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URANIUM DAUGHTER GROWTH MUST NOT BE NEGLECTED WHEN ADJUSTING PLUTONIUM MATERIALS FOR ASSAY AND ISOTOPIC CONTENTS

by

S. F. Marsh, W. D. Spall,
R. M. Abernathey, and J. E. Rein

ABSTRACT

Relationships are provided to compute the decreasing plutonium content and changing isotopic distribution of plutonium materials for the radioactive decay of ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{242}Pu to long-lived uranium daughters and of ^{241}Pu to ^{241}Am. This computation is important to the use of plutonium reference materials to calibrate destructive and nondestructive methods for assay and isotopic measurements, as well as to accountability inventory calculations.

I. INTRODUCTION

Calculation of the decreasing plutonium content and changing isotopic distribution of plutonium reference materials for the radioactive decay of ^{241}Pu to ^{241}Am is generally applied in analytical chemistry laboratories. Not usually recognized is that the effects of the radioactive decay of ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{242}Pu can exceed that of ^{241}Pu decay, depending on the plutonium isotopic distribution of the material. This is the case especially for materials having low ^{241}Pu isotopic abundances, a characteristic of presently available National Bureau of Standards "Standard Reference Materials" (SRM) certified for plutonium assay use.

The calculational relationships in this report provide, as a function of time, (a) the plutonium content, (b) grown-in quantities of ^{234}U, ^{235}U, ^{236}U, ^{238}U, and ^{241}Am, (c) plutonium isotopic distribution, and (d) plutonium atomic weight. The Fortran IV program for these calculations is provided as an appendix.

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II. DISCUSSION

A. General

For a time interval Δt, the number of parent atoms decayed is

$$N_o - N = N_o \left[1 - e^{-(\Delta t)(\ln 2)/(t_{\frac{1}{2}})} \right] . \qquad (1)$$

The published $t_{\frac{1}{2}}$ values[1,2] for the five plutonium isotopes given in Table I should be replaced by more reliable values as they become available. Table I also provides the atomic weights of the five plutonium isotopes, four uranium daughter isotopes, and ^{241}Am. Alpha decay, the main decay mode of ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{242}Pu, produces long-lived uranium daughters having essentially four fewer atomic mass units than the plutonium parents. The calculations account for these mass changes. Beta decay of ^{241}Pu to ^{241}Am does not change mass significantly, but does, of course, change the plutonium content.

TABLE I

PLUTONIUM ISOTOPE HALF-LIVES AND ATOMIC WEIGHTS

Isotope	Half-Life, Yr[a]	Atomic Weight
238	87.8	238.0495
239	24 390	239.0522
240	6 540	240.0538
241	14.7	241.0569
242	387 000	242.0588

[a]Ref. 1 for ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{242}Pu.
Ref. 2 for ^{241}Pu.

URANIUM DAUGHTER AND ^{241}AM ATOMIC WEIGHTS

Isotope	Atomic Weight
^{234}U	234.0410
^{235}U	235.0439
^{236}U	236.0456
^{238}U	238.0508
^{241}Am	241.0568

B. Plutonium Mass Decrease

The general equation giving the mass decrease of an individual plutonium isotope with time is

$$\Delta P_i/P_t = \frac{(AW)_{P_i}\left[(N_o)_{P_i}\left(1-e^{-(\Delta t)(\ln 2)/(t_{\frac{1}{2}})_{P_i}}\right)\right]\Big/6.0225\ E17}{(AW)_{P_t}\ (N_o)_{P_t}\Big/6.0225\ E23}\ , \qquad (2)$$

which reduces to

$$\Delta P_i/P_t = (1E6)(AF_o)_{P_i}\left[(AW)_{P_i}\ /\ (AW)_{P_t}\right]\left[1-e^{-(\Delta t)(\ln 2)\ /\ (t_{\frac{1}{2}})_{P_i}}\right]\ , \qquad (3)$$

in which

ΔP_i = micrograms decrease of individual plutonium isotope, P_i
P_t = grams total plutonium
$(AW)_{P_i}$ = atomic weight of P_i
$(AW)_{P_t}$ = atomic weight of P_t
$(N_o)_{P_i}$ = atoms of P_i per gram of P_t at initial time
$(N_o)_{P_t}$ = atoms of P_t per gram of P_t at initial time
Δt = decay time, years
$(t\frac{1}{2})_{P_i}$ = half-life, years, of P_i
$(AF_o)_{P_i}$ = atom abundance fraction of P_i at initial time.

