TO 704
  706 CONTINUE
      IF((K(I).EQ.LB).AND.(I.LT.6))GO TO 700
      GO TO 999
  700 J=J+1
      M(J)=N(J)
      KK=IN(I)
      C=(N(I+1)-N(I))/(KK+1)
      DO 701 IV=1,KK
      J=J+1
      M(J)=M(J-1)+C
  701 CONTINUE
      GO TO 2
  704 CONTINUE
      M(J)=NL
      CC=(N(I)-NL)/(KL+1)
      DO 705 IV=1,IN1
      J=J+1
      M(J)=M(J-1)+CC
  705 CONTINUE
      GO TO 706
C         **********************************
  999 CONTINUE
      IF(K(I).EQ.LR) GO TO 7
      IF(K(I).EQ.LT) GO TO 9
      GO TO 14
```

```
      C *****TERMINATION
          9 WRITE(N6,100) JJ
        100 FORMAT(1H0,10H          ,I7,13H ENTRIES READ)
            IF(J.EQ.JJ)RETURN
            WRITE(N6,200)J
        200 FORMAT(1X,13H ERROR***NOW ,I7,14H  ENTRIES READ)
            STOP
          7 L=IN(I)
            DO 18 II=1,L
            J=J+1
            M(J)=N(I)
         18 CONTINUE
            GO TO 2
      C ****REGULAR INPUT
         14 IF(N(I).NE.0) GO TO 17
            IF(SIGN(1,N(I)).LT.0) GO TO 2
         17 J=J+1
            M(J)=N(I)
          2 CONTINUE
            GO TO 1
            END
```

10.2. Appendix B

Input example.

===== (ACTEN*PROG) DATA(9) =====

```
      64    28     25   142
      10   133      0     1     1     0     0     0     0     3
    1.00000E+15
           0.0 4I      0.5      500.50      600.0010I   600.20      611.20
       612.20      613.20       613.3020I   613.50      634.50      634.90
    9I   635.10    645.10 1I    645.3569I   647.3512I   717.35      730.35
    T
       3
       8     8
      59    58     60
    2.15525E-05 3.87944E-05 5.17259E-05
       5
       9    19
      59    58     60    61    57
    1.93972E-06 3.49150E-06 4.65534E-06 2.28189E-02 4.31965E-03
       6
      20    22
      59    58     60    53    54    57
    1.50867E-06 2.71561E-06 3.62081E-06 2.32210E-03 2.89730E-02 5.84428E-03
       3
      23    23
      59    58     60
    9.36000E-03 1.45000E-02 6.14000E-02
       6
      24    45
      59    58     60    55    63    57
    1.99287E-06 3.58717E-06 4.76269E-06 1.38706E-02 6.93530E-03 1.50315E-02
       3
      46    46
      59    58     60
    9.36000E-03 1.45000E-02 6.14000E-02
       6
      47    57
      59    58     60    53    54    57
    1.93972E-06 3.49150E-06 4.65533E-06 2.45479E-03 3.06286E-02 4.31969E-03
       3
      58    59
      59    58     60
    2.15525E-05 3.87944E-05 5.17259E-05
       5
      60   129
      59    58     60    61    56
    4.69000E-04 7.25000E-04 3.07000E-03 9.37488E-03 4.57311E-02
       5
     130   142
      59    58     60    53    54
    8.44200E-04 1.30500E-03 5.52600E-03 2.45479E-03 3.06286E-02
    6R        53 6R        54 4R        5623R        5717R        5818R        59
   25R        6027R        61 7R        63
    T
       3     2      4     5     6     7     2     3     4     5     6     7
       2     3      4     5     2     3     4     5     6     7     8     9
      10    11     12    13    14    15    16    17    18    19    20    21
      22    23     24     2     3     4     5     6     7     8     9    10
