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NAC: NEUTRON ACTIVATION CODE

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ABSTRACT

NAC is a computer code designed to predict the neutron-induced gamma ray radioactivity for a wide variety of composite materials. This code is a subset of the NAP code, and the code output has been altered to provide convenient analysis by experimenters. The NAC output includes the input data, a list of all reactions for each constituent element, and the end-of-irradiation disintegration rates for each reaction. The code also compiles a product isotope inventory containing the isotope name, the disintegration rate, the gamma-ray source strength, and the absorbed dose rate at 1 meter from an unshielded point source. The induced activity is calculated as a function of irradiation and decay times; the effect of cyclic irradiation can also be calculated.

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E-4447

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SUMMARY

NAC is a computer program designed to predict the neutron-induced gamma ray radioactivity for a wide variety of composite materials. The unshielded induced radioactivity is calculated as a function of neutron exposure and decay times. The effects of cyclic exposure to a neutron flux and target atom burn-up can also be calculated.

NAC, a subset of NAP, provides fewer computational options than NAP and the output has been altered to provide for more convenient analysis by experimenters. The NAC output includes the input data, a list of all reactions for each constituent element, and the end of irradiation disintegration rates for each reaction. The code also compiles a product isotope inventory containing the isotope name, the disintegration rate, the gamma ray source strength, and the absorbed dose rate at one meter from an unshielded point source. A breakdown of the above data as a function of gamma energy for each product isotope is available as an option.

INTRODUCTION

NAC is a computer code written to provide a means of rapid analysis of the neutron-induced gamma ray radioactivity for a wide variety of composite materials. The code is a simplified version of the NAP program (see ref. 1). NAP was written to calculate the induced activity and unshielded gamma dose as a function of time, space, and gamma energy. NAP was designed to use the neutron spectrum output from a transport code and to provide input data for a gamma shielding code. NAP is highly versatile and well suited to this type of activation calculation. However, the detailed calculations available with NAP are not warranted in experimental situations in which knowledge of the neutron spectrum is limited and the activation information required is minimal. Such a situation would occur when the knowledge of the post-irradiation activation hazards of an experimental capsule, to be irradiated in a test reactor, is desired.

NAC was written to provide this type of activation calculation, and the code output has been designed to provide for convenient analysis by experimenters. The output consists of two sections. The first contains the input data (material composition, neutron fluxes, irradiation time, a list of the reactions considered for each element, the end of irradiation disintegration rates (dis/sec) for each reaction, and the fraction of the activity produced by each neutron energy group. The second section is a product isotope inventory containing the product name, disintegration rate (mCi), gamma source strength (MeV/sec), and the absorbed dose rate (m rads (C)/hr) at one meter from an unshielded point source. A breakdown of the above data as a function of gamma energy for each product isotope is available as an option. This output section also includes the decay time considered and totals of the inventory data. Simple scanning of the output will pin-point the product (s) which presents the greatest hazard and the reaction (s) which produces this product (see Appendix C).

The induced activity is calculated as a function of the duration of neutron exposure and the decay times. The effects of cyclic neutron exposure and of target atom burn-up can also be evaluated. The activity is calculated per-unit volume, per-unit mass, or for the total mass of the composite material, depending on the input specification.

ACTIVATION EQUATIONS

The build-up and decay of neutron-induced radioactivity are calculated from the equations given below which have been derived from the basic activation equations (see ref. 2). In each of the equations listed below, the term $\sigma\varphi$ represents a summation over the entire neutron energy range and is independent of time.

For an irradiation time t_1, with zero decay time, where target atom burn-up is ignored, the induced activities are:

for the parent

$$S_1(t_1) = N\sigma\varphi\left(1 - e^{-\lambda_1 t_1}\right)$$

for the daughter

$$S_2(t_1) = \frac{N\sigma\varphi}{(\lambda_2 - \lambda_1)}\left[\lambda_2\left(1 - e^{-\lambda_1 t_1}\right) - \lambda_1\left(1 - e^{-\lambda_2 t_1}\right)\right] \qquad (1)$$

for the granddaughter

$$S_3(t_1) = \frac{N\sigma\varphi}{(\lambda_2 - \lambda_1)}\left[(\lambda_2 - \lambda_1)\left(1 - e^{-\lambda_3 t_1}\right) - \frac{\lambda_2\lambda_3}{(\lambda_3 - \lambda_1)}\left(e^{-\lambda_1 t_1} - e^{-\lambda_3 t_1}\right) + \frac{\lambda_1\lambda_3}{(\lambda_3 - \lambda_2)}\left(e^{-\lambda_2 t_1} - e^{-\lambda_3 t_1}\right)\right]$$

where S_1, S_2, S_3 are the disintegration rates (dis/sec), N is the initial number of target atoms (number), σ is the activation cross section (cm^2/neutron), φ is the neutron flux (neutrons/cm^2-sec), $\lambda_1, \lambda_2, \lambda_3$ are the decay constants for the parent, daughter, and granddaughter, respectively (sec^{-1}).

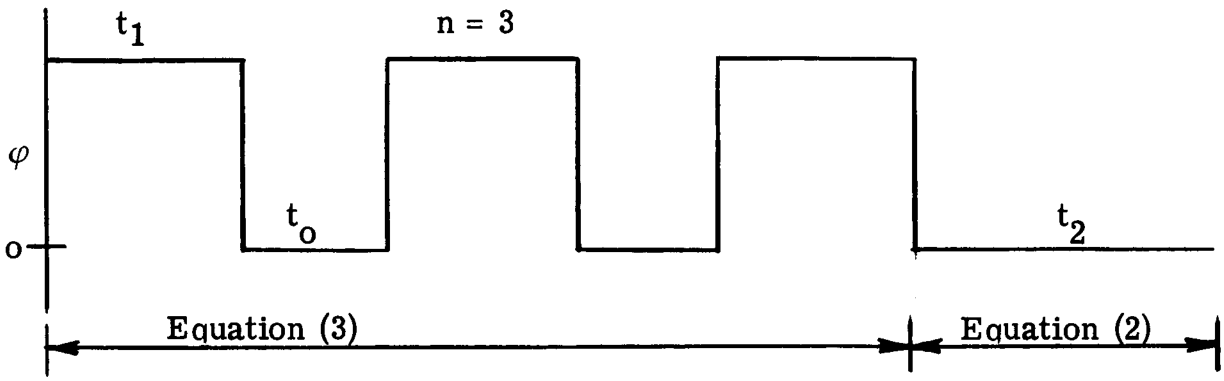
For a neutron irradiation time t_1 followed by a decay time t_2, the induced activities are

$$
\left.
\begin{aligned}
S_1(t_1, t_2) &= S_1(t_1)e^{-\lambda_1 t_2} \\
S_2(t_1, t_2) &= S_2(t_1)e^{-\lambda_2 t_2} + \frac{\lambda_2 S_1(t_1)}{(\lambda_2 - \lambda_1)}\left(e^{-\lambda_1 t_2} - e^{-\lambda_2 t_2}\right) \\
S_3(t_1, t_2) &= S_3(t_1)e^{-\lambda_3 t_2} + \frac{\lambda_3 S_2(t_1)}{\lambda_3 - \lambda_2}\left(e^{-\lambda_2 t_2} - e^{-\lambda_3 t_2}\right) \\
&\quad + \frac{\lambda_2 \lambda_3 S_1(t_1)}{(\lambda_2 - \lambda_1)}\left(\frac{e^{-\lambda_1 t_2} - e^{-\lambda_3 t_2}}{\lambda_3 - \lambda_1} - \frac{e^{-\lambda_2 t_2} - e^{-\lambda_3 t_2}}{\lambda_3 - \lambda_2}\right)
\end{aligned}
\right\} \quad (2)
$$

For a cyclic neutron exposure, with zero decay time following the end of the last exposure, the induced activities, adjusted for target atom burnup, are:

$$
\left.
\begin{aligned}
S_1 &= \frac{N\sigma\varphi\lambda_1}{\lambda_1 - \sigma\varphi}\left(e^{-\sigma\varphi t_1} - e^{-\lambda_1 t_1}\right)\left[\frac{e^{-n\sigma\varphi t_1} - e^{-n\lambda_1(t_1 + t_o)}}{e^{-\sigma\varphi t_1} - e^{-\lambda_1(t_1 + t_o)}}\right] \\
S_2 &= \frac{N\sigma\varphi\lambda_1\lambda_2}{\lambda_1 - \sigma\varphi}\left(\frac{e^{-\sigma\varphi t_1} - e^{-\lambda_2 t_1}}{\lambda_2 - \lambda_1}\right)\left[\frac{e^{-n\sigma\varphi t_1} - e^{-n\lambda_1(t_1 + t_o)}}{e^{-\sigma\varphi t_1} - e^{-\lambda_1(t_1 + t_o)}}\right] \\
S_3 &= \frac{N\sigma\varphi\lambda_1\lambda_2\lambda_3}{\lambda_1 - \sigma\varphi}\left[\left(\frac{1}{\lambda_2 - \sigma\varphi}\right)\left(\frac{e^{-\sigma\varphi t_1} - e^{-\lambda_3 t_1}}{\lambda_3 - \sigma\varphi} - \frac{e^{-\lambda_2 t_1} - e^{-\lambda_3 t_1}}{\lambda_3 - \lambda_2}\right) - \left(\frac{1}{\lambda_2 - \lambda_1}\right)\right. \\
&\quad \left. \times\left(\frac{e^{-\lambda_1 t_1} - e^{-\lambda_3 t_1}}{\lambda_3 - \lambda_1} - \frac{e^{-\lambda_2 t_1} - e^{\lambda_3 t_1}}{\lambda_3 - \lambda_2}\right)\right]\left[\frac{e^{-n\sigma\varphi t_1} - e^{-n\lambda_1(t_1 + t_o)}}{e^{-\sigma\varphi t_1} - e^{-\lambda_1(t_1 + t_o)}}\right]
\end{aligned}
\right\} \quad (3)
$$

where n is the number of cycles, t_1 is the irradiation time per cycle, and t_o is the non-irradiation time per cycle. Note that equations (3) calculate the end-of-exposure activity for n cycles (n irradiation and (n-1) non-irradiation periods) with burn-up. The results of these equations are then used in equations (2) to calculate the activity after decay periods following cyclic exposure. See sketch (a).



Sketch (a)

The above equations yield the disintegration rates in disintegrations per second which are then converted to the desired output quantities. The gamma ray source strength (MeV/sec) is obtained by multiplying the disintegration rate by the appropriate gamma ray energies and the fraction of gamma rays emitted at each energy per disintegration. The absorbed dose rate $\dot{D}$ in m rads (C)/hr at one meter from an unshielded point source is calculated from

$$\dot{D} = \frac{K}{4\pi R^2} \, S(\mathrm{MeV/sec}) = 1.285 \times 10^{-8} \, S \tag{4}$$

where K is an energy flux to dose conversion factor, R is the distance from the source (1 m), and S is the source strength. K consists of a unit conversion factor and the mass energy absorption coefficient for carbon, which was arbitrarily selected as the 1 MeV value (0.0280 cm^2/g). See reference 2. Appendix A is a complete FORTRAN listing of the NAC code.

PROGRAM DESCRIPTION

The NAC data library (see appendix B) contains the activation constants for 71 naturally occurring elements with a total of 251 reactions producing 226 radioactive isotopes. For each material to be analyzed, up to 20 different elements may be specified. Provision has been made for the analysis of as many different materials, per computer run, as desired. For each analysis, up to 20 decay time intervals may be specified. The NAC data library contains the data listed below for 71 naturally occurring elements.

(1) target element names
(2) isotopic reaction
(3) activation cross sections (cm^2/g)
(4) decay constants (min^{-1})
(5) atomic densities (atoms/g)
(6) product isotope name
(7) decay gamma energies (MeV)
(8) fraction of gammas at a given energy

The elements required for a material analysis are identified, during input, by their atomic number (Z) and are listed in the data library in order of increasing Z. If an element not present in the data library is specified during input, the code will write a message identifying the element in question and then will eliminate it from the calculation. Data input for each material must also include the material density or mass, the weight fractions of the constituent elements, the irradiation and decay time, and the neutron flux in the four energy groups listed below:

Group 1	$0.82\ \text{MeV} < E$
Group 2	$5.5\ \text{KeV} < E < 0.82\ \text{MeV}$
Group 3	$1.1\ \text{eV} < E \leq 5.5\ \text{KeV}$
Group 4	$E < 1.1\ \text{eV}$

The cross sections, taken from references 1 and 3, have been averaged as follows: for $0 < E \leq 0.2$ eV, a Maxwellian distribution was used; for $0.2\ \text{eV} < E \leq 0.82$ MeV, a 1/E distribution was used; and for $E > 0.82$ MeV, the U^{235} fission spectrum was used.

PROGRAM OUTPUT

The program output contains the following data in the order listed. Appendix C contains the output for 3 sample problems.

item 1: information provided by the user to identify each material;

item 2: the neutron flux in order of decreasing energy and the irradiation time, if the cycling option is used this is the irradiation time per cycle

item 3: messages, if any, for elements requested which are not present in the library.

item 4: element name and weight fraction

item 5: list of reactions for the element; each followed by the disintegration rates (dis/sec) for the parent, daughter, and granddaughter at zero decay time; and the fraction of induced activity due to each neutron group in order of decreasing energy.

Items 4 and 5 are repeated for all elements in a given material. The above information appears only once for each material. The following information is repeated for each decay time.

item 6: the time after irradiation in minutes and the units in which the output is calculated: per-gram, per-cubic centimeter, or for the total mass.

item 7: the product isotope name and total disintegration rate, source strength, and absorbed dose rate.

The following three lines appear if the breakdown of the activity as a function of gamma energy is desired.

item 8: the gamma ray energies

item 9: the absorbed dose rate at each gamma energy

item 10: the source strength at each gamma energy.

The last item (11) appears regardless of the options used:

11: the total material disintegration rate, source strength, and absorbed dose rate.