The total mass decrease of plutonium is the sum of the five individual plutonium isotope mass decreases.

C. Uranium Mass Increase

The general equation giving the mass increase of a uranium daughter with time is

$$\Delta U_i \;/\; P_t = \left(\Delta P_i \;/\; P_t\right) \quad \left[(AW)_{U_i} \;/\; (AW)_{P_i}\right] \quad , \tag{4}$$

in which

ΔU_i = micrograms increase of uranium daughter from decay of parent P_i
$(AW)_{U_i}$ = atomic weight of U_i.

The total mass increase of uranium is the sum of the four individual uranium isotope mass increases.

D. ^{241}Am Mass Increase

The ^{241}Am mass increase is not significantly different from the ^{241}Pu mass decrease given by Eq. (3).

E. Plutonium Content

The equation giving the decreasing plutonium content with time is

$$A = \frac{A_o - A_o D/1E6}{A_o - A_o D/1E6 + (1-A_o) + A_o G/1E6} \quad , \tag{5}$$

which reduces to

$$A = \frac{A_o(1E6) - D)}{1E6 - A_o(D-G)} \quad , \tag{6}$$

in which

A = plutonium content, grams plutonium per gram material, at time $t_o + \Delta t$
A_o = plutonium content, grams plutonium per gram material, at time t_o
D = total plutonium mass decrease, micrograms plutonium per gram initial plutonium, during time Δt
G = mass increase of ^{241}Am and total uranium, micrograms per gram initial plutonium, in time Δt.

F. Plutonium Isotopic Distribution

The basic equation applies:

$$N_{P_i} = N_{o_{P_i}} \left[e^{-(\Delta t)(\ln 2)/(t_{\frac{1}{2}})} \right] \quad . \tag{7}$$

The five N_i values are computed and renormalized to a total atom fraction of 1 (total atom percentage of 100).

G. Plutonium Atomic Weight

The atomic weight of the plutonium at time $t_o + \Delta t$ is given by

$$(AW)_{P_t} = \sum \left[(AF)_{P_i} \quad (AW)_{P_i} \right] \quad , \tag{8}$$

in which

$(AW)_{P_t}$ = atomic weight of plutonium, at time $t_o + \Delta t$
$(AF)_{P_i}$ = renormalized atom fraction of individual plutonium isotope calculated by use of Eq. (7)
$(AW)_{P_i}$ = atomic weight of P_i.

III. EXAMPLE CALCULATION

Table II gives the decreased plutonium content; grown-in quantities of ^{234}U, ^{235}U, ^{236}U, ^{238}U, and ^{241}Am; and changed plutonium isotopic distribution for a plutonium metal typical of a National Bureau of Standards SRM at a 10-yr Δt. For purposes of demonstration, the initial plutonium content is taken as 1 g Pu per gram material (or 100% purity). It is noted that the plutonium content decreases 0.05% from 100.00% to 99.95% and that 0.02% (or 40 relative per cent of the 0.05% decrease) is caused by ^{241}Pu decay.

TABLE II

EXAMPLE CALCULATION FOR 10-YR DECAY

Pu Isotope	$(AF_o)_{P_i}$	$(AF)_{P_i}$	$\Delta P_i/P_t$, μg/g	Daughter Formed Isotope	μg/g
238	0.00003	0.000027_7	2.268	^{234}U	2.229
239	0.97617	0.97638_7	277.353	^{235}U	272.703
240	0.02324	0.02322_7	24.719	^{236}U	24.306
241	0.00054	0.00033_7	204.693	^{241}Am	204.693
242	0.00002	0.000002_0	0.000_4	^{238}U	0.000_4
$(AW)_{P_t}$ = 239.0764			Σ = 509.033		Σ = 503.931

Plutonium Content

$$A = \frac{A_o(1E6-D)}{1E6-A_o(D-G)} = \frac{1(1E6 - 509.033)}{1E6 - 1\ (509.033-503.931)}$$

$$= 0.99949_6 \text{ (or 99.95\%)}$$

Plutonium Atomic Weight

$$(AW)_{P_t} = \sum \left[(AF)_{P_i}\ (AW)_{P_i}\right]$$

$$= (0.000027_7)(238.0495) + (0.97638_7)(239.0522) + (0.02322_7)(240.0538) + (0.00033_7)(241.0569) + (0.00002_0)(242.0588)$$

$$= 239.0759.$$

REFERENCES

1. N. E. Holden and F. W. Walker, Chart of the Nuclides, Eleventh Edition, Knolls Atomic Power Laboratory (1972).

2. E. Garner, National Bureau of Standards, Personal Communication, April 1976. Also value recommended on National Bureau of Standards certificates for plutonium SRM.