      11    12     13    14    15    16    17    18     2     3     4     5
       6     7      8     9    10    11    12    13    14    15    16    17
      18    19      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     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     1     2     3     4     5     7
      10
  -3.56200E+00-3.69600E+00-1.47100E+00 7.25200E+00-2.73300E+00 4.78600E+00
  -7.25200E+00-8.72300E+00-4.78000E-01-2.46600E+00 2.03200E+00-7.76000E+00
  -4.43300E+00-7.27400E+00 4.94700E+00-5.69500E+00-1.24100E+01-4.39000E-01
  -2.07800E+00-2.39300E+00-2.64000E+00-2.70500E+00-2.98300E+00-3.68000E+00
  -3.88000E+00-4.43000E+00-4.77000E+00-5.38000E+00-5.53000E+00-5.76000E+00
  -5.95500E+00-6.07900E+00-6.27000E+00-7.11000E+00-7.79000E+00 0.00000E+00
   6.96200E+00-3.59700E+00-3.86600E+00-1.20300E+01 0.00000E+00-5.64000E-01
  -1.00800E+00-1.29000E+00-1.43400E+00-1.98000E+00-2.33000E+00-2.37000E+00
  -2.64800E+00-2.76900E+00-2.96500E+00-3.16100E+00 0.00000E+00 8.12700E+00
  -3.08800E+00-8.65700E-01-1.21900E+01-8.17760E+00-1.33200E+00-1.45200E+00
  -2.15800E+00-2.28700E+00-2.45800E+00-2.50200E+00-2.63000E+00-2.77200E+00
  -3.03500E+00-3.13000E+00-3.26000E+00-3.52000E+00 0.00000E+00 8.60200E+00
  -5.03400E-01 2.31700E+00-1.12000E+01-8.46000E-01-1.40800E+00-2.08400E+00
  -2.65400E+00-2.93900E+00-2.95700E+00-3.11900E+00-3.12200E+00-3.36800E+00
  -3.38800E+00-3.44500E+00-3.45000E+00-3.60000E+00-3.60500E+00-3.74700E+00
  -3.82900E+00-3.85600E+00-4.04600E+00-4.09900E+00-4.11600E+00-4.18700E+00
   7.80300E+00-2.73100E+00 3.92600E-01-6.73300E+00-5.70000E-01-8.03000E-01
  -8.98000E-01-1.17500E+00-1.34100E+00-1.46200E+00-1.63300E+00-1.68200E+00
  -1.76200E+00-1.99800E+00-2.16000E+00-2.34000E+00-2.38500E+00-2.61500E+00
  -2.62400E+00-2.63400E+00-2.78300E+00-3.01700E+00-3.05700E+00-3.19800E+00
  -3.25000E+00-3.38200E+00-3.45300E+00-3.47500E+00-3.56000E+00-3.70800E+00
  -6.43040E+00-1.14540E+01 2.00000E+02 4.07920E+00-2.17745E+00 4.78340E+00
  -5.21050E+00
       1     6     3     1     7     1     4     2    14     6
       8     8
       9    10    11    12    13    14    15    16    17    18    19    19
      20    20    21    21    22    22
      23    23
      24    26    27    29    30    32    33    35    36    38    39    41
      42    45
      46    46
      47    49    50    52    53    55    56    57
      58    58    59    59
      60    64    65    69    70    74    75    79    80    84    85    89
      90    94    95    99   100   104   105   109   110   114   115   119
     120   124   125   129
     130   131   132   133   134   135   136   137   138   139   140   142
       5
  -9.36742E-01-8.68890E-01-3.50021E-01 3.50021E-01 8.68890E-01
   0.00000E+00 1.66667E-01 3.33333E-01 3.33333E-01 1.66667E-01
     1.4918E+07  1.3499E+07  1.2214E+07  1.1052E+07  1.0000E+07  9.0494E+06
     8.1873E+06  7.4082E+06  6.7032E+06  6.0653E+06  5.4881E+06  4.4933E+06
     3.6788E+06  3.0119E+06  2.4660E+06  1.3534E+06  7.4274E+05  4.0762E+05
     1.6573E+05  3.1828E+04  3.3546E+03  3.5358E+02  3.7267E+01  3.9279E+00
     4.1399E-01  2.2200E-02
```

10.3. Appendix C

Output example.