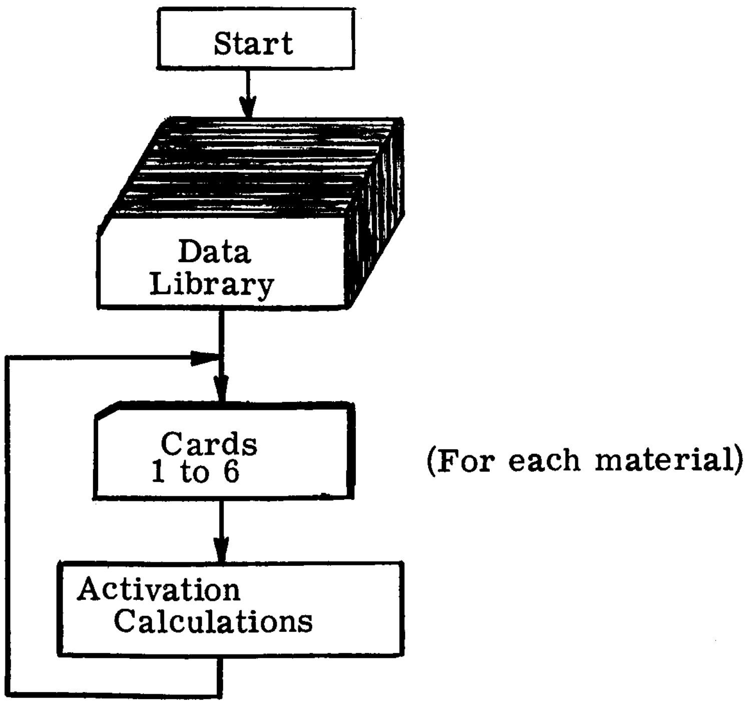
Items 6 through 11 are repeated for each time after irradiation. Those product activities which are zero (less than 10^{-38}) are not printed out.

PROGRAM LIMITATIONS

Each composite material may consist of up to 20 different elements and up to 20 different decay times may be included. The number of different materials that can be analyzed during a single computer "run" is limited only by the machine time available. All reactions for each element for which cross sections were available are included in the NAC library. These include the (n,γ), (n,p), (n,α), and $(n, 2n)$ reactions; the formation of excited states and isometric states are also included. The activity for each reaction is traced through the first three generations or until a stable product is formed. However, there are some exclusions: reactions which have products having half-lives less than about one minute and products which are not gamma emitters. The dose rate contributions of alpha and beta particles are not included.

INPUT PREPARATION

Each "data link" consists of one material to be analyzed. The library data deck must preced the first data link (see sketch (b)). The number of data links that can be processed per computer run is not limited; but all the cards listed below must be present for each link.



Sketch (b)

Input Flow

Card no.	Columns	Data
1	FORMAT (12A6)	
	1-72	any information desired by user to identify the material
2	FORMAT (22I3)	
	3	= 1, if the gamma energy breakdown is not desired = 2, if the gamma energy breakdown is desired
	5,6	the number of elements desired;
	7-66	the Z value for each element desired;
3	FORMAT (8F10.4)	
	1-10	= 1.0, for output per gram = density (g/cm^3) for output per cm^3 = - mass, for output per total mass
	11-80	the weight fraction of each element in the same order as the Z values on card 2
4	FORMAT (4E10.4)	
	1-40	neutron flux in order of decreasing in energy;
5	FORMAT (I3,2E10.4,I3)	
	1-3	number of reactor cycles; columns are left blank if cycling is not desired
	4-13	irradiation time in minutes (if cycling is desired, the irradiation time per cycle)
	14-23	non-irradiation time per cycle in minutes; columns are left blank if cycling is not desired
	24-26	the number of decay times desired
6	FORMAT (8E10.4)	
	1-80	the decay times in minutes from the end of irradiation (from the end of the last exposure for cycling)

Note that card five must be used with or without cycling. Normal (non-cyclic) calculations (equations (1)) do not include target atom burn-up. Calculation of target burn-up without cycling may be obtained by setting the number of cycles to 1 and the non-irradiation time per cycle to zero on card 5.

APPENDIX A   A COMPLETE FORTRAN LISTING OF THE NAC CODE

```
      INTEGER OPT,Z(21),PA(251),PB(251),PC(251)
      REAL LA(251),LB(251),LC(251)
      DIMENSION ELEM(2,71),REAC(5,251),SIGMA(4,251),ISO(2,226),NE(226),
     AEGAM(7,226),FRAC(7,226),IE(71),IDEL(71),AD(71),NAME(12),WTF(20),
     BPHI(4),T(20),FN(4),PROD(50,20),IP(50),SF(4),SFX(4),S(7),R(7),DF(4)
     C,DFN(4)
C
C     READ IN DATA LIBRARY
C
      READ (5,100)((ELEM(I,K),I=1,2),K=1,71)
  100 FORMAT (12A6)
      READ (5,101) (IE(J),IDEL(J),J=1,71)
  101 FORMAT (20I4)
      READ (5,102) (AD(J),J=1,71)
  102 FORMAT (8E10.4)
      READ (5,103) ((REAC(I,J),I=1,5),(SIGMA(I,J),I=1,4),PA(J),LA(J),
     APB(J),LB(J),PC(J),LC(J),J=1,251)
  103 FORMAT (5A6,4E10.4/I4,E9.4,I4,E9.4,I4,E9.4)
      READ (5,104) ((ISO(I,J),I=1,2),NE(J),(EGAM(I,J),FRAC(I,J),I=1,7),
     AJ=1,226)
  104 FORMAT (A3,A4,I3,14F5.2)
C
C     READ IN MATERIAL DATA
C
 9999 READ (5,100) (NAME(L),L=1,12)
      READ (5,105) OPT,JJ,(Z(J),J=1,JJ)
  105 FORMAT (22I3)
      READ (5,106) WT,(WTF(J),J=1,JJ)
  106 FORMAT (8F10.4)
      READ (5,107) (PHI(I),I=1,4),IN,T1,T2,LL,(T(L),L=1,LL)
  107 FORMAT (4E10.4/I3,2E10.4,I3/(8E10.4))
      TN=FLOAT(IN)
      WRITE (6,200)
  200 FORMAT (1H1,2X)
C
C     WRITE INPUT DATA--MATERIAL IDENTIFICATION INFORMATION, NEUTRON
C                       FLUX, IRRADIATION TIME OR NUMBER OF CYCLES AND
C                       IRRADIATION TIME PER CYCLE
C
      WRITE (6,201) (NAME(L),L=1,12)
  201 FORMAT (1H ,29X,12A6///2X)
      IF (TN.NE.0.) GO TO 1
      WRITE (6,202) (PHI(I),I=1,4),T1
  202 FORMAT (13H NEUTRON FLUX,4(5X,1PE10.3),20X,16HIRRADIATION TIME,
     A  1PE12.3,4H MIN//2X)
      GO TO 2
    1 WRITE (6,203) (PHI(I),I=1,4),IN,T1
  203 FORMAT (13H NEUTRON FLUX,4(5X,1PE10.3),10X,I4,7H CYCLES,5X,
     A16HIRRADIATION TIME,1PE10.3,4H MIN//2X)
C
C     CONVERT INPUT  Z  TO KEY TO REACTION INDEXING PARAMETERS
C
C     TRAP ELEMENTS REQUESTED, BUT NOT IN THE LIBRARY, WRITE MESSAGE
C
    2 DO 1000 J=1,JJ
```

```
      M=Z(J)
      IF (M.LT.9.OR.M.EQ.10.OR.M.EQ.39.OR.M.EQ.43.OR.M.EQ.61.OR.M.EQ.68.
     AOR.M.EQ.76.OR.M.EQ.82.OR.M.GE.84.AND.M.LE.89.OR.M.GT.92) GO TO 11
      IF (M.NE.9) GO TO 3
      Z(J)=1
      GO TO 1000
    3 IF (M.GT.39) GO TO 4
      Z(J)=Z(J)-9
      GO TO 1000
    4 IF (M.GT.43) GO TO 5
      Z(J)=Z(J)-10
      GO TO 1000
    5 IF (M.GT.61) GO TO 6
      Z(J)=Z(J)-11
      GO TO 1000
    6 IF (M.GT.68) GO TO 7
      Z(J)=Z(J)-12
      GO TO 1000
    7 IF (M.GT.76) GO TO 8
      Z(J)=Z(J)-13
      GO TO 1000
    8 IF (M.GT.82) GO TO 9
      Z(J)=Z(J)-14
      GO TO 1000
    9 IF (M.NE.83) GO TO 10
      Z(J)=68
      GO TO 1000
   10 Z(J)=Z(J)-21
      GO TO 1000
   11 WRITE (6,204) M
  204 FORMAT (37H ELEMENT IS NOT LISTED IN LIBRARY  Z=,I3//2X)
      Z(J)=0
 1000 CONTINUE
C
C     BEGIN CALCULATION OF END OF IRRADIATION DISINTEGRATION RATES
C
      N=0
      WRITE (6,205)
  205 FORMAT(5X,7HELEMENT,11X,15HWEIGHT FRACTION13X,22HDPS AT ZERO DECAY
     A TIME,17X,35HACTIVITY FRACTION PER NEUTRON GROUP/2X)
      DO 1012 J=1,JJ
      M=Z(J)
      IF (M.EQ.0) GO TO 1012
      KK=IE(M)
      KKK=IDEL(M)+KK-1
      PERC=ABS(WT*WTF(J))
C
C     WRITE ELEMENT NAME AND WEIGHT FRACTION
C
      WRITE (6,206) (ELEM(I,M),I=1,2),WTF(J)
  206 FORMAT (2X/5X,2A6,10X,0PF8.5//2X)
      DO 1011 K=KK,KKK
      TOT=0.
      DO 1002 I=1,4
      FN(I)=PHI(I)*SIGMA(I,K)
      DFN(I)=FN(I)
 1002 TOT=TOT+FN(I)
      IF (TN.NE.0.) GO TO 20
C
C     ACTIVATION WITHOUT CYCLING AND BURN-UP
```

```
C
      A=PERC*TOT
      AL=LA(K)
      ALX=EXP(-AL*T1)
      IPA=PA(K)
C
C     CALCULATE PARENT POST-IRRADIATION ACTIVITY (DIS/SEC)
C
      S1=A*(1.-ALX)
      IF (PB(K).EQ.0) GO TO 12
      BL=LB(K)
      BLX=EXP(-BL*T1)
      IPB=PB(K)
C
C     CALCULATE DAUGHTER POST-IRRADIATION ACTIVITY (DIS/SEC)
C
      S2=A*(BL*(1.-ALX)-AL*(1.-BLX))/(BL-AL)
      IF (PC(K).EQ.0) GO TO 13
      CL=LC(K)
      CLX=EXP(-CL*T1)
      IPC=PC(K)
C
C     CALCULATE GRAND DAUGHTER POST-IRRADIATION ACTIVITY (DIS/SEC)
C
      S3=A*((BL-AL)*(2.-CLX)-BL*CL*(ALX-CLX)/(CL-AL)+AL*CL*(BLX-CLX)
     A/(CL-BL))/(BL-AL)
      GO TO 14
   12 IPB=0
      S2=0.
   13 IPC=0
      S3=0.
C
C     CALCULATE NEUTRON GROUP ACTIVITY FRACTIONS
C
C     WRITE REACTION, POST-IRRADIATION DISINTEGRATION RATES, AND NEUTRON
C     GROUP ACTIVITY FRACTIONS
C
   14 DO 1003 I=1,4
 1003 DF(I)=DFN(I)/TOT
      WRITE (6,207) (REAC(I,K),I=1,5),S1,S2,S3,(DF(I),I=1,4)
  207 FORMAT (10X,5A6,3(5X,1PE10.3),4(5X,0PF6.4))
C
C     CALCULATE DISINTEGRATION RATES FOR REQUIRED DECAY TIMES
C
      DO 1007 L=1,LL
      IF (T(L).GT.0.) GO TO 15
      AT=S1
      BT=S2
      CT=S3
      GO TO 16
   15 ALT=EXP(-AL*T(L))
      AT=S1*ALT
      IF (IPB.EQ.0) GO TO 16
      BLT=EXP(-BL*T(L))
      BT=S2*BLT+BL*S1*(ALT-BLT)/(BL-AL)
      IF (IPC.EQ.0) GO TO 16
      CLT=EXP(-CL*T(L))
      CT=S3*CLT+CL*S2*(BLT-CLT)/(CL-BL)+CL*BL*S1*((ALT-CLT)/(CL-AL)
     A-(BLT-CLT)/(CL-BL))/(BL-AL)
C
```

```
C     INCLUDE PARENT, DAUGHTER, GRAND DAUGHTER DISINTEGRATIONS RATES IN
C     PRODUCT ISOTOPE ARRAY--(1) IF ISOTOPE IS ALREADY PRESENT, ADD TO
C     TOTAL,  (2) IF NEW ISOTOPE, INCLUDE IT IN ARRAY
C
   16 IF (N.NE.0) GO TO 17
      PROD(1,1)=AT
      IP(1)=IPA
      N=1
      GO TO 18
   17 DO 1004 NN=1,N
      IF (IPA.NE.IP(NN)) GO TO 1004
      PROD(NN,L)=PROD(NN,L)+AT
      GO TO 18
 1004 CONTINUE
      N=N+1
      PROD(N,L)=AT
      IP(N)=IPA
   18 IF (IPB.EQ.0) GO TO 1007
      DO 1005 NN=1,N
      IF (IPB.NE.IP(NN)) GO TO 1005
      PROD(NN,L)=PROD(NN,L)+BT
      GO TO 19
 1005 CONTINUE
      N=N+1
      PROD(N,L)=BT
      IP(N)=IPB
   19 IF (IPC.EQ.0) GO TO 1007
      DO 1006 NN=1,N
      IF (IPC.NE.IP(NN)) GO TO 1006
      PROD(NN,L)=PROD(NN,L)+CT
      GO TO 1007
 1006 CONTINUE
      N=N+1
      PROD(N,L)=CT
      IP(N)=IPC
 1007 CONTINUE
      GO TO 1011
C
C     ACTIVATION CALCULATION FOR CYCLING AND BURN-UP
C
   20 AL=LA(K)
      ALX=EXP(-AL*T1)
      TOT=0.
      IPA=PA(K)
      S1=0.
      DO 1008 I=1,4
      SF(I)=60.*FN(I)/AD(M)
      SFX(I)=EXP(-SF(I)*T1)
      IF ((SFX(I)-ALX).NE.0.) GO TO 21
      ALC=TN
      DFN(I)=FN(I)*T1*ALC
      GO TO 1008
C
C     CALCULATE PARENT POST-IRRADIATION ACTIVITY (DIS/SEC)
C
   21 ALC=(SFX(I)**TN-EXP(-TN*AL*(T1+T2)))/(SFX(I)-EXP(-AL*(T1+T2)))
      DFN(I)=FN(I)*(SFX(I)-ALX)/(AL-SF(I))*ALC
 1008 TOT=TOT+DFN(I)
      S1=TOT*PERC*AL
      IF (PB(K).EQ.0) GO TO 22
```

```
      IPB=PB(K)
      BL=LB(K)
      BLX=EXP(-BL*T1)
      S2=0.
C
C     CALCULATE DAUGHTER POST-IRRADIATION ACTIVITY (DIS/SEC)
C
      DO 1009 I=1,4
 1009 S2=S2+FN(I)*((SFX(I)-BLX)/(BL-SF(I))-(ALX-BLX)/(BL-AL))/(AL-SF(I))
      S2=S2*PERC*AL*BL*ALC
      IF (PC(K).EQ.0) GO TO 23
      IPC=PC(K)
      CL=LC(K)
      CLX=EXP(-CL*T1)
      S3=0.
C
C     CALCULATE GRAND DAUGHTER POST-IRRADIATION ACTIVITY (DIS/SEC)
C
      DO 1010 I=1,4
 1010 S3=S3+FN(I)*(((SFX(I)-CLX)/(CL-SF(I))-(BLX-CLX)/(CL-BL))/(BL-SF(I)
     A)-((ALX-CLX)/(CL-AL)-(BLX-CLX)/(CL-BL))/(BL-AL))
      S3=S3*PERC*AL*BL*CL*ALC
      GO TO 14
   22 IPB=0
      S2=0.
   23 IPC=0
      S3=0.
      GO TO 14
C
C     GO BACK AND CALCULATE ACTIVITY AFTER DECAY TIMES AND INCLUDE IN
C     PRODUCT ISOTOPE ARRAY
C
 1011 CONTINUE
 1012 CONTINUE
      NEND=N
      DO 1015 L=1,LL
      WRITE (6,200)
      CTT=0.
      RTT=0.
      STT=0.
      IF (ABS(WT-1.).LT..00001) GO TO 24
      IF (WT.LT.0.) GO TO 25
C
C     WRITE THE DECAY TIME AND UNITS FOR CALCULATION
C
      WRITE (6,208) T(L)
  208 FORMAT (23H TIME AFTER IRRADIATION,1PE12.4,4H MIN,20X,31HALL OUTPU
     AT PER CUBIC CENTIMETER//2X)
      GO TO 26
   24 WRITE (6,209) T(L)
  209 FORMAT (23H TIME AFTER IRRADIATION,1PE12.4,4H MIN,20X,19HALL OUTPU
     AT PER GRAM//2X)
      GO TO 26
   25 WRITE (6,210) T(L)
  210 FORMAT (23H TIME AFTER IRRADIATION,1PE12.4,4H MIN,20X,25HALL OUTPU
     AT FOR TOTAL MASS//2X)
C
C     CALCULATE DISINTEGRATION RATES (MCI), SOURCE STRENGTHS (MEV/SEC),
C     DOSE RATES (MR(C)/HR), AND TOTALS
C
```

```
   26 DO 1014 N=1,NEND
      K=IP(N)
      NN=NE(K)
      IF (PROD(N,L).EQ.0.) GO TO 1014
      RT=0.
      ST=0.
      P=PROD(N,L)
      CT=P/3.7E7
      DO 1013 I=1,NN
      S(I)=FRAC(I,K)*EGAM(I,K)*P
      R(I)=S(I)*1.285E-8
      ST=ST+S(I)
 1013 RT=RT+R(I)
C
C     WRITE PRODUCT ISOTOPE INVENTORY
C
      WRITE (6,211) (ISO(M,K),M=1,2),CT,RT,ST
  211 FORMAT (5X,A3,A4,10X,1PE10.4,12H MILLICURIES,5X,1PE10.4,14H MR/HR
     AAT 1 M ,5X,1PE10.4,8H MEV/SEC/2X)
      IF (OPT.EQ.1) GO TO 27
      WRITE (6,212) (EGAM(I,K),I=1,NN)
  212 FORMAT (12X,13HGAMMA ENERGY ,7(5X,0PF10.4))
      WRITE (6,213) (R(I),I=1,NN)
  213 FORMAT (12X,13HMR/HR AT 1 M ,7(5X,1PE10.4))
      WRITE (6,214) (S(I),I=1,NN)
  214 FORMAT (12X,13HMEV/SEC      ,7(5X,1PE10.4)/2X)
   27 CTT=CTT+CT
      RTT=RTT+RT
      STT=STT+ST
 1014 CONTINUE
      WRITE (6,215) CTT,RTT,STT
  215 FORMAT(2X/24H TOTAL MATERIAL ACTIVITY,10X,1PE10.4,12H MILLICURIES,
     A5X,1PE10.4,14H MR/HR AT 1 M ,5X,1PE10.4,8H MEV/SEC)
 1015 CONTINUE
      GO TO 9999
      END
```