APPENDIX

FORTRAN IV COMPUTATIONAL PROGRAM
LASL IDENTIFICATION: LP-0710

```
00100 PROGRAM PUDCAY(INPUT,OUTPUT)
00110C*****************************************************************
00120C
00130C PROGRAM TO CALCULATE PLUTONIUM PURITY DECREASE AS A FUNCTION OF
00140C TIME. WRITTEN 5-12-76 BY W. DALE SPALL FOR USE ON THE LASL 6600
00150C KRONOS TIME SHARING SYSTEM.
00160C
00170C THIS PROGRAM GENERATES TABLES OF DAUGHTER ISOTOPE GROW-IN BASED
00180C ON AN INITIAL ANALYZED PLUTONIUM CONTENT AND ISOTOPIC DISTRIBUTION.
00190C THE CALCULATED VALUES ARE TABULATED BY THE MONTH, WITH ZERO TIME SET
00200C AS THE FIRST OF THE MONTH DESIGNATED BY THE ANALYSIS DATE. THE
00210C VALUES CALCULATED ARE FOR ONE MONTH INTERVALS FROM THAT DATE. CARE
00220C MUST BE TAKEN IN SELECTING THE STARTING MONTH DATE TO MINIMIZE THE
00230C EFFECTS OF PARTIAL MONTHS. THE PU ISOTOPIC DISTRIBUTION MUST BE IN
00240C ATOM PERCENTS. SINGLE TIME VALUES CANNOT BE CALCULATED EASILY.
00250C
00260C VARIABLE LIST
00270C ITIT, COM1, COM2, COM3 -- FREE FORM INFORMATION LINES
00280C PU(1 TO 5) -- INITIAL PLUTONIUM ISOTOPIC 238 TO 242
00290C UG -- INITIAL URANIUM CONTENT IN UG/G
00300C GAM -- INITIAL AMERICIUM CONTENT IN UG/G
00310C PUI -- INITIAL PLUTONIUM PURITY IN PERCENT
00320C OUTPUT OPTIONS
00330C K2 -- INDIVIDUAL URANIUM ISOTOPIC GROW-IN IN UG
00340C K3 -- TOTAL URANIUM GROW-IN IN UG
00350C K4 -- TOTAL AMERICIUM GROW-IN
00360C K5 -- PLUTONIUM PURITY IN %
00370C K6 -- PLUTONIUM ISOTOPIC VARIATION AS FUNCTION OF TIME-ATOM %
00380C Y -- NUMBER OF YEARS TO BE COVERED IN THE TABLES
00390C N -- TOTAL NUMBER OF MONTHS TO BE COVERED IN THE TABLES
00400C SPU -- SUM OF THE UG PU LOST IN TIME DELTA T
00410C SU -- SUM OF UG U GAINED IN TIME DELTA T
00420C U234,U235,U236,U238 -- UG OF EACH U ISOTOPE GAINED IN DELTA T
00430C PU238,PU239,PU240,PU241,PU242 -- UG PU LOST IN DELTA T
00440C PURE -- PU PURITY IN TIME DELTA T
00450C AW -- INITIAL ATOMIC WEIGHT PU CALCULATED FROM ISOTOPIC
00460C AWT -- ATOMIC WEIGHT PU CALCULATED AT DELTA T
00470C AM241 -- UG AM241 FORMED IN DELTA T
00480C PUA,PUB,PUC,PUD,PUE -- ATOM % PU ISOTOPES IN DELTA T
00490C TIM -- DELTA TIME IN DECIMAL MONTHS
00500C T(1 TO 5) -- HALF LIVES OF PU USED IN DECAY CALCULATION
00510C
00520C*****************************************************************
00530 DIMENSION ITIT(8),COM1(8),COM2(8),COM3(8),T(5),PU(5),SU(300),
00540+U234(300),U235(300),U236(300),U238(300),AM241(300),PU238(300),