```
****** DESCRIPTION ******

ZONE NUMBER        =      1
EXTENDED FROM INT.         8   TO       8
INCLUDES ELEMENTS        59     58     60
THEIR DENSITIES ARE   2.1552-05   3.8794-05   5.1726-05
ZONE NUMBER        =      2
EXTENDED FROM INT.         9   TO      19
INCLUDES ELEMENTS        59     58     60     61     57
THEIR DENSITIES ARE   1.9397-06   3.4915-06   4.6553-06   2.2819-02   4.3196-03
ZONE NUMBER        =      3
EXTENDED FROM INT.        20   TO      22
INCLUDES ELEMENTS        59     58     60     53     54     57
THEIR DENSITIES ARE   1.5087-06   2.7156-06   3.6208-06   2.3221-03   2.8973-02   5.8443-03
ZONE NUMBER        =      4
EXTENDED FROM INT.        23   TO      23
INCLUDES ELEMENTS        59     58     60
THEIR DENSITIES ARE   9.3800-03   1.4500-02   6.1400-02
ZONE NUMBER        =      5
EXTENDED FROM INT.        24   TO      45
INCLUDES ELEMENTS        59     58     60     55     63     57
THEIR DENSITIES ARE   1.9929-06   3.5872-06   4.7829-06   1.3871-02   6.9353-03   1.5031-02
ZONE NUMBER        =      6
EXTENDED FROM INT.        46   TO      46
INCLUDES ELEMENTS        59     58     60
THEIR DENSITIES ARE   9.3800-03   1.4500-02   6.1400-02
ZONE NUMBER        =      7
EXTENDED FROM INT.        47   TO      57
INCLUDES ELEMENTS        59     58     60     53     54     57
THEIR DENSITIES ARE   1.9397-06   3.4915-06   4.6553-06   2.4548-03   3.0629-02   4.3197-03
ZONE NUMBER        =      8
EXTENDED FROM INT.        58   TO      59
INCLUDES ELEMENTS        59     58     60
THEIR DENSITIES ARE   2.1552-05   3.8794-05   5.1726-05
ZONE NUMBER        =      9
EXTENDED FROM INT.        60   TO     129
INCLUDES ELEMENTS        59     58     60     61     56
THEIR DENSITIES ARE   4.6900-04   7.2500-04   3.0700-03   9.3749-03   4.5731-02
ZONE NUMBER        =     10
EXTENDED FROM INT.       130   TO     142
INCLUDES ELEMENTS        59     58     60     53     54
THEIR DENSITIES ARE   8.4420-04   1.3050-03   5.5260-03   2.4548-03   3.0629-02

          133 ENTRIES READ
```

ELEM.	POSITION	Q VALUE	DECAY ENRGY
53	3	-3.5620+00	0.0000
53	2	-3.6960+00	0.0000
53	4	-1.4710+00	0.0000
53	5	7.2520+00	0.0000
53	6	-2.7330+00	0.0000
53	7	4.7860+00	0.0000
54	2	-7.2520+00	0.0000
54	3	-8.7230+00	0.0000
54	4	-4.7600-01	0.0000
54	5	-2.4660+00	0.0000
54	6	2.0320+00	0.0000