APPENDIX B

DATA LIBRARY LISTING

The NAC data library is listed below in three sections. The first section contains the target element names, atomic densities, and reaction indices. The second section contains the individual reactions and reaction parameters. The third section contains the product isotopes and gamma energy yields.

Section I contains the name of each element present in the data library, in order of increasing Z, on the first 12 cards. The next 8 cards contain one pair of reaction indices for each element. The first index identifies the first reaction for an element in the reaction table listed in Section II and the second index is the number of reactions for a given element. For example, the first two pair on the first card:

1 $\rightarrow$ first reaction for fluorine
3 $\rightarrow$ three fluorine reactions

4 $\rightarrow$ first reaction for sodium
4 $\rightarrow$ four sodium reactions

The final nine cards contain the atomic density (atoms per gram) of each element in order of increasing Z.

SECTION I ELEMENT NAMES, REACTION INDICES, ATOMIC DENSITIES (ATOMS/GRAMS)

FLUORINE	SODIUM	MAGNESIUM	ALUMINUM	SILICON	PHOSPHORUS
SULFUR	CHLORINE	ARGON	POTASSIUM	CALCIUM	SCANDIUM
TITANIUM	VANADIUM	CHROMIUM	MANGANESE	IRON	COBALT
NICKEL	COPPER	ZINC	GALLIUM	GERMANIUM	ARSENIC
SELENIUM	BROMINE	KRYPTON	RUBIDIUM	STRONTIUM	ZIRCONIUM
NIOBIUM	MOLYBDENUM	RUTHENIUM	RHODIUM	PALLADIUM	SILVER
CADMIUM	INDIUM	TIN	ANTIMONY	TELLURIUM	IODINE
XENON	CESIUM	BARIUM	LANTHANUM	CERIUM	PRASEODYMIUM
NEODYMIUM	SAMARIUM	EUROPIUM	GADOLINIUM	TERBIUM	DYSPROSIUM
HOLMIUM	THULIUM	YTTERBIUM	LUTIUM	HAFNIUM	TANTALUM
TUNGSTEN	RHENIUM	IRIDIUM	PLATINUM	GOLD	MERCURY
THALLIUM	BISMUTH	THORIUM	PROTACTINIUMURANIUM		

1	3	4	4	8	2	10	4	14	4	18	2	20	2	22	3	25	1	26	4
30	3	33	4	37	5	42	3	45	3	48	3	51	4	55	6	61	7	68	5
73	8	81	4	85	8	93	3	96	5	101	5	106	6	112	4	116	4	120	6
126	2	128	7	135	2	137	1	138	3	141	5	146	7	153	3	156	5	161	6
167	7	174	4	178	5	183	4	187	5	192	1	193	3	196	1	197	3	200	2
202	3	205	2	207	1	208	2	210	1	211	1	212	1	213	2	215	3	218	2
220	3	223	2	225	3	228	4	232	4	236	4	240	2	242	1	243	2	245	1
246	6																		

3.164E22	2.615E22	2.477E22	2.233E22	2.145E22	1.945E22	1.879E22	1.699E22
1.508E22	1.540E22	1.503E22	1.340E22	1.258E22	1.181E22	1.158E22	1.097E22
1.079E22	1.022E22	1.026E22	9.471E21	9.215E21	8.644E21	8.298E21	8.042E21
7.630E21	7.539E21	7.184E21	7.050E21	6.885E21	6.604E21	6.488E21	6.279E21
5.926E21	5.856E21	5.641E21	5.585E21	5.359E21	5.247E21	5.079E21	4.948E21
4.720E21	4.747E21	4.579E21	4.533E21	4.386E21	4.341E21	4.304E21	4.278E21
4.181E21	4.000E21	3.964E21	3.841E21	3.782E21	3.703E21	3.653E21	3.555E21
3.481E21	3.626E21	3.375E21	3.329E21	3.273E21	3.235E21	3.118E21	3.088E21
3.058E21	3.003E21	2.945E21	2.878E21	2.591E21	2.570E21	2.529E21	

Section II consists of two cards for each of the 251 reactions. The first card contains the reaction, followed by the activation cross sections (cm^2/g) for the four neutron groups in order of decreasing energy. Blanks indicate that the particular cross section is zero or unknown. The second card contains up to three pairs of numbers, each pair corresponding to a radioactive isotope. The first number of each pair is an index which identifies the product isotope (Section III). The second number of the pair is the isotope decay constant (min^{-1}).

For example for the first three reactions:

product isotope 3 is F^{20}

product isotope 2 is O^{19}

product isotope 1 is N^{16}

SECTION II REACTION, CROSS SECTIONS (CM 2/GRAM), PRODUCT ISOTOPE INDEX, DECAY CONSTANT (MIN -1)

F 19 (N,G) F 20	3	3.707+0	2.286-6	9.130-5	3.393-5	2.814-4
F 19 (N,P) O 19	2	1.435+0	7.581-5			
F 19 (N,A) N 16	1	5.635+0	3.786-4			
NA 23 (N,G) NA 24	6	7.702-4	1.602-6	2.689-5	4.851-4	1.124-3
NA 23 (N,P) NE 23	4	1.019+0	3.927-5			
NA 23 (N,A) F 20	3	3.707+0	1.749-5			
NA 23 (N,2N) NA 22	5	5.059-7	1.649-7			
MG 24 (N,P) NA 24	6	7.702-4	4.279-3			
MG 26 (N,G) MG 27	7	7.374-2	1.678-8	2.853-7	2.348-6	5.424-5
AL 27 (N,G) AL 28	9	3.000-1	8.262-6	6.394-4	1.822-4	4.212-3
AL 27 (N,P) MG 27	7	7.374-2	1.200-4			
AL 27 (N,A) NA 24	6	7.702-4	2.552-5			
AL 27 (N,2N) AL 26	8	1.635-12	5.192-4			
SI 28 (N,P) AL 28	9	3.000-1	2.295-4			
SI 29 (N,P) AL 29	10	1.035-1	2.703-6			
SI 30 (N,G) SI 31	11	4.077-3	3.288-9	5.656-8	2.499-6	5.469-4
SI 30 (N,A) MG 27	7	7.374-2	8.042-6			
P 31 (N,P) SI 31	11	4.077-3	7.455-4			
P 31 (N,A) AL 28	9	3.000-1	6.866-5			
S 34 (N,A) SI 31	11	4.077-3	2.409-6			
S 36 (N,G) S 37	12	1.375-1	2.549-11	3.527-10	1.484-8	3.598-7
CL 35 (N,2N) CL 34M	13	2.139-2	9.585-6			
CL 37 (N,G) CL 38	14	1.858-2	1.370-7	1.416-6	6.153-5	1.443-3
CL 37 (N,P) S 37	12	1.375-1	2.924-8			
A 40 (N,G) A 41	15	6.301-3	6.974-7	7.220-6	3.182-4	7.358-3
K 39 (N,G) K 40	17	1.039-13	2.119-7	2.194-6	9.671-5	2.236-3
K 39 (N,2N) K 38			3.830-7			

16 9.002-2				
K 41 (N,G) K 42	1.052-7	1.090-6	4.804-5	1.110-4
18 9.242-4				
K 41 (N,A) CL 38	8.821-6			
14 1.858-2				
CA 42 (N,P) K 42	5.679-5			
18 9.242-4				
CA 46 (N,G) CA 47--SC 47	7.832-12	8.720-11	3.845-9	1.331-7
19 1.024-4 24 1.416-4				
CA 48 (N,G) CA 49	2.331-9	2.406-8	9.752-7	2.457-5
20 7.877-3				
SC 45 (N,G) SC 46	2.259-5	2.353-4	1.038-2	2.399-2
23 5.729-6				
SC 45 (N,A) K 42	4.958-6			
18 9.242-4				
SC 45 (N,2N) SC 44M--SC 44	4.336-7			
21 2.003-4 22 2.962-3				
SC 45 (N,2N) SC 44	5.577-7			
22 2.962-3				
TI 46 (N,P) SC 46	1.589-5			
23 5.729-6				
TI 47 (N,P) SC 47	3.400-5			
24 1.416-4				
TI 48 (N,P) SC 48	4.312-7			
25 2.626-4				
TI 50 (N,G) TI 51	5.344-9	7.403-8	3.265-6	7.551-5
26 1.197-2				
TI 50 (N,A) CA 47--SC 47	1.344-10			
19 1.024-4 24 1.416-4				
V 51 (N,G) V 52	1.379-5	3.966-4	1.843-3	4.266-2
27 1.844-1				
V 51 (N,P) TI 51	3.560-7			
26 1.197-2				
V 51 (N,A) SC 48	1.957-7			
25 2.626-4				
CR 50 (N,G) CR 51	8.222-7	8.500-6	3.747-4	8.670-3
29 1.733-5				
CR 50 (N,2N) CR 49	3.646-9			
28 1.650-2				
CR 52 (N,P) V 52	2.772-5			
27 1.844-1				
MN 55 (N,G) MN 56	2.505-5	3.740-4	9.454-3	1.199-1
31 4.501-3				
MN 55 (N,A) V 52	2.128-5			
27 1.844-1				
MN 55 (N,2N) MN 54	6.554-6			
30 1.534-6				
FE 54 (N,P) MN 54	8.216-5			
30 1.534-6				
FE 54 (N,A) CR 51	2.332-7			
29 1.733-5				
FE 56 (N,P) MN 56	1.698-5			
31 4.501-3				
FE 58 (N,G) FE 59	2.567-9	2.661-8	1.174-6	5.370-4
32 1.066-5				
CO 59 (N,G) CO 60M--CO 60	1.244-5	2.116-4	6.346-3	1.313-1
36 6.602-2 37 2.502-7				
CO 59 (N,G) CO 60	1.346-5	1.222-4	8.015-3	1.641-1
37 2.502-7				
CO 59 (N,P) FE 59	3.443-4			