54	7	-7.7600+00	0.0000
56	2	-4.4330+00	0.0000
56	3	-7.2740+00	0.0000
56	4	4.9470+00	0.0000
56	5	-5.6950+00	0.0000
57	2	-1.2410+01	0.0000
57	3	-4.3900-01	0.0000
57	4	-2.0780+00	0.0000
57	5	-2.3930+00	0.0000
57	6	-2.6400+00	0.0000
57	7	-2.7050+00	0.0000
57	8	-2.9830+00	0.0000
57	9	-3.6800+00	0.0000
57	10	-3.8800+00	0.0000
57	11	-4.4300+00	0.0000
57	12	-4.7700+00	0.0000
57	13	-5.3800+00	0.0000
57	14	-5.5300+00	0.0000
57	15	-5.7600+00	0.0000
57	16	-5.9550+00	0.0000
57	17	-6.0790+00	0.0000
57	18	-6.2700+00	0.0000
57	19	-7.1100+00	0.0000
57	20	-7.7900+00	0.0000
57	21	0.0000	0.0000
57	22	6.9620+00	0.0000
57	23	-3.5970+00	0.0000
57	24	-3.8660+00	0.0000
58	2	-1.2030+01	0.0000
58	3	0.0000	0.0000
58	4	-5.6400-01	0.0000
58	5	-1.0080+00	0.0000
58	6	-1.2900+00	0.0000
58	7	-1.4340+00	0.0000
58	8	-1.9800+00	0.0000
58	9	-2.3300+00	0.0000
58	10	-2.3700+00	0.0000
58	11	-2.6480+00	0.0000
58	12	-2.7690+00	0.0000
58	13	-2.9650+00	0.0000
58	14	-3.1610+00	0.0000
58	15	0.0000	0.0000
58	16	8.1270+00	0.0000
58	17	-3.0880+00	0.0000
58	18	-8.6570-01	0.0000
59	2	-1.2190+01	0.0000
59	3	-8.1776+00	0.0000
59	4	-1.3320+00	0.0000
59	5	-1.4520+00	0.0000
59	6	-2.1580+00	0.0000
59	7	-2.2870+00	0.0000
59	8	-2.4580+00	0.0000
59	9	-2.5020+00	0.0000
59	10	-2.6300+00	0.0000
59	11	-2.7720+00	0.0000
59	12	-3.0350+00	0.0000
59	13	-3.1300+00	0.0000
59	14	-3.2600+00	0.0000
59	15	-3.5200+00	0.0000
59	16	0.0000	0.0000
59	17	8.6020+00	0.0000
59	18	-5.0340-01	0.0000
59	19	2.3170+00	0.0000
60	2	-1.1200+01	0.0000
60	3	-8.4600-01	0.0000
60	4	-1.4080+00	0.0000
60	5	-2.0840+00	0.0000
60	6	-2.6540+00	0.0000
60	7	-2.9390+00	0.0000
60	8	-2.9570+00	0.0000
60	9	-3.1190+00	0.0000
60	10	-3.1220+00	0.0000
60	11	-3.3630+00	0.0000
60	12	-3.3880+00	0.0000
60	13	-3.4450+00	0.0000
60	14	-3.4500+00	0.0000
60	15	-3.6000+00	0.0000
60	16	-3.6050+00	0.0000
60	17	-3.7470+00	0.0000
60	18	-3.8290+00	0.0000
60	19	-3.8560+00	0.0000
60	20	-4.0460+00	0.0000
60	21	-4.0990+00	0.0000
60	22	-4.1160+00	0.0000
60	23	-4.1870+00	0.0000
60	24	7.8030+00	0.0000
60	25	-2.7310+00	0.0000
60	26	3.9260-01	0.0000
61	2	-6.7330+00	0.0000
61	3	-5.7000-01	0.0000
61	4	-8.0300-01	0.0000
61	5	-8.9800-01	0.0000
61	6	-1.1750+00	0.0000
61	7	-1.3410+00	0.0000
61	8	-1.4620+00	0.0000
61	9	-1.6330+00	0.0000

61	10	-1.6820+00	0.0000
61	11	-1.7620+00	0.0000
61	12	-1.9980+00	0.0000
61	13	-2.1600+00	0.0000
61	14	-2.3400+00	0.0000
61	15	-2.3850+00	0.0000
61	16	-2.6150+00	0.0000
61	17	-2.6240+00	0.0000
61	18	-2.6340+00	0.0000
61	19	-2.7830+00	0.0000
61	20	-3.0170+00	0.0000
61	21	-3.0570+00	0.0000
61	22	-3.1980+00	0.0000
61	23	-3.2500+00	0.0000
61	24	-3.3820+00	0.0000
61	25	-3.4530+00	0.0000
61	26	-3.4750+00	0.0000
61	27	-3.5600+00	0.0000
61	28	-3.7080+00	0.0000
63	1	-6.4304+00	0.0000
63	2	-1.1454+01	0.0000
63	3	2.0000+02	0.0000
63	4	4.0792+00	0.0000
63	5	-2.1774+00	0.0000
63	7	4.7834+00	0.0000
63	10	-5.2105+00	0.0000

ZONE	SUBZONE	SEQ.	INT1	INT2
1	1	1	8	8
2	1	2	9	10
2	2	3	11	12
2	3	4	13	14
2	4	5	15	16
2	5	6	17	18
2	6	7	19	19
3	1	8	20	20
3	2	9	21	21
3	3	10	22	22
4	1	11	23	23
5	1	12	24	26
5	2	13	27	29
5	3	14	30	32
5	4	15	33	35
5	5	16	36	38
5	6	17	39	41
5	7	18	42	45
6	1	19	46	46
7	1	20	47	49
7	2	21	50	52
7	3	22	53	55
7	4	23	56	57
8	1	24	58	58
8	2	25	59	59
9	1	26	60	64
9	2	27	65	69
9	3	28	70	74
9	4	29	75	79
9	5	30	80	84
9	6	31	85	89
9	7	32	90	94
9	8	33	95	99
9	9	34	100	104
9	10	35	105	109
9	11	36	110	114
9	12	37	115	119
9	13	38	120	124
9	14	39	125	129
10	1	40	130	131
10	2	41	132	133
10	3	42	134	135
10	4	43	136	137
10	5	44	138	139
10	6	45	140	142

ENERGY DEPOSITED BY SUBZONE FOR Q VALUE&SOURCE

ZONE	SUB	THK	VOL.SUB	Q(MEV/3.)	Q(MEV)	SRC(MEV/CM3)	SRC(MEV)	TOT(MEV/CM3)	TOT(MEV)
1	1	.200	9.051+05	-1.6008-10	-1.449-04	2.4179-07	2.1884-01	2.4163-07	2.1869-01
2	1	2.000	9.084+06	-9.6920-08	-8.804-01	2.0689-07	1.8794+00	1.0997-07	9.9895-01
2	2	2.000	9.145+06	-8.5133-08	-7.785-01	1.8135-07	1.6583+00	9.6212-08	8.7982-01
2	3	2.000	9.205+06	-7.3589-08	-6.774-01	1.5651-07	1.4408+00	8.2925-08	7.6335-01
2	4	2.000	9.266+06	-6.2892-08	-5.828-01	1.3364-07	1.2383+00	7.0746-08	6.5555-01
2	5	2.000	9.327+06	-5.3293-08	-4.971-01	1.1321-07	1.0560+00	5.9919-08	5.5888-01
2	6	1.000	4.687+06	-4.6812-08	-2.194-01	9.9467-08	4.6626-01	5.2675-08	2.4687-01
3	1	1.000	4.702+06	4.7204-08	2.220-01	5.1146-08	2.4049-01	9.8350-08	4.6245-01
3	2	1.000	4.717+06	4.5817-08	2.161-01	4.9209-08	2.3214-01	9.5026-08	4.4828-01
3	3	.100	4.726+05	4.5281-08	2.140-02	4.8178-08	2.2768-02	9.3459-08	4.4168-02
4	1	.200	9.457+05	-5.1247-08	-4.846-02	1.6547-07	1.5648-01	1.1423-07	1.0802-01
5	1	3.000	1.426+07	1.2743-07	1.817+00	6.9366-08	9.8907-01	1.9679-07	2.8060+00