32 1.066-5				
CO 59 (N,A) MN 56	1.162-6			
31 4.501-3				
CO 59 (N,2N) CO 58M--CO 58	9.577-7			
34 1.284-3 35 6.665-6				
CO 59 (N,2N) CO 58	9.577-7			
35 6.665-6				
NI 58 (N,P) CO 58M--CO 58	9.038-5			
34 1.284-3 35 6.665-6				
NI 58 (N,P) CO 58	9.119-4			
35 6.665-6				
NI 58 (N,NP) CO 57	2.973-4			
33 1.783-6				
NI 58 (N,2N) NI 57	4.358-8			
38 3.067-4				
NI 60 (N,P) CO 60	1.342-5			
37 2.502-7				
NI 62 (N,A) FE 59	5.257-8			
32 1.066-5				
NI 64 (N,G) NI 65	1.386-8	1.436-7	6.333-6	1.464-4
39 4.444-3				
CU 63 (N,G) CU 64	6.810-6	1.688-4	3.418-4	4.717-3
41 8.887-4				
CU 63 (N,A) CO 60	4.718-6			
37 2.502-7				
CU 63 (N,2N) CU 62	1.501-6			
40 6.974-2				
CU 65 (N,G) CU 66	1.180-5	5.629-5	5.602-4	4.355-3
42 1.359-1				
CU 65 (N,2N) CU 64	1.189-6			
41 8.887-4				
ZN 64 (N,G) ZN 65	1.596-7	1.668-6	7.347-5	1.700-3
45 1.969-6				
ZN 64 (N,P) CU 64	3.156-5			
41 8.887-4				
ZN 64 (N,2N) ZN 63	1.740-7			
44 1.926-2				
ZN 66 (N,P) CU 66	8.372-6			
42 1.359-1				
ZN 67 (N,P) CU 67	1.014-7			
43 1.904-4				
ZN 68 (N,G) ZN 69M	5.394-9	1.332-7	5.881-6	2.083-4
46 8.252-4				
ZN 68 (N,A) NI 65	3.421-8			
39 4.444-3				
ZN 70 (N,G) ZN 71	1.569-10	3.889-9	1.714-7	3.963-6
47 3.151-1				
GA 69 (N,G) GA 70	1.087-5	6.186-5	2.529-4	5.848-3
49 3.285-2				
GA 69 (N,P) ZN 69M	1.166-6			
46 8.252-4				
GA 69 (N,2N) GA 68	3.107-6			
48 1.019-2				
GA 71 (N,G) GA 72		6.420-5	5.972-4	1.381-2
50 8.622-4				
GE 70 (N,P) GA 70	5.924-5			
49 3.285-2				
GE 70 (N,2N) GE 69	4.251-7			
52 2.888-5				
GE 72 (N,P) GA 72	2.271-8			

50 8.622-4				
GE 73 (N,P) GA 73	2.381-5			
51 2.407-3				
GE 74 (N,A) ZN 71	1.222-5			
47 3.157-1				
GE 76 (N,G) GE 77--AS 77	8.357-10	4.091-8	1.768-6	4.088-5
55 1.050-3 58 2.962-4				
GE 76 (N,G) GE 77M--AS 77	7.187-10	3.518-8	1.520-6	3.516-5
53 7.702-2 58 2.962-4				
GE 76 (N,G) GE 77M--GE77--AS77	1.170-10	4.730-9	2.480-7	4.620-6
54 7.702-2 55 1.050-3 58 2.962-4				
AS 75 (N,G) AS 76	1.809-5	1.616-4	1.199-3	2.776-2
57 4.360-4				
AS 75 (N,A) GA 72	1.733-7			
50 8.622-4				
AS 75 (N,2N) AS 74	1.816-6			
56 2.676-5				
SE 74 (N,G) SE 75	1.195-6	3.660-6	5.995-5	1.386-3
60 3.984-6				
SE 77 (N,P) AS 77	6.955-6			
58 2.985-4				
SE 80 (N,G) SE 81M		8.086-8	3.961-6	9.153-5
61 1.220-2				
SE 82 (N,G) SE 83M--SE83--BR83			3.841-5	1.738-3
62 6.028-1 63 2.773-2 67 5.023-3				
SE 82 (N,G) SE 83--BR 83			1.384-4	3.043-3
63 2.773-2 67 5.023-3				
BR 79 (N,G) BR 80		2.640-4	1.124-3	2.599-2
65 3.939-2				
BR 79 (N,A) AS 76	4.882-7			
57 4.360-4				
BR 81 (N,G) BR 82	6.675-6	1.568-3	8.602-3	9.850-3
66 3.209-4				
BR 81 (N,A) AS 78	1.027-4			
59 7.617-3				
BR 81 (N,2N) BR 80M--BR 80	1.526-6			
64 5.767-3 65 3.939-2				
KR 78 (N,G) KR 79	3.831-9	3.962-8	1.756-6	4.040-5
68 3.398-4				
KR 80 (N,G) KR 81	7.054-8	2.300-5	6.778-4	1.246-2
69 6.413-12				
KR 84 (N,G) KR 85M	2.231-6	3.301-4	4.948-4	6.244-5
70 2.526-3				
KR 84 (N,G) KR 85M--KR 85	9.512-6	1.407-3	2.109-3	2.662-4
70 2.626-3 71 1.238-7				
KR 84 (N,G) KR 85	7.019-6	1.046-3	1.558-3	1.972-4
71 1.238-7				
KR 86 (N,G) KR 87		5.903-8	2.603-6	6.015-5
72 8.887-3				
RB 85 (N,G) RB 86	1.529-7	9.959-5	2.198-4	3.717-3
74 2.530-5				
RB 85 (N,2N) RB 84	3.686-6			
73 1.459-5				
RB 87 (N,G) RB 88	3.659-6	2.559-5	1.285-5	1.892-4
75 3.894-2				
RB 87(N,2N) RB 86	1.703-6			
74 2.530-5				
SR 84 (N,G) SR 85M	4.124-10	4.246-9	1.872-7	5.952-6
77 9.403-3				
SR 84 (N,G) SR 85M--SR 85	3.081-9	3.819-8	1.685-6	6.033-5

76 9.903-3 78 7.618-5				
SR 84 (N,G) SR 85	3.493-9	4.243-8	1.872-6	6.628-5
78 7.618-5				
SR 86 (N,G) SR 87M	8.522-8	8.799-7	3.885-5	8.982-4
79 4.120-3				
ZR 90 (N,2N) ZR 89	7.668-7			
84 1.453-4				
ZR 94 (N,G) ZR 95--NB95M--NB95		4.674-7	5.934-9	1.397-6
85 7.382-6 90 1.283-4 91 1.372-5				
ZR 94 (N,G) ZR 95--NB 95		2.291-5	2.909-7	6.848-5
85 7.382-6 91 1.372-5				
ZR 94 (N,A) SR 91--Y 91M--Y 91	2.321-10			
80 1.195-3 82 1.378-2 83 8.242-6				
ZR 94 (N,A) SR 91--Y 91	1.613-10			
81 1.195-3 83 8.242-6				
ZR 96 (N,G) ZR 97--NB 97	7.836-8	6.549-6	2.935-7	1.446-5
86 6.796-4 92 9.614-3				
NB 93 (N,G) NB 94M--NB 94	1.545-5	3.927-3	4.655-3	5.992-3
88 1.050-1 89 6.301-11				
NB 93 (N,2N) NB 92	3.977-8			
87 4.813-5				
MO 92 (N,G) MO 93M	5.400-8	2.298-5	1.516-6	4.000-5
93 1.650-3				
MO 92 (N,P) NB 92	1.319-6			
87 4.814-5				
MO 92 (N,A) ZR 89	1.695-8			
84 1.462-4				
MO 95 (N,P) NB 95	9.858-8			
91 1.375-5				
MO 97 (N,P) NB 97	1.744-5			
92 9.367-3				
MO 98 (N,G) MO 99	6.686-6	2.853-4	6.334-3	6.110-4
94 1.724-4				
MO100 (N,G) MO101--TC101	5.118-8	2.233-5	3.367-5	9.706-5
95 4.621-2 96 4.951-2				
RU102 (N,G) RU103	3.400-6	6.265-4	3.443-3	2.192-3
97 1.222-5				
RU104 (N,G) RU105--RH105	4.390-6	2.794-4	1.813-3	6.136-4
97 2.606-3 100 3.224-4				
RH104 (N,G) RH105M--RH105	3.306-6	4.075-4	4.224-3	8.950-2
99 1.575-1 100 3.224-4				
PD102 (N,G) PD103	1.722-8	6.760-6	1.837-5	1.742-4
101 2.876-5				
PD108 (N,G) PD109M	2.244-7	7.878-5	4.777-4	2.181-3
103 1.459-1				
PD110 (N,G) PD111-AG111M-AG111	2.438-7	1.150-4	3.036-3	1.285-4
104 3.150-2 107 5.776-1 108 6.418-5				
AG107 (N,G) AG108	1.534-5	2.342-3	1.457-2	7.142-2
105 2.888-1				
AG107 (N,2N) AG106M	2.421-8			
104 5.728-5				
AG109 (N,G) AG110M	3.597-7	5.848-5	3.801-5	4.746-3
106 1.904-6				
AG109 (N,P) PD109M	3.084-8			
103 1.459-1				
AG109 (N,2N) AG108	4.537-4			
105 2.888-1				
CD106 (N,G) CD107	2.040-8	9.100-6	1.933-5	5.252-5
109 1.724-3				
CD110 (N,G) CD111M	2.075-7	1.006-4	5.933-4	1.067-4

110 1.386-2				
CD114 (N,G)CD115M-CD115-IN115M	4.357-7	2.089-4	1.133-3	1.378-3
111 1.130-5 112 2.179-4 117 2.567-3				
CD114 (N,G) CD115--IN115M	5.458-8	2.662-5	1.495-4	1.752-4
112 2.179-4 117 2.567-3				
CD116 (N,G)CD117M-CD117-IN117M	1.269-7	6.186-5	1.451-4	4.895-4
113 3.983-3 114 1.386-2 119 6.080-3				
CD116(N,2N)CD115M-CD115-IN115M	3.410-8			
111 1.130-5 112 2.179-4 117 2.567-3				
CD116 (N,2N)CD115--IN115M	3.399-8			
112 2.179-4 117 2.567-3				
IN113 (N,G) IN114M--IN114	2.610-7	4.196-5	2.478-3	9.988-3
115 9.627-6 116 5.776-1				
IN113 (N,G) IN114	9.329-9	1.496-6	8.888-5	3.569-4
116 5.776-1				
IN115 (N,G) IN116M	1.355-5	1.199-3	2.432-1	6.256-1
118 1.286-2				
IN115 (N,P) CD115--IN115M	2.014-5			
112 2.179-4 117 2.567-3				
IN115 (N,2N) IN114M--IN114	1.130-6			
115 9.627-6 116 5.776-1				
SN112 (N,G) SN113	2.885-8	1.220-5	3.500-5	5.034-5
120 4.077-6				
SN122 (N,G) SN123	9.499-8	4.304-5	8.457-5	3.064-5
121 1.754-2				
SN124 (N,G) SN125--SB125	1.205-7	5.248-5	4.757-5	4.875-5
122 7.146-2 128 4.881-7				
SB121 (N,G) SB122M	1.690-7	4.857-5	2.761-4	4.320-4
124 1.980-1				
SB121 (N,G) SB122	4.900-6	1.410-3	8.676-3	1.252-2
125 1.724-4				
SB121 (N,2N) SB120	2.041-6			
123 8.301-5				
SB 123 (N,G) SB124M--SB124	2.001-8	7.850-6	6.233-5	1.017-5
126 3.300-2 127 8.023-6				
SB123 (N,G) SB124	8.334-7	3.284-4	2.110-3	4.249-3
127 8.023-6				
SB123 (N,2N) SB122	2.020-6			
125 1.724-4				
TE122 (N,G) TE123M	4.832-8	1.724-5	9.843-5	1.026-4
129 4.621-6				
TE124 (N,G) TE125M	7.835-8	3.496-5	1.405-4	1.188-3
130 8.291-6				
TE126 (N,G) TE127M--TE127	2.105-8	1.104-5	5.325-5	6.389-5
131 4.560-6 132 1.229-3				
TE126 (N,G) TE127		9.744-5	4.634-4	5.679-4
132 1.229-3				
TE128 (N,G) TE129M--TE129	1.113-8	5.406-6	8.313-6	1.809-5
133 1.429-5 134 1.034-2				
TE128 (N,G) TE129	9.982-7	4.938-5	7.198-5	1.568-4
134 1.034-2				
TE130 (N,G) TE131--I 131	4.552-7	1.065-4	1.617-4	2.886-4
135 2.795-2 140 5.924-5				
I 127 (N,G) I 128	5.530-6	1.586-3	6.754-3	2.050-2
138 2.783-2				
I 127 (N,P) TE127	7.067-9			
132 1.229-3				
I 127 (N,A) SB124	5.099-10			
127 8.023-6				
I 127 (N,2N) I 126	4.476-6			

137 3.629-5				
XE124 (N,G) XE125--I 125		6.232-7	4.313-5	2.618-4
141 6.418-4 136 8.013-6				
XE128 (N,G) XE129M	1.213-8	5.825-6	3.378-5	1.487-4
142 5.332-5				
XE132 (N,G) XE133	3.333-7	1.055-4	2.507-4	2.081-4
143 9.145-5				
XE134 (N,G) XE135		1.084-5	8.916-6	8.079-5
144 1.269-3				
XE136 (N,G) XE137--CS137		6.636-6	2.017-6	4.904-5
145 1.777-1 149 4.951-8				
CS133 (N,G) CS134	5.815-6	1.332-3	2.113-2	9.470-2
147 5.975-7				
CS133 (N,P) XE133	6.146-8			
143 9.145-5				
CS133 (N,A) I 130	7.110-9			
139 9.242-4				
CS133 (N,2N) CS132	4.755-6			
146 7.429-5				
BA132 (N,G) BA133M--BA133	1.021-8	1.910-8	5.538-6	1.702-5
151 1.758-7 152 2.962-4				
BA132 (N,P) CS132	2.237-8			
146 7.764-5				
BA134 (N,G) BA135M	4.494-7	1.767-5	4.911-4	1.709-4
153 4.030-4				
BA136 (N,P) CS136	5.263-10			
148 3.703-5				
BA138 (N,P) CS138	3.360-6			
150 2.153-2				
LA139 (N,G) LA140	8.950-7	2.533-4	8.192-3	3.099-2
154 2.876-4				
CE138 (N,2N) CE137M--CE137	1.300-8			
155 3.398-4 156 1.327-3				
CE140 (N,G) CE141		1.112-5	3.892-5	9.476-4
157 1.459-5				
CE142 (N,G) CE143		9.522-6	2.025-5	3.593-4
158 3.501-4				
PR141 (N,G) PR142	8.822-7	2.448-4	2.149-3	3.884-2
159 5.874-4				
ND146 (N,G) ND147--PM147	1.671-8	4.037-6	4.913-4	6.523-4
160 4.359-5 163 5.023-7				
ND148 (N,G) ND149--PM149	1.328-7	2.396-5	4.913-4	6.523-4
161 6.080-3 164 2.179-4				
ND150 (N,G) ND151--PM151	6.499-8	1.174-5	2.362-5	2.817-4
162 5.776-2 165 4.126-4				
SM152 (N,G) SM153	6.144-7	1.826-4	1.603-2	1.200-1
166 2.458-4				
SM154 (N,G) SM155	2.734-7	5.343-5	4.784-4	3.624-3
167 3.150-2				
EU151 (N,G) EU152M	1.968-4	1.292-2	5.228-1	9.541+0
168 1.064-7				
EU151 (N,G) EU152	4.380-5	2.874-3	1.157-1	2.121+0
169 1.242-3				
EU153 (N,G) EU154		3.809-3	2.347-1	7.691-1
170 8.242-8				
GD158 (N,G) GD159	8.172-7	1.402-4	2.636-3	3.062-3
171 6.418-4				
GD160 (N,G) GD161	7.196-7	1.204-4	2.357-3	5.069-4
172 1.873-1				
TB159 (N,G) TB160	2.208-5	4.720-3	6.125-2	1.401-1