5	2	3.000	1.440+07	1.0444-07	1.504+00	5.6525-08	8.1386-01	1.6096-07	2.3175+00
5	3	3.000	1.454+07	8.8110-08	1.281+00	4.6133-08	6.7070-01	1.3424-07	1.9517+00
5	4	3.000	1.468+07	7.5427-08	1.107+00	3.7683-08	5.5316-01	1.1311-07	1.6604+00
5	5	3.000	1.482+07	6.5359-08	9.687-01	3.0799-08	4.5646-01	9.6158-08	1.4251+00
5	6	3.000	1.496+07	5.7614-08	8.621-01	2.5191-08	3.7693-01	8.2805-08	1.2390+00
5	7	3.400	1.713+07	5.2576-08	9.006-01	2.0365-08	3.4887-01	7.2941-08	1.2495+00
6	1	.200	1.013+06	-4.9698-09	-5.037-03	3.7913-08	3.8422-02	3.2943-08	3.3386-02
7	1	3.000	1.528+07	2.2030-08	3.366-01	1.0889-08	1.6636-01	3.2919-08	5.0294-01
7	2	3.000	1.542+07	2.2819-08	3.519-01	9.6106-09	1.4822-01	3.2429-08	5.0013-01
7	3	3.000	1.557+07	2.7384-08	4.263-01	8.5306-09	1.3280-01	3.5915-08	5.5910-01
7	4	1.250	6.529+06	5.4232-08	3.541-01	7.8670-09	5.1366-02	6.2099-08	4.0547-01
8	1	1.000	5.242+06	3.3052-11	1.732-04	1.3888-08	7.2795-02	1.3921-08	7.2968-02
8	2	1.000	5.258+06	4.1300-11	2.172-04	1.2657-08	6.6548-02	1.2698-08	6.6765-02
9	1	5.000	2.653+07	-8.2189-10	-2.181-02	8.1442-09	2.1610-01	7.3224-09	1.9429-01
9	2	5.000	2.694+07	1.7291-09	4.659-02	5.6613-09	1.5254-01	7.3904-09	1.9913-01
9	3	5.000	2.736+07	3.4275-09	9.377-02	3.9248-09	1.0737-01	7.3524-09	2.0114-01
9	4	5.000	2.777+07	4.4095-09	1.225-01	2.7163-09	7.5442-02	7.1258-09	1.9791-01
9	5	5.000	2.819+07	4.8206-09	1.359-01	1.8782-09	5.2953-02	6.6989-09	1.8886-01
9	6	5.000	2.862+07	4.8081-09	1.376-01	1.2981-09	3.7146-02	6.1062-09	1.7473-01
9	7	5.000	2.904+07	4.5051-09	1.308-01	8.9691-10	2.6047-02	5.4020-09	1.5688-01
9	8	5.000	2.947+07	4.0221-09	1.185-01	6.1958-10	1.8259-02	4.6417-09	1.3679-01
9	9	5.000	2.990+07	3.4435-09	1.030-01	4.2791-10	1.2795-02	3.8715-09	1.1576-01
9	10	5.000	3.034+07	2.8286-09	8.581-02	2.9544-10	8.9626-03	3.1241-09	9.4772-02
9	11	5.000	3.077+07	2.2143-09	6.814-02	2.0386-10	6.2736-03	2.4181-09	7.4417-02
9	12	5.000	3.122+07	1.6193-09	5.055-02	1.4048-10	4.3854-03	1.7598-09	5.4932-02
9	13	5.000	3.166+07	1.0482-09	3.319-02	9.6537-11	3.0564-03	1.1447-09	3.6243-02
9	14	5.000	3.211+07	4.8638-10	1.562-02	6.5837-11	2.1139-03	5.5222-10	1.7731-02
10	1	2.000	1.297+07	7.6581-09	9.932-02	3.0885-11	4.0056-04	7.6890-09	9.9720-02
10	2	2.000	1.304+07	1.6134-09	2.104-02	2.8554-11	3.7239-04	1.6420-09	2.1414-02
10	3	2.000	1.311+07	8.5066-10	1.116-02	2.6451-11	3.4688-04	8.7711-10	1.1502-02
10	4	2.000	1.319+07	5.7435-10	7.574-03	2.4546-11	3.2369-04	5.9890-10	7.8975-03
10	5	2.000	1.326+07	4.1815-10	5.545-03	2.2814-11	3.0251-04	4.4097-10	5.8471-03
10	6	3.000	2.003+07	2.9889-10	5.986-03	2.0861-11	4.1777-04	3.1975-10	6.4035-03

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ENERGY DEPOSITED IN ZONE     1  FOR Q VALUE =  -1.4489-04  MEV
ENERGY DEPOSITED IN ZONE     2  FOR Q VALUE =  -3.6356+00  MEV
ENERGY DEPOSITED IN ZONE     3  FOR Q VALUE =   4.5949-01  MEV
ENERGY DEPOSITED IN ZONE     4  FOR Q VALUE =  -4.8462-02  MEV
ENERGY DEPOSITED IN ZONE     5  FOR Q VALUE =   8.4402+00  MEV
ENERGY DEPOSITED IN ZONE     6  FOR Q VALUE =  -5.0366-03  MEV
ENERGY DEPOSITED IN ZONE     7  FOR Q VALUE =   1.4689+00  MEV
ENERGY DEPOSITED IN ZONE     8  FOR Q VALUE =   3.9040-04  MEV
ENERGY DEPOSITED IN ZONE     9  FOR Q VALUE =   1.1201+00  MEV
ENERGY DEPOSITED IN ZONE    10  FOR Q VALUE =   1.5062-01  MEV

TOTAL ENERGY DEPOSITED IN THE BLANKET   FOR Q VALUE =   7.9505+00  MEV

ENERGY DEPOSITED IN ZONE     1  FOR SOURCE =   2.1884-01  MEV
ENERGY DEPOSITED IN ZONE     2  FOR SOURCE =   7.7390+00  MEV
ENERGY DEPOSITED IN ZONE     3  FOR SOURCE =   4.9540-01  MEV
ENERGY DEPOSITED IN ZONE     4  FOR SOURCE =   1.5648-01  MEV
ENERGY DEPOSITED IN ZONE     5  FOR SOURCE =   4.2091+00  MEV
ENERGY DEPOSITED IN ZONE     6  FOR SOURCE =   3.8422-02  MEV
ENERGY DEPOSITED IN ZONE     7  FOR SOURCE =   4.9875-01  MEV
ENERGY DEPOSITED IN ZONE     8  FOR SOURCE =   1.3934-01  MEV
ENERGY DEPOSITED IN ZONE     9  FOR SOURCE =   7.2345-01  MEV
ENERGY DEPOSITED IN ZONE    10  FOR SOURCE =   2.1638-03  MEV

TOTAL ENERGY DEPOSITED IN THE BLANKET   FOR SOURCE =   1.4221+01  MEV
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*** SUMMERY BY ZONE ***

ZONE	VOLUME(CM3)	TOTAL ENR. DEPOS(MEV)	ENERGY DENSITY(MEV/CM3.)
1	9.0506+05	2.1869-01	2.4163-07
2	5.0714+07	4.1034+00	8.0912-08
3	9.8921+06	9.5490-01	9.6531-08
4	9.4567+05	1.0802-01	1.1423-07
5	1.0479+08	1.2649+01	1.2071-07
6	1.0134+06	3.3386-02	3.2943-08
7	5.2797+07	1.9676+00	3.7268-08
8	1.0500+07	1.3973-01	1.3308-08
9	4.0992+08	1.8436+00	4.4974-09
10	8.5598+07	1.5278-01	1.7849-09

TOTAL ENERGY DEPOSITED IN THE BLANKET = 2.2171+01
POWER MULTIPLICATION = 1.5724+00

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