173 6.665-6				
DY164 (N,G) DY165M--DY165	3.320-5	1.623-3	6.807-2	1.679+0
174 5.545-1 175 4.916-3				
DY164 (N,G) DY165	1.328-5	6.497-4	2.968-2	6.715-1
175 4.916-3				
HO165 (N,G) HO166M	1.006-5	2.316-3	5.114-2	1.907-1
176 1.100-6				
TM169 (N,G) TM170	1.435-5	2.364-3	4.290-2	3.638-1
177 3.726-6				
YB168 (N,G) YB169	1.655-6	4.160-5	1.861-3	4.294-2
178 1.554-5				
LU175 (N,G) LU176M	2.111-5	4.153-3	1.857-1	9.441-2
179 3.122-3				
LU176 (N,G) LU177	5.698-6	4.539-4	2.290-2	2.708-1
180 7.183-5				
HF174 (N,G) HF175	1.447-7	7.097-6	3.483-4	7.316-3
181 6.863-6				
HF179 (N,G) HF180M	4.650-7	5.412-6	1.796-2	8.438-3
182 2.100-3				
HF180 (N,G) HF181	7.594-6	1.994-4	3.128-3	1.344-2
183 1.119-5				
TA181 (N,G) TA182	1.216-5	2.454-3	8.288-2	5.618-2
185 4.077-6				
TA181 (N,2N) TA180M	4.497-6			
184 1.417-3				
W 184 (N,G) W 185	7.966-7	2.065-4	1.332-3	1.612-3
187 6.245-6				
W 186 (N,G) W187	4.583-6	1.406-4	1.691-3	2.617-2
188 4.813-4				
W 186 (N,P) TA186	6.602-10			
186 6.601÷2				
RE185 (N,G) RE186	5.232-6	1.854-3	4.079-2	1.002-1
189 5.291-6				
RE187 (N,G) RE188	4.204-6	9.999-4	1.770-2	1.079-1
190 6.932-4				
IR191 (N,G) IR192M--IR192	7.312-6	6.398-4	1.694-2	2.483-1
191 4.881-1 192 6.478-6				
IR191 (N,G) IR192	1.968-5	1.724-3	4.565-2	6.555-1
192 6.478-6				
IR193 (N,G) IR194	6.633-4	1.448-1	3.297+1	2.014-1
193 6.080-4				
PT192 (N,G) PT193M	2.614-9	6.883-7	1.053-5	1.586-4
194 1.118-4				
PT196 (N,G) PT197	7.844-5	4.025-7	1.118-4	6.176-4
195 5.415-4				
PT198 (N,G) PT199--AU199	3.059-7	7.279-5	6.884-4	7.140-4
196 2.311-2 199 1.537-4				
PT198 (N,2N) PT197	1.646-3			
195 5.415-4				
AU197 (N,G) AU198	5.731-6	1.210-3	1.689-2	2.427-1
198 1.782-4				
AU197 (N,P) PT197	3.293-6			
195 5.415-4				
AU197 (N,A) IR194	6.431-11			
193 6.080-4				
AU197 (N,2N) AU196	1.824-5			
197 7.788-5				
HG196 (N,G) HG197M--HG197	4.384-7	8.719-6	7.423-5	1.802-3
201 4.814-4 202 1.777-4				
HG198 (N,G) HG199M	3.824-7	9.261-5	2.081-4	4.545-6

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 203   1.650-2
HG200  (N,P) AU200                   6.682-7
 200   1.444-2
HG202  (N,G) HG203                   8.949-5    2.181-6    2.008-5    3.393-3
 204   1.024-5
TL203  (N,P) HG203                   1.739-9
 204   1.024-5
TL203  (N,2N) TL202                  1.112-6
 205   4.006-5
BI209  (N,G) BI210--PO210                       3.047-6    2.088-4    4.401-5
 206   9.627-5 207  3.483-6
TH232  (N,G) TH233--PA233--U233      4.535-6    8.604-4    4.838-3    1.564-2
 213   3.136-2 216  1.777-5 218   1.772-8
TH232  (N,2N) TH231--PA231           5.904-5
 211   4.501-4 214 3.916-11
PA231  (N,G) PA232--U232--TH228      2.929-6    9.335-4    1.283-1    4.190-1
 215   3.667-4 217  1.772-8 209   6.863-7
U 234  (N,G) U235--TH231--PA231      5.726-9    5.179-8    3.755-7    8.775-6
 220 1.904-15 211  4.501-4 214  3.916-11
U 234  (N,2N)U233--TH229--RA225     4.700-11
 218 8.069-12 210  1.795-9 208    3.239-5
U 235  (N,G) U 236--TH232            9.998-7    1.645-5    3.549-4    1.451-3
 221 4.847-14 212 9.431-17
U 235  (N,2N) U 234                  2.664-7
 219 5.291-11
U 238  (N,G) U239--NP239--PU239      1.375-4    8.644-4    6.482-3    5.449-3
 223   2.949-2 225  2.038-4 226  5.415-11
U 238  (N,2N)U237--NP237--PA233      5.404-5
 222   7.131-5 224 5.975-13.216   1.772-8
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Section III consists of one card for each of the 226 radioactive product isotopes. Each card contains the isotope name followed by the number of gamma rays emitted. The remainder of the card contains up to seven pairs of numbers. Each pair consists of a gamma ray energy (MeV) followed by the fraction of gamma rays emitted at that energy per disintegration. A few isotopes emit gammas at more than seven energies. In these cases, the lowest energy groups are averaged into a single gamma energy.

SECTION III PRODUCT ISOTOPE NAME, NUMBER OF GAMMAS, GAMMA ENERGY (MEV), FRACTION OF GAMMAS AT A GIVEN ENERGY

N 16	3	7.1	.08	6.13	.99	2.15	.01								
O 19	4	1.44	.03	1.37	.56	.2	.97	.112	.03						
F 20	1	1.63	1.												
NE 23	2	1.65	.03	.44	.97										
NA 22	1	1.28	1.0												
NA 24	2	2.75	1.	1.37	1.0										
MG 27	3	1.02	.43	.834	1.	1.75	.01								
AL 26	3	2.96	.003	1.83	.997	1.12	.04								
AL 28	1	1.78	1.												
AL 29	2	2.43	.062	1.28	.938										
SI 31	1	1.27	.001												
S 37	1	3.09	.9												
CL 34M	5	.145	1.	4.1	.009	3.3	.24	2.13	.751	1.16	.24				
CL 38	2	2.16	.47	1.6	.31										
A 41	1	.29	.01												
K 38	1	2.16	1.												
K 40	1	1.46	.1												
K 42	2	1.53	.18	.32	.01										
CA 47	3	1.3	.93	.81	.07	.5	.07								
CA 49	3	4.68	.01	4.05	.1	3.1	.89								
SC 44M	1	.27	1.												
SC 44	4	2.69	.002	2.28	.002	1.5	.01	1.14	.03						
SC 46	2	1.12	1.	.89	1.										
SC 47	1	.16	.7												
SC 48	3	1.31	1.	1.04	1.	.99	1.								
TI 51	3	.93	.048	.61	.014	.322	.952								
V 52	1	1.44	1.												
CR 49	3	.15	.14	.09	.35	.06	.15								
CR 51	3	.65	.01	.33	.01	.32	.09								
MN 54	1	.835	1.												
MN 56	7	3.39	.002	2.96	.004	2.66	.007	2.52	.012	2.12	.153	1.81	.296	.845	1.
FE 59	3	1.29	.43	1.1	.57	.2	.03								
CO 57	2	.707	.002	.136	.998										
CO 58M	1	.025	1.												
CO 58	3	1.65	.005	.81	.016	.805	.995								
CO 60M	1	.059	1.												
CO 60	2	1.33	1.	1.17	1.										
NI 57	3	1.9	.14	1.37	.86	.127	.14								
NI 65	3	1.46	.29	1.1	.14	.37	.3								
CU 62	3	1.17	.005	1.13	.001	.88	.003								
CU 64	1	1.34	.42												
CU 66	2	1.04	.09	.83	.002										
CU 67	3	.388	.01	.184	.45	.093	.35								
ZN 63	2	.97	.086	.67	.113										
ZN 65	1	1.11	.44												
ZN 69M	1	.438	1.												
ZN 71	1	.51	1.												
GA 68	4	1.88	.04	1.24	.03	1.07	.98	.81	.06						
GA 70	3	1.21	.001	1.04	.004	.174	.001								
GA 72	7	3.05	.01	2.4	.72	1.88	.25	1.04	.22	.835	1.	.63	.34	.39	.04
GA 73	4	1.04	.01	.74	.06	.31	1.	.054	.14						
GE 69	7	2.04	.01	1.65	.01	1.33	.04	1.1	.39	.86	.18	.58	.15	.19	.1
GE 77M	1	.215	1.												

GE 77M	1	.159	1.												
GE 77	7	2.32	.01	1.96	.04	1.5	.07	1.08	.23	.709	.4	.416	.82	.153	1.
AS 74	7	2.2	.003	1.83	.003	1.61	.003	1.2	.003	1.	.003	.635	.006	.596	.154
AS 76	5	2.06	.02	1.41	.01	1.21	.12	.648	.03	.561	.37				
AS 77	4	.525	.008	.245	.025	.16	.003	.086	.001						
AS 78	7	2.65	.01	2.24	.01	1.82	.07	1.31	.19	.83	.08	.695	.54	.27	.06
SE 75	7	.77	.02	.628	.01	.427	.02	.273	1.4	.264	1.	.199	.08	.129	1.33
SE 81M	1	.103	1.												
SE 83M	4	2.02	.35	1.01	.88	.65	.18	.35	.11						
SE 83	7	2.29	.1	1.88	.1	1.31	.1	1.06	.1	.833	.1	.524	.1	.358	.1
BR 80M	2	.049	1.	.037	1.										
BR 80	1	.62	.13												
BR 82	7	1.32	.09	1.04	.1	.828	.09	.777	.27	.698	.1	.619	.14	.554	.31
BR 83	2	.087	.2	.046	1.										
KR 79	7	.3	.05	.217	.2	.201	.2	.181	.2	.136	.2	.084	.2	.045	.2
KR 81	1	.012	1.												
KR 85M	1	.15	1.												
KR 85	1	.514	.007												
KR 87	4	2.57	.22	2.05	.03	.847	.13	.403	.65						
RB 84	3	1.9	.008	1.01	.005	.88	.74								
RB 86	1	1.08	.09												
RB 88	7	4.87	.003	3.24	.02	2.68	.03	2.11	.01	1.84	.23	1.39	.01	.899	.15
SR 85M	2	.232	.012	.225	.988										
SR 85M	1	.15	1.												
SR 85	1	.513	1.												
SR 87M	1	.388	1.												
SR 91	2	1.03	.508	.748	.492										
SR 91	2	1.41	.171	.93	.073										
Y 91M	1	.551	1.												
Y 91	1	1.19	.002												
ZR 89	1	.913	1.												
ZR 95	2	.76	.439	.726	.561										
ZR 97	4	1.72	.1	1.15	.6	1.02	.3	.747	1.						
NB 92	3	1.83	.02	.93	.01	.9	.98								
NB 94M	1	.042	1.												
NB 94	2	.874	1.	.7	1.										
NB 95M	1	.231	1.												
NB 95	1	.765	1.												
NB 97	2	1.02	.01	.665	.99										
MO 93M	3	1.48	1.	.685	1.	.264	1.								
MO 99	4	.78	.04	.74	.1	.372	.01	.181	.04						
MO101	7	2.08	.16	1.56	.11	1.38	.19	1.02	.41	.704	.2	.591	.46	.191	.27
TC101	5	.72	.01	.635	.01	.545	.08	.385	.02	.307	.91				
RU103	7	.61	.065	.555	.005	.498	.885	.44	.005	.362	.003	.297	.004	.053	.015
RU105	7	1.35	.001	.966	.03	.874	.043	.726	.48	.67	.15	.475	.26	.318	.14
RH105M	1	.13	1.												
RH105	1	.319	1.												
PD103	4	.538	.001	.36	.001	.095	.1	.04	.9						
PD109M	1	.19	1.												
PD111	4	1.4	.08	.81	.01	.6	.13	.377	.05						
AG106M	7	1.55	.296	1.05	.6	.82	.48	.72	.49	.612	.23	.513	.86	.41	.67
AG108	3	.633	.019	.617	.01	.433	.03								
AG110M	7	1.5	.4	.937	.34	.885	.72	.764	.3	.706	.37	.656	.93	.619	.1
AG111M	1	.065	1.												
AG111	3	.342	.061	.247	.012	.095	.001								
CD107	2	.846	.004	.093	1.										
CD111M	2	.247	.94	.15	.29										
CD115M	3	1.3	.01	.935	.023	.485	.003								
CD115	6	.523	.24	.49	.122	.263	.002	.26	.017	.23	.006	.033	.002		
CD117M	2	1.27	1.	.28	1.										

CD117	1	.425	1.												
IN114M	3	.722	.04	.556	.04	.192	.96								
IN114	1	1.3	.002												
IN115M	1	.335	1.												
IN116M	7	2.09	.19	1.49	.1	1.27	.83	1.09	.57	.82	.15	.406	.4	.137	.06
IN117M	3	.822	.04	.315	.04	.161	.23								
SN113	2	.393	1.	.255	0.02										
SN123	1	.153	1.												
SN125	4	1.39	.019	1.07	.003	.64	.003	.326	.997						
SB120	4	1.18	1.	1.04	1.	.199	1.	.089	.9						
SB122M	2	.075	1.	.061	1.										
SB122	4	1.26	.007	1.14	.008	.69	.031	.564	.679						
SB124M	1	.018	1.												
SB124	7	2.09	.07	1.69	.52	1.37	.04	1.32	.03	1.05	.04	.722	.14	.645	.99
SB125	7	.668	.02	.633	.11	.598	.24	.462	.41	.176	.07	.11	.21	.035	.76
TE123M	2	.159	1.	.089	1.										
TE125M	2	.11	1.	.035	1.										
TE127M	1	.089	.98												
TE127	5	.418	.008	.36	.001	.203	.001	.145	.001	.059	.005				
TE129M	1	.106	1.												
TE129	4	1.12	.1	1.08	.007	.44	.09	.027	.71						
TE131	5	1.13	.1	.92	.05	.6	.05	.454	.2	.145	.8				
I 125	1	.035	1.												
I 126	3	.86	.023	.48	.114	.386	.773								
I 128	4	.98	.009	.75	.004	.53	.009	.45	.16						
I 130	5	1.15	.235	.74	.765	.66	1.	.53	1.	.41	.235				
I 131	5	.724	.028	.638	.091	.364	.81	.284	.055	.08	.055				
XE125	5	.242	.5	.188	.25	.113	.25	.075	.025	.055	.5				
XE129M	2	.196	1.	.04	1.										
XE133	1	.081	1.												
XE135	3	.61	.005	.36	.01	.25	1.								
XE137	1	0.	0.												
CS132	3	1.2	.006	1.08	.006	.673	.99								
CS134	7	1.37	.05	1.17	.03	1.04	.06	.797	.84	.605	.98	.569	.26	.475	.04
CS136	7	1.26	.21	1.07	.84	.83	1.	.337	.59	.27	.22	.17	.26	.152	.19
CS137	1	.662	.92												
CS138	7	2.63	.1	2.21	.18	1.01	.25	.87	.04	.463	.31	.426	.76	.139	.04
BA133M	2	.276	1.	.012	1.										
BA133	7	.38	.06	.355	.6	.302	.17	.274	.05	.16	.02	.081	1.08	.053	.11
BA135M	1	.268	1.												
LA140	7	3.	.01	2.5	.01	1.6	1.	.815	.46	.49	.5	.438	.06	.328	.4
CE137M	1	.255	1.												
CE137	2	.445	.03	.01	1.										
CE141	1	.145	.7												
CE143	4	.722	.09	.668	.01	.351	.08	.294	.43						
PR142	1	1.57	.04												
ND147	7	.688	.02	.532	.13	.441	.02	.321	.02	.198	.02	.121	.02	.091	.85
ND149	7	.266	.1	.24	.31	.211	.44	.192	.055	.124	.06	.114	.43	.1	.15
ND151	7	2.17	.1	1.13	.1	.738	.1	.256	.28	.117	1.	.11	.17	.085	.13
PM147	1	.121	.001												
PM149	3	.85	.002	.582	.002	.286	.03								
PM151	7	.832	.04	.578	.181	.368	.271	.241	.342	.166	.573	.108	.139	.041	.084
SM153	5	.609	.001	.531	.001	.173	.001	.103	.81	.07	.32				
SM155	3	.246	.04	.142	.01	.104	.96								
EU152M	7	1.41	.25	1.29	.015	1.1	.315	.965	.14	.869	.035	.779	.13	.355	.545
EU152	5	1.39	.003	1.32	.008	.972	.004	.963	.025	.344	.02				
EU154	7	1.28	.4	1.01	.19	.997	.11	.874	.15	.724	.28	.593	.06	.123	.75
GD159	6	.58	.001	.363	.12	.305	.001	.225	.003	.076	.003	.058	.24		
GD161	7	.531	.035	.361	.6	.315	.24	.284	.11	.165	.08	.102	.14	.057	.83
TB160	7	1.27	.105	1.18	.207	.966	.338	.879	.34	.299	.28	.197	.08	.087	.12

DY165M	1	.108	1.												
DY165	5	.715	.007	.634	.007	.362	.014	.28	.007	.095	.156				
HO166M	7	.83	.106	.81	.6	.751	.144	.711	.58	.28	.31	.184	.98	.081	1.
TM170	1	.084	.24												
YB169	7	.308	.11	.198	.49	.177	.34	.131	.25	.11	.59	.094	.15	.063	.55
LU176M	1	.089	1.												
LU177	5	.321	.002	.25	.002	.208	.11	.113	.058	.072	.001				
HF175	6	.432	.015	.343	.985	.319	.002	.229	.01	.114	.01	.089	.135		
HF180M	6	.501	.16	.444	.8	.332	.93	.215	.82	.093	.16	.058	.47		
HF181	7	.615	.003	.482	.83	.476	.02	.346	.14	.217	.005	.137	.04	.136	.15
TA180M	2	.102	.004	.093	.23										
TA182	7	1.23	.11	1.22	.28	1.19	.15	.222	.13	.122	.33	.1	.56	.068	.34
TA186	7	1.1	.1	.94	.15	.73	.75	.51	1.	.3	.25	.2	1.	.125	.25
W 185	1	0.56	.024												
W 187	6	.721	.01	.686	.3	.479	.3	.134	.31	.114	.01	.072	.3		
RE186	3	.768	.001	.137	.202	.123	.002								
RE188	6	1.96	.01	1.78	.001	1.67	.001	1.13	.01	.633	.01	.155	.2		
IR192M	1	.058	1.												
IR192	7	.79	.01	.6	.532	.485	.001	.417	.048	.375	.038	.302	1.8	.127	.097
IR194	7	.994	.002	.939	.014	.645	.027	.622	.01	.328	.252	.301	.01	.294	.033
PT193M	2	.135	1.	.013	1.										
PT197	3	.279	.01	.191	.09	.077	.99								
PT199	7	.96	.1	.79	.1	.475	.1	.318	.1	.246	.1	.197	.1	.074	.1
AU196	3	.426	.06	.356	.94	.333	.263								
AU198	3	1.09	.002	.675	.011	.412	1.								
AU199	3	.208	.16	.158	.77	.05	.08								
AU200	3	1.6	.01	1.23	.24	.368	.29								
HG197M	2	.164	.97	.133	.97										
HG197	2	.191	.02	.077	1.										
HG199M	2	.368	1.	.159	1.										
HG203	1	.279	1.												
TL202	3	.965	.002	.523	.002	.44	.996								
BI210	1	0.	0.												
PO210	1	.804	.001												
RA225	1	.04	.63												
TH228	4	.214	.5	.167	.01	.132	.029	.085	.29						
TH229	2	.2	.75	.148	.25										
TH231	5	.163	.02	.069	.2	.025	.13	.018	.2						
TH232	2	.79	.2	.059	1.										
TH233	5	.67	.003	.453	.01	.195	.01	.057	.01	.029	.02				
PA231	6	.3	.2	.074	.2	.053	.2	.044	.2	.028	.2	.01	.2		
PA232	5	.584	.2	.455	.2	.389	.2	.109	.2	.047	.2				
PA233	5	.476	.2	.341	.2	.313	.85	.272	.2	.016	.2				
U 232	5	.33	.06	.268	.001	.131	.001	.13	.001	.058	.002				
U 233	2	.056	.001	.043	.01										
U 234	2	.117	.003	.05	.28										
U 235	7	.367	.04	.289	.07	.177	.55	.165	.04	.146	.12	.109	.05	.093	.09
U 236	1	.05	.27												
U 237	7	.644	.2	.371	.2	.367	.2	.267	.2	.06	.2	.033	.2	.026	.2
U 239	1	.074	1.												
NP237	6	.2	.003	.175	.001	.15	.008	.087	.14	.057	.2	.029	.14		
NP239	5	.94	.1	.925	.1	.871	.1	.102	.1	.044	.1				
PU239	3	.124	.15	.051	.11	.013	.17								

APPENDIX C

SAMPLE PROBLEMS

The input data and the code output are presented below for three sample problems. These problems will include all of the features available in NAC. The three materials were analyzed in a single computer run and execution time was 0.14 minutes.

Each of the problems will use the same neutron flux:

Group 1	3.0×10^{12}
Group 2	1.5×10^{13}
Group 3	2.7×10^{13}
Group 4	4.0×10^{13}

Sample problem I: Aluminum 6063

Calculate the induced activity per gram for an irradiation period of 10 days with decay times of 0, 1 hour, 1 day, and 10 days

Composition (weight fraction):

Aluminum	.9765
Magnesium	.009
Silicon	.006
Iron	.0035
Copper	.001
Manganese	.001
Chromium	.001
Zinc	.001
Titanium	.001

Sample problem II: Stainless Steel 304L

Calculate the induced activity per cm^3 for an irradiation of 10 days with zero decay time. Perform gamma energy breakdown.

Density:	7.75 gram per-cubic centimeter

Composition (weight fraction):

Iron	.6412
Chromium	.200
Nickel	.12
Manganese	.02
Silicon	.01
Carbon	.008

Sample problem III: Experimental capsule

Calculate the induced activity for a total mass of 653.0 grams for an exposure of 5 cycles consisting of 10 days irradiation and 2 days non-irradiation with zero decay time.

Composition (weight fraction):

Tungsten	.151
Tantalum	.0583
Nickel	.495
Iron	.0743
Chromium	.0942
Aluminum	.127

INPUT DATA FOR THE THREE SAMPLE PROBLEMS, ILLUSTRATING THE CARD FORMAT

```
SAMPLE PROBLEM I    ALUMINUM 6063
  1  9 13 12 14 26 29 25 24 30 22
      1.0      .9765      .009      .006      .0035      .001      .001      .001
     .001      .001
    3.0E+12   1.5E+13   2.7E+13   4.0E+13
     1.44E+4            4
    0.0E+0    6.0E+1    1.44E+3   1.44E+4

SAMPLE PROBLEM II   STAINLESS STEEL   304 L
  2  6 26 24 28 25 14  6
     7.75      .6412      .20       .12       .02       .01       .008
    3.0E+12   1.5E+13   2.7E+13   4.0E+13
     1.44E+4            1
    0.0E+0

SAMPLE PROBLEM III EXPERIMENTAL CAPSULE
  1  6 74 73 28 26 24 13
    -653.      .151      .0583     .495      .0743     .0942     .127
    3.0E+12   1.5E+13   2.7E+13   4.0E+13
  5  1.44E+4   2.88E+3  1
    0.0E+0
```

SAMPLE PROBLEM I ALUMINUM 6063

NEUTRON FLUX 3.000E 12 1.500E 13 2.700E 14 4.000E 13 IRRADIATION TIME 1.440E 04 MIN

ELEMENT	WEIGHT FRACTION	DPS AT ZERO DECAY TIME			ACTIVITY FRACTION PER NEUTRON GROUP			
ALUMINUM	0.97650							
AL 27 (N,G) AL 28		1.787E 11	0.	0.	0.0001	0.0524	0.0269	0.9206
AL 27 (N,P) MG 27		3.515E 08	0.	0.	1.0000	0.	0.	0.
AL 27 (N,A) NA 24		7.474E 07	0.	0.	1.0000	0.	0.	0.
AL 27 (N,2N) AL 26		3.400E 01	0.	0.	1.0000	0.	0.	0.
MAGNESIUM	0.00500							
MG 24 (N,P) NA 24		1.155E 08	0.	0.	1.0000	0.	0.	0.
MG 26 (N,G) MG 27		2.014E 07	0.	0.	0.0000	0.0019	0.0283	0.9697
SILICON	0.00600							
SI 28 (N,P) AL 28		4.131E 06	0.	0.	1.0000	0.	0.	0.
SI 29 (N,P) AL 29		4.865E 04	0.	0.	1.0000	0.	0.	0.
SI 30 (N,G) SI 31		1.317E 08	0.	0.	0.0000	0.0000	0.0031	0.9969
SI 30 (N,A) MG 27		1.444E 05	0.	0.	1.0000	0.	0.	0.
IRON	0.00350							
FE 54 (N,P) MN 54		1.885E 04	0.	0.	1.0000	0.	0.	0.
FE 54 (N,A) CR 51		5.406E 02	0.	0.	1.0000	0.	0.	0.
FE 56 (N,P) MN 56		1.784E 05	0.	0.	1.0000	0.	0.	0.
FE 58 (N,G) FE 59		1.071E 07	0.	0.	0.0000	0.0000	0.0015	0.9985
COPPER	0.00100							
CU 63 (N,G) CU 64		2.005E 08	0.	0.	0.0001	0.0126	0.0460	0.9412
CU 63 (N,A) CO 60		5.091E 01	0.	0.	1.0000	0.	0.	0.
CU 63 (N,2N) CU 62		4.504E 03	0.	0.	1.0000	0.	0.	0.
CU 65 (N,G) CU 66		1.902E 08	0.	0.	0.0002	0.0044	0.0795	0.9159
CU 65 (N,2N) CU 64		3.567E 03	0.	0.	1.0000	0.	0.	0.
MANGANESE	0.00100							
MN 55 (N,G) MN 56		5.057E 09	0.	0.	0.0000	0.0011	0.0505	0.9484
MN 55 (N,A) V 52		6.384E 04	0.	0.	1.0000	0.	0.	0.
MN 55 (N,2N) MN 54		4.296E 02	0.	0.	1.0000	0.	0.	0.
CHROMIUM	0.00100							

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CR 50 (N,G) CR 51	7.885E 07	0.	0.	0.0000	0.0004	0.0283	0.9713
CR 50 (N,2N) CR 49	1.094E 01	0.	0.	1.0000	0.	0.	0.
CR 52 (N,P) V 52	8.316E 04	0.	0.	1.0000	C.	0.	0.

ZINC C.CC1CC

ZN 64 (N,G) ZN 65	1.957E 06	0.	0.	0.0000	C.0004	0.0283	0.9713
ZN 64 (N,P) CU 64	9.464E 04	0.	0.	1.0000	C.	0.	0.
ZN 64 (N,2N) ZN 63	5.220E 02	0.	0.	1.0000	C.	0.	0.
ZN 66 (N,P) CU 66	2.517E 04	0.	0.	1.0000	C.	0.	0.
ZN 67 (N,P) CU 67	2.845E 02	0.	0.	1.0000	0.	0.	0.
ZN 68 (N,G) ZN 69M	8.491E 06	0.	0.	0.0000	C.0002	0.0187	0.9811
ZN 68 (N,A) NI 65	1.026E 02	0.	0.	1.0000	C.	0.	0.
ZN 70 (N,G) ZN 71	1.637E 05	0.	0.	C.0000	C.0004	0.0284	0.9713

TITANIUM C.CC1CC

TI 46 (N,P) SC 46	3.775E 03	0.	0.	1.0000	0.	0.	0.
TI 47 (N,P) SC 47	8.877E 04	0.	0.	1.0000	C.	0.	0.
TI 48 (N,P) SC 48	1.264E 03	0.	0.	1.0000	C.	0.	0.
TI 50 (N,G) TI 51	3.110E 06	0.	0.	0.0000	C.0004	0.0283	0.9713
TI 50 (N,A) CA 47--SC 47	3.109E-01	2.069E-01	0.	1.0000	C.	0.	0.

TIME AFTER IRRADIATION 0. MIN ALL OUTPUT PER GRAM

AL 28	4.8302E 03 MILLICURIES	4.0078E 03 MR/HR AT 1 M	3.1812E 11 MEV/SEC
MG 27	1.0049E 01 MILLICURIES	6.1640E 00 MR/HR AT 1 M	4.7969E 08 MEV/SEC
NA 24	5.1430E 00 MILLICURIES	1.0074E 01 MR/HR AT 1 M	7.8400E 08 MEV/SEC
AL 26	9.1884E-07 MILLICURIES	8.2051E-07 MR/HR AT 1 M	6.3853E 01 MEV/SEC
AL 29	1.3150E-03 MILLICURIES	8.4484E-04 MR/HR AT 1 M	6.5746E 04 MEV/SEC
SI 31	3.5585E 00 MILLICURIES	2.1487E-03 MR/HR AT 1 M	1.6722E 05 MEV/SEC
MN 54	5.2100E-04 MILLICURIES	2.0684E-04 MR/HR AT 1 M	1.6096E 04 MEV/SEC
CR 51	2.1312E 00 MILLICURIES	3.9113E-02 MR/HR AT 1 M	3.0438E 06 MEV/SEC
MN 56	1.3668E 02 MILLICURIES	1.1519E 02 MR/HR AT 1 M	8.9643E 09 MEV/SEC
FE 59	2.6558E-01 MILLICURIES	1.6352E-01 MR/HR AT 1 M	1.2725E 07 MEV/SEC
CU 64	5.4209E 00 MILLICURIES	1.4504E 00 MR/HR AT 1 M	1.1287E 08 MEV/SEC
CO 60	1.3758E-06 MILLICURIES	1.6353E-06 MR/HR AT 1 M	1.2726E 02 MEV/SEC
CU 62	1.2170E-04 MILLICURIES	5.5665E-07 MR/HR AT 1 M	4.3319E 01 MEV/SEC
CU 66	5.1414E 00 MILLICURIES	2.3286E-01 MR/HR AT 1 M	1.8121E 07 MEV/SEC
V 52	3.9730E-03 MILLICURIES	2.7201E-03 MR/HR AT 1 M	2.1168E 05 MEV/SEC
CR 49	2.9562E-07 MILLICURIES	8.6440E-09 MR/HR AT 1 M	6.7269E-01 MEV/SEC
ZN 65	5.2896E-02 MILLICURIES	1.2283E-02 MR/HR AT 1 M	9.5586E 05 MEV/SEC
ZN 63	1.4108E-05 MILLICURIES	1.0674E-06 MR/HR AT 1 M	8.3066E 01 MEV/SEC
CU 67	7.6917E-06 MILLICURIES	4.3603E-07 MR/HR AT 1 M	3.3932E 01 MEV/SEC
ZN 69M	2.2953E-01 MILLICURIES	4.7800E-02 MR/HR AT 1 M	3.7198E 06 MEV/SEC
NI 65	2.7738E-06 MILLICURIES	9.0786E-07 MR/HR AT 1 M	7.0650E 01 MEV/SEC
ZN 71	4.4110E-03 MILLICURIES	1.0696E-03 MR/HR AT 1 M	8.3235E 04 MEV/SEC
SC 46	1.0202E-04 MILLICURIES	9.7496E-05 MR/HR AT 1 M	7.5874E 03 MEV/SEC
SC 47	2.3580E-03 MILLICURIES	1.2769E-04 MR/HR AT 1 M	9.9371E 03 MEV/SEC
SC 48	3.4165E-05 MILLICURIES	5.4255E-05 MR/HR AT 1 M	4.2222E 03 MEV/SEC
TI 51	6.4049E-02 MILLICURIES	1.4374E-02 MR/HR AT 1 M	1.1186E 06 MEV/SEC
CA 47	8.4031E-09 MILLICURIES	5.1966E-09 MR/HR AT 1 M	4.0441E-01 MEV/SEC

TOTAL MATERIAL ACTIVITY 4.5550E 03 MILLICURIES 4.2212E 03 MR/HR AT 1 M 3.2850E 11 MEV/SEC

TIME AFTER IRRADIATION 6.0000E 01 MIN   ALL OUTPUT PER GRAM

AL 28	7.3564E-05 MILLICURIES	6.2258E-05 MR/HR AT 1 M	4.8449E 03 MEV/SEC
MG 27	1.2040E-01 MILLICURIES	7.4653E-02 MR/HR AT 1 M	5.7473E 06 MEV/SEC
NA 24	4.5107E 00 MILLICURIES	9.6194E 00 MR/HR AT 1 M	7.4859E 08 MEV/SEC
AL 26	5.1884E-07 MILLICURIES	8.2351E-07 MR/HR AT 1 M	6.3853E 01 MEV/SEC
AL 29	2.6421E-06 MILLICURIES	1.6975E-06 MR/HR AT 1 M	1.3210E 02 MEV/SEC
SI 31	2.7863E 00 MILLICURIES	1.6425E-03 MR/HR AT 1 M	1.3093E 05 MEV/SEC
MN 54	5.2055E-04 MILLICURIES	2.0682E-04 MR/HR AT 1 M	1.6095E 04 MEV/SEC
CR 51	2.1290E 00 MILLICURIES	3.9172E-02 MR/HR AT 1 M	3.0406E 06 MEV/SEC
MN 56	1.0433E 02 MILLICURIES	8.7929E 01 MR/HR AT 1 M	6.8427E 09 MEV/SEC
FE 59	2.8539E-01 MILLICURIES	1.6542E-01 MR/HR AT 1 M	1.2717E 07 MEV/SEC
CU 64	5.1390E 00 MILLICURIES	1.4751E 00 MR/HR AT 1 M	1.0701E 08 MEV/SEC
CO 60	1.3757E-06 MILLICURIES	1.6452E-06 MR/HR AT 1 M	1.2726E 02 MEV/SEC
CU 62	1.8537E-06 MILLICURIES	8.4785E-09 MR/HR AT 1 M	6.5580E-01 MEV/SEC
CU 66	1.4786E-03 MILLICURIES	6.5966E-05 MR/HR AT 1 M	5.2114E 03 MEV/SEC
V 52	6.2242E-08 MILLICURIES	4.2614E-08 MR/HR AT 1 M	3.3162E 00 MEV/SEC
CR 49	1.0985E-07 MILLICURIES	3.2119E-09 MR/HR AT 1 M	2.4995E-01 MEV/SEC
ZN 65	5.2865E-02 MILLICURIES	1.2281E-02 MR/HR AT 1 M	9.5575E 05 MEV/SEC
ZN 63	4.4422E-06 MILLICURIES	3.4609E-07 MR/HR AT 1 M	2.6155E 01 MEV/SEC
CU 67	7.6043E-06 MILLICURIES	4.4107E-07 MR/HR AT 1 M	3.3546E 01 MEV/SEC
ZN 69M	2.1845E-01 MILLICURIES	4.5691E-02 MR/HR AT 1 M	3.5401E 06 MEV/SEC
NI 65	2.1246E-06 MILLICURIES	6.9537E-07 MR/HR AT 1 M	5.4115E 01 MEV/SEC
ZN 71	2.7150E-11 MILLICURIES	6.3832E-12 MR/HR AT 1 M	5.1231E-04 MEV/SEC
SC 46	1.0155E-04 MILLICURIES	9.7464E-05 MR/HR AT 1 M	7.5848E 03 MEV/SEC
SC 47	2.3777E-03 MILLICURIES	1.2561E-04 MR/HR AT 1 M	9.8531E 03 MEV/SEC
SC 48	3.3631E-05 MILLICURIES	5.3407E-05 MR/HR AT 1 M	4.1562E 03 MEV/SEC
TI 51	4.0583E-02 MILLICURIES	7.0194E-03 MR/HR AT 1 M	5.4548E 05 MEV/SEC
CA 47	6.3517E-09 MILLICURIES	5.1648E-09 MR/HR AT 1 M	4.0193E-01 MEV/SEC

TOTAL MATERIAL ACTIVITY 1.2002E 02 MILLICURIES 9.9267E 01 MR/HR AT 1 M 7.7250E 09 MEV/SEC

TIME AFTER IRRADIATION 1.4400E 03 MIN ALL OUTPUT PER GRAM

NA 24	1.6565E 00 MILLICURIES	3.4231E 00 MR/HR AT 1 M	2.5861E 08 MEV/SEC
AL 26	5.1884E-07 MILLICURIES	8.2051E-07 MR/HR AT 1 M	6.3853E 01 MEV/SEC
SI 31	1.0036E-02 MILLICURIES	6.0502E-06 MR/HR AT 1 M	4.7161E 02 MEV/SEC
MN 54	5.1565E-04 MILLICURIES	2.0038E-04 MR/HR AT 1 M	1.6061E 04 MEV/SEC
CR 51	2.0767E 00 MILLICURIES	3.8149E-02 MR/HR AT 1 M	2.9688E 06 MEV/SEC
MN 56	2.0534E-01 MILLICURIES	1.7543E-01 MR/HR AT 1 M	1.3730E 07 MEV/SEC
FE 59	2.8516E-01 MILLICURIES	1.6103E-01 MR/HR AT 1 M	1.2532E 07 MEV/SEC
CU 64	1.5075E 00 MILLICURIES	4.0539E-01 MR/HR AT 1 M	3.1392E 07 MEV/SEC
CO 60	1.3753E-06 MILLICURIES	1.6347E-06 MR/HR AT 1 M	1.2721E 02 MEV/SEC
CR 49	1.4187E-17 MILLICURIES	4.1084E-19 MR/HR AT 1 M	3.2283E-11 MEV/SEC
ZN 65	5.2746E-02 MILLICURIES	1.2248E-02 MR/HR AT 1 M	9.5316E 05 MEV/SEC
ZN 63	1.2722E-17 MILLICURIES	9.6256E-19 MR/HR AT 1 M	7.4908E-11 MEV/SEC
CU 67	5.6472E-06 MILLICURIES	3.4147E-07 MR/HR AT 1 M	2.5795E 01 MEV/SEC
ZN 69M	6.9945E-02 MILLICURIES	1.4567E-02 MR/HR AT 1 M	1.1336E 06 MEV/SEC
NI 65	4.6116E-09 MILLICURIES	1.5094E-09 MR/HR AT 1 M	1.1746E-01 MEV/SEC
SC 46	1.0116E-04 MILLICURIES	9.6597E-05 MR/HR AT 1 M	7.5250E 03 MEV/SEC
SC 47	1.9556E-03 MILLICURIES	1.0414E-04 MR/HR AT 1 M	8.1042E 04 MEV/SEC
SC 48	2.3408E-05 MILLICURIES	3.7172E-05 MR/HR AT 1 M	2.8927E 03 MEV/SEC
TI 51	2.7458E-09 MILLICURIES	4.6961E-10 MR/HR AT 1 M	3.6546E-02 MEV/SEC
CA 47	7.2511E-09 MILLICURIES	4.4842E-09 MR/HR AT 1 M	3.4896E-01 MEV/SEC

TOTAL MATERIAL ACTIVITY 5.9125E 00 MILLICURIES 4.1294E 00 MR/HR AT 1 M 3.2135E 08 MEV/SEC

6

TIME AFTER IRRADIATION 1.4400E 04 MIN ALL OUTPUT PER GRAM

NA 24	7.8435E-05 MILLICURIES	1.5[illegible]54E-04 MR/HR AT 1 M	1.1957E 04 MEV/SEC
AL 26	5.1864E-07 MILLICURIES	8.2[illegible]51E-07 MR/HR AT 1 M	6.3853E 01 MEV/SEC
SI 31	1.1333E-25 MILLICURIES	6.[illegible]34E-29 MR/HR AT 1 M	5.3256E-21 MEV/SEC
MN 54	5.0561E-04 MILLICURIES	2.0732E-04 MR/HR AT 1 M	1.5745E 04 MEV/SEC
CR 51	1.6605E 00 MILLICURIES	3.0475E-02 MR/HR AT 1 M	2.3716E 06 MEV/SEC
MN 56	5.7088E-27 MILLICURIES	8.1[illegible]24E-27 MR/HR AT 1 M	6.3676E-19 MEV/SEC
FE 59	2.4837E-01 MILLICURIES	1.[illegible]25E-01 MR/HR AT 1 M	1.0915E 07 MEV/SEC
CU 64	1.5006E-05 MILLICURIES	4.0[illegible]52E-06 MR/HR AT 1 M	3.1247E 02 MEV/SEC
CO 60	1.3708E-06 MILLICURIES	1.5[illegible]94E-06 MR/HR AT 1 M	1.2680E 02 MEV/SEC
ZN 65	5.1417E-02 MILLICURIES	1.[illegible]39E-02 MR/HR AT 1 M	9.2914E 05 MEV/SEC
CU 67	4.9578E-07 MILLICURIES	2.[illegible]05E-08 MR/HR AT 1 M	2.1871E 00 MEV/SEC
ZN 69M	1.5855E-06 MILLICURIES	3.[illegible]18E-07 MR/HR AT 1 M	2.5695E 01 MEV/SEC
NI 65	4.4772E-34 MILLICURIES	1.[illegible]54E-34 MR/HR AT 1 M	1.1404E-26 MEV/SEC
SC 46	9.3943E-05 MILLICURIES	8.[illegible]77E-05 MR/HR AT 1 M	6.9866E 03 MEV/SEC
SC 47	3.1211E-04 MILLICURIES	1.[illegible]20E-05 MR/HR AT 1 M	1.2934E 03 MEV/SEC
SC 48	7.7862E-07 MILLICURIES	1.[illegible]65E-06 MR/HR AT 1 M	9.6222E 01 MEV/SEC
CA 47	1.9233E-09 MILLICURIES	1.[illegible]94E-09 MR/HR AT 1 M	9.2561E-02 MEV/SEC

TOTAL MATERIAL ACTIVITY 1.9613E 00 MILLICURIES 1.8314E-01 MR/HR AT 1 M 1.[illegible]2E 07 MEV/SEC

SAMPLE PROBLEM II STAINLESS STEEL 304L

NEUTRON FLUX 3.000E 12 1.500E 13 2.710E 13 4.000E 13 IRRADIATION TIME 1.440E 04 MIN

ELEMENT IS NOT LISTED IN LIBRARY Z= 6

ELEMENT	WEIGHT FRACTION	DPS AT ZERO DECAY TIME			ACTIVITY FRACTION PER NEUTRON GROUP			
IRON	0.64120							
FE 54 (N,P) MN 54		2.676E 07	0.	0.	1.0000	0.	0.	0.
FE 54 (N,A) CR 51		7.674E 05	0.	0.	1.0000	0.	0.	0.
FE 56 (N,P) MN 56		2.531E 08	0.	0.	1.0000	0.	0.	0.
FE 58 (N,G) FE 59		1.521E 10	0.	0.	0.0000	0.0000	0.0015	0.9985
CHROMIUM	0.20000							
CR 50 (N,G) CR 51		1.227E 11	0.	0.	0.0003	0.0004	0.0283	0.9713
CR 50 (N,2N) CR 49		1.695E 04	0.	0.	1.0000	0.	0.	0.
CR 52 (N,P) V 52		1.289E 08	0.	0.	1.0000	0.	0.	0.
NICKEL	0.12000							
NI 58 (N,P) CO 58M--CO 58		2.527E 08	2.188E 07	0.	1.0000	0.	0.	0.
NI 58 (N,P) CO 58		2.328E 08	0.	0.	1.0000	0.	0.	0.
NI 58 (N,NP) CO 57		2.104E 07	0.	0.	1.0000	0.	0.	0.
NI 58 (N,2N) NI 57		1.201E 05	0.	0.	1.0000	0.	0.	0.
NI 60 (N,P) CO 60		1.347E 05	0.	0.	1.0000	0.	0.	0.
NI 62 (N,A) FE 59		2.087E 04	0.	0.	1.0000	0.	0.	0.
NI 64 (N,G) NI 65		5.607E 09	0.	0.	0.0000	0.0004	0.0284	0.9713
MANGANESE	0.02000							
MN 55 (N,G) MN 56		7.838E 11	0.	0.	0.0000	0.0011	0.0505	0.9484
MN 55 (N,A) V 52		9.895E 06	0.	0.	1.0000	0.	0.	0.
MN 55 (N,2N) MN 54		6.658E 04	0.	0.	1.0000	0.	0.	0.
SILICON	0.01000							
SI 28 (N,P) AL 28		5.338E 07	0.	0.	1.0000	0.	0.	0.
SI 29 (N,P) AL 29		6.284E 05	0.	0.	1.0000	0.	0.	0.
SI 30 (N,G) SI 31		1.701E 09	0.	0.	0.0000	0.0000	0.0031	0.9969
SI 30 (N,A) MG 27		1.873E 06	0.	0.	1.0000	0.	0.	0.

TIME AFTER IRRADIATION 0. MIN ALL OUTPUT PER CUBIC CENTIMETER

MN 54 7.2503E-01 MILLICURIES 2.[illegible]84E-01 MR/HR AT 1 M 2.2400E 07 MEV/SEC

GAMMA ENERGY	0.8350	
MR/HR AT 1 M	2.8784E-01	
MEV/SEC	2.2400E 07	

CR 51 3.3034E 03 MILLICURIES 6.[illegible]24E 01 MR/HR AT 1 M 4.7179E 09 MEV/SEC

GAMMA ENERGY	0.6500	0.[illegible]00	0.3200
MR/HR AT 1 M	1.0209E 01	5.182[illegible]E 00	4.5233E 01
MEV/SEC	7.9446E 08	4.033[illegible]E 08	3.5201E 09

MN 56 2.1191E 04 MILLICURIES 1.[illegible]60E 04 MR/HR AT 1 M 1.3899E 12 MEV/SEC

GAMMA ENERGY	3.3900	2.[illegible]00	2.6600	2.5200	2.1200	1.8100	0.8450
MR/HR AT 1 M	6.6311E 01	1.192[illegible]E 02	1.8760E 02	[illegible].0468E 02	3.[illegible]1E 03	5.3980E 03	8.5137E 03
MEV/SEC	5.3161E 09	9.283[illegible]E 09	1.4600E 10	2.3711E 10	2.[illegible]432E 11	4.2008E 11	6.6255E 11

FE 59 4.1114E 02 MILLICURIES 2.[illegible]17E 02 MR/HR AT 1 M 1.8068E 10 MEV/SEC

GAMMA ENERGY	1.2900	1.[illegible]00	0.2000
MR/HR AT 1 M	1.0843E 02	1.225[illegible]E 02	1.1729E 00
MEV/SEC	8.4382E 09	9.538[illegible]E 09	9.1273E 07

CR 49 4.5821E-04 MILLICURIES 1.[illegible]98E-05 MR/HR AT 1 M 1.0427E 04 MEV/SEC

GAMMA ENERGY	0.1500	0.[illegible]00	0.0600
MR/HR AT 1 M	4.5750E-06	6.862[illegible]E-06	1.9607E-06
MEV/SEC	3.5603E 02	5.340[illegible]E 02	1.5259E 02

V 52 3.7512E 00 MILLICURIES 2.[illegible]82E 00 MR/HR AT 1 M 1.9986E 08 MEV/SEC

GAMMA ENERGY	1.4400	
MR/HR AT 1 M	2.5682E 00	
MEV/SEC	1.9986E 08	

CO 58M 6.8151E 00 MILLICURIES 8.[illegible]0[illegible]E-02 MR/HR AT 1 M 6.3040E 06 MEV/SEC

GAMMA ENERGY	0.0250	
MR/HR AT 1 M	8.1006E-02	
MEV/SEC	6.3040E 06	

CO 58 6.8841E 00 MILLICURIES 2.[illegible]10E 00 MR/HR AT 1 M 2.0942E 08 MEV/SEC

GAMMA ENERGY	1.6500	0.[illegible]00	0.8050
MR/HR AT 1 M	2.7003E-02	4.241[illegible]E-02	2.6216E 00
MEV/SEC	2.1014E 06	3.301[illegible]E 06	2.0402E 08

CO 57 5.6826E-01 MILLICURIES 3.[illegible]53E-02 MR/HR AT 1 M 2.8835E 06 MEV/SEC

GAMMA ENERGY	0.7070	0.[illegible]60
MR/HR AT 1 M	3.8203E-04	3.667[illegible]E-02
MEV/SEC	2.9730E 04	2.853[illegible]E 06

NI 57 3.2465E-03 MILLICURIES 2.[illegible]66E-03 MR/HR AT 1 M 1.7561E 05 MEV/SEC

GAMMA ENERGY	1.9000	1.[illegible]00	0.1270
MR/HR AT 1 M	4.1058E-04	1.818[illegible]E-03	2.7444E-05
MEV/SEC	3.1952E 04	1.415[illegible]E 05	2.1357E 03

CO 60 3.6393E-03 MILLICURIES 4.[illegible]58E-03 MR/HR AT 1 M 3.3664E 05 MEV/SEC

GAMMA ENERGY	1.3300	1.[illegible]00
MR/HR AT 1 M	2.3013E-03	2.024[illegible]E-03
MEV/SEC	1.7909E 05	1.575[illegible]E 05

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NI 65          1.5154E 02 MILLICURIES     4.9500E 01 MR/HR AT 1 M      3.8600E 09 MEV/SEC

     GAMMA ENERGY        1.4800        1.1300        0.3700
     MR/HR AT 1 M     3.0507E 01    1.1094E 01    7.9977E 00
     MEV/SEC          2.3741E 09    8.6351E 08    6.2239E 08
AL 28          1.4421E 00 MILLICURIES     1.2205E 00 MR/HR AT 1 M      9.4979E 07 MEV/SEC

     GAMMA ENERGY        1.7800
     MR/HR AT 1 M     1.2205E 00
     MEV/SEC          9.4979E 07
AL 29          1.6965E-02 MILLICURIES     1.0912E-02 MR/HR AT 1 M      8.4922E 05 MEV/SEC

     GAMMA ENERGY        2.4300        1.2800
     MR/HR AT 1 M     1.2167E-03    9.6958E-03
     MEV/SEC          9.4682E 04    7.5454E 05
SI 31          4.5964E 01 MILLICURIES     2.7754E-02 MR/HR AT 1 M      2.1599E 06 MEV/SEC

     GAMMA ENERGY        1.2700
     MR/HR AT 1 M     2.7754E-02
     MEV/SEC          2.1599E 06
MG 27          5.0534E-02 MILLICURIES     3.0997E-02 MR/HR AT 1 M      2.4122E 06 MEV/SEC

     GAMMA ENERGY        1.0200        0.8440        1.7500
     MR/HR AT 1 M     1.0538E-02    2.0034E-02    4.2046E-04
     MEV/SEC          8.2008E 05    1.5594E 06    3.2721E 04

TOTAL MATERIAL ACTIVITY       2.5124E 04 MILLICURIES     1.8209E 04 MR/HR AT 1 M      1.4170E 12 MEV/SEC
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SAMPLE FFCELEM III EXPERIMENTAL CAPSULE

NEUTRON FLUX 3.000E 12 1.500E 13 2.[illegible]E 13 4.000E 13 5 CYCLES IRRADIATION TIME 1.440E 04 MIN

ELEMENT	WEIGHT FRACTION	DPS AT ZERO DECAY TIME			ACTIVITY FRACTION PER NEUTRON GROUP			
TUNGSTEN	0.15100							
W 184 (N,G) W 185		3.574E 12	0.	0.	0.0000	0.0295	0.3473	0.6227
W 186 (N,G) W187		1.077E 14	0.	0.	0.0000	0.0019	0.0418	0.9563
W 186 (N,P) TA186		1.954E 05	0.	0.	1.0000	0.	0.	0.
TANTALUM	0.05830							
TA181 (N,G) TA182		4.277E 13	0.	0.	0.0000	0.0082	0.4949	0.4970
TA181 (N,2N) TA180M		5.136E 06	0.	0.	1.0000	0.	0.	0.
NICKEL	0.45500							
NI 58 (N,P) CO 58M--CO 58		8.764E 10	7.605E 09	0.	1.0000	0.	0.	0.
NI 58 (N,P) CO 58		3.257E 11	0.	0.	1.0000	0.	0.	0.
NI 58 (N,NP) CO 57		3.434E 10	0.	0.	1.0000	0.	0.	0.
NI 58 (N,2N) NI 57		4.196E 07	0.	0.	1.0000	0.	0.	0.
NI 60 (N,P) CO 60		2.320E 08	0.	0.	1.0000	0.	0.	0.
NI 62 (N,A) FE 59		2.596E 07	0.	0.	1.0000	0.	0.	0.
NI 64 (N,G) NI 65		1.944E 12	0.	0.	0.0000	0.0004	0.0284	0.9713
IRON	0.07430							
FE 54 (N,P) MN 54		1.240E 09	0.	0.	1.0000	0.	0.	0.
FE 54 (N,A) CR 51		2.244E 07	0.	0.	1.0000	0.	0.	0.
FE 56 (N,P) MN 56		2.477E 09	0.	0.	1.0000	0.	0.	0.
FE 58 (N,G) FE 59		5.314E 11	0.	0.	0.0000	0.0000	0.0015	0.9985
CHROMIUM	0.09420							
CR 50 (N,G) CR 51		1.456E 13	0.	0.	0.0000	0.0004	0.0283	0.9713
CR 50 (N,2N) CR 49		6.724E 05	0.	0.	1.0000	0.	0.	0.
CR 52 (N,P) V 52		5.116E 09	0.	0.	1.0000	0.	0.	0.
ALUMINUM	0.12700							
AL 27 (N,G) AL 28		1.514E 13	0.	0.	0.0001	0.0524	0.0269	0.9206
AL 27 (N,P) MG 27		2.986E 10	0.	0.	1.0000	0.	0.	0.
AL 27 (N,A) NA 24		6.344E 09	0.	0.	1.0000	0.	0.	0.
AL 27 (N,2N) AL 26		1.357E 04	0.	0.	1.0000	0.	0.	0.

TIME AFTER IRRADIATION 0. MIN

ALL OUTPUT FOR TOTAL MASS

W 185	5.6737E 04 MILLICURIES	6.[illegible]15E 02 MR/HR AT 1 M	4.8105E 10 MEV/SEC
W 187	2.9111E 06 MILLICURIES	5.[illegible]09E 05 MR/HR AT 1 M	4.5345E 13 MEV/SEC
TA186	5.2782E-03 MILLICURIES	4.[illegible]22E-03 MR/HR AT 1 M	3.1535E 05 MEV/SEC
TA182	1.1560E 06 MILLICURIES	4.[illegible]72E 05 MR/HR AT 1 M	3.4375E 13 MEV/SEC
TA182M	1.3881E 01 MILLICURIES	1.[illegible]86E-01 MR/HR AT 1 M	1.1195E 07 MEV/SEC
CO 58M	2.3667E 03 MILLICURIES	2.[illegible]55E 01 MR/HR AT 1 M	2.1910E 09 MEV/SEC
CO 58	5.0069E 03 MILLICURIES	3.[illegible]09E 03 MR/HR AT 1 M	2.7400E 11 MEV/SEC
CO 57	5.2540E 02 MILLICURIES	6.[illegible]01E 01 MR/HR AT 1 M	4.7160E 09 MEV/SEC
NI 57	1.1340E 00 MILLICURIES	7.[illegible]26E-01 MR/HR AT 1 M	6.1343E 07 MEV/SEC
CO 60	6.2702E 00 MILLICURIES	7.[illegible]29E 00 MR/HR AT 1 M	5.7999E 08 MEV/SEC
FE 59	1.4362E 04 MILLICURIES	8.[illegible]01E 03 MR/HR AT 1 M	6.3114E 11 MEV/SEC
NI 65	5.2671E 04 MILLICURIES	1.[illegible]39E 04 MR/HR AT 1 M	1.3416E 12 MEV/SEC
MN 54	3.3507E 01 MILLICURIES	1.[illegible]02E 01 MR/HR AT 1 M	1.0352E 09 MEV/SEC
CR 51	3.9321E 05 MILLICURIES	7.[illegible]64E 03 MR/HR AT 1 M	5.6159E 11 MEV/SEC
MN 56	6.6797E 01 MILLICURIES	5.[illegible]96E 01 MR/HR AT 1 M	4.3810E 09 MEV/SEC
CR 49	1.8164E-02 MILLICURIES	5.[illegible]72E-04 MR/HR AT 1 M	4.1379E 04 MEV/SEC
V 52	1.3825E 02 MILLICURIES	9.[illegible]55E 01 MR/HR AT 1 M	7.3662E 09 MEV/SEC
AL 28	4.1019E 05 MILLICURIES	3.[illegible]15E 05 MR/HR AT 1 M	2.7015E 13 MEV/SEC
MG 27	8.0690E 02 MILLICURIES	4.[illegible]93E 02 MR/HR AT 1 M	3.8516E 10 MEV/SEC
NA 24	1.7160E 02 MILLICURIES	3.[illegible]13E 02 MR/HR AT 1 M	2.6158E 10 MEV/SEC
AL 26	3.6666E-04 MILLICURIES	3.[illegible]62E-04 MR/HR AT 1 M	2.5496E 04 MEV/SEC

TOTAL MATERIAL ACTIVITY 5.0479E 06 MILLICURIES 1.4093E 06 MR/HR AT 1 M 1.[illegible]968E 14 MEV/SEC

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