00550+PU239(300),PU240(300),PU241(300),PU242(300),PURE(300),
00560+TIM(300),SPU(300)
00570 101 PRINT 100
00580 100 FORMAT(*PU DECAY TABLE GENERATOR*,/,
00590+*ALL INPUT VALUES MUST EITHER BE TERMINATED BY A DECIMAL, OR*,/,
00600+*CONTAIN A DECIMAL. THE EXCEPTIONS ARE THE OUTPUT SELECTIONS*,/,
00610+*AND THE ANALYSIS DATE*)
00620 PRINT 110
00630 110 FORMAT(*INPUT SAMPLE NAME--UP TO 80 CHRS*)
00640 READ 120, (ITIT(I),I=1,8)
00650 120 FORMAT(8A10)
00660 PRINT 130
00670 130 FORMAT(*INPUT UP TO 3 LINES OF COMMENTS OR 3 SPACE-BAR RETURNS*)
00680 READ 120, (COM1(I),I=1,8)
00690 READ 120, (COM2(I),I=1,8)
00700 READ 120, (COM3(I),I=1,8)
00710 PRINT 140
```

```
00720 140 FORMAT(*INPUT DATE ANALYZED AS MMYY*,
00730 READ 150, DATE,YEAR
00740 150 FORMAT(2F2.0)
00750 PRINT 160
00760 160 FORMAT(*INPUT PU ISOTOPIC DISTRIBUTION AS ATOM PERCENTS*,/,*PU238*)
00770 READ 170, PU(1)
00780 260 FORMAT(I1)
00790 170 FORMAT(F10.0)
00800 PRINT 180
00810 180 FORMAT(*PU239*,
00820 READ 170, PU(2)
00830 PRINT 190
00840 190 FORMAT(*PU 240*)
00850 READ 170, PU(3)
00860 PRINT 200
00870 200 FORMAT(*PU241*)
00880 READ 170,PU(4)
00890 PRINT 210
00900 210 FORMAT(*PU242*)
00910 READ 170,PU(5)
00920 PRINT 220
00930 220 FORMAT(*INPUT INITIAL ANALYZED TOTAL URANIUM CONTENT IN UG/G*)
00940 READ 170, UG
00950 PRINT 230
00960 230 FORMAT(*INPUT INITIAL ANALYZED AMERICIUM CONTENT IN UG/G*)
00970 READ 170, GAM
00980 PRINT 240
00990 240 FORMAT(*INPUT INITIAL ANALYZED PLUTONIUM CONTENT IN PERCENT*)
01000 READ 170, PUI
01010 320 PRINT 330
01020 330 FORMAT(*INPUT NUMBER OF YEARS TO BE COVERED IN THE TABLES AS YY.*,
01030*/,*THE DECIMAL IS REQUIRED, AND NOT MORE THAN 25 YEARS MAY BE USED*)
01040 READ 170, Y
01050 PRINT 340
01060 340 FORMAT(*INPUT A 1 FOR EACH OUTPUT OPTION DESIRED. A ZERO GIVES*,/,
01070**NO OUTPUT FOR THAT TABLE*,/,*INDIVIDUAL URANIUM ISOTOPE GROW-IN IN UG*)
01080 READ 260,K2
01090 PRINT 350
01100 350 FORMAT(*TOTAL URANIUM GROW-IN IN UG*)
01110 READ 260, K3
01120 PRINT 360
01130 360 FORMAT(*TOTAL AMERICIUM GROW-IN IN UG*)
01140 READ 260, K4
01150 PRINT 370
01160 370 FORMAT(*PLUTONIUM PURITY IN % DUE TO DECAY*)
01170 READ 260, K5
01180 PRINT 380
01190 380 FORMAT(*PU ISOTOPIC DISTRIBUTION AS ATOM % FOR ALL PU ISOTOPES*)
01200 READ 260, K6
01210C    SET UP INITIAL INDICIES
01220 K=DATE
01230 L=K+1
01240 M=12.*Y
01250 M=K+M
01260C     ZERO INITIAL WEIGHT ARRAYS
01270 DO 390 I=1,K
01280 SPU(I)=0.
01290 SU(I)=0.
01300 U234(I)=0.
01310 U235(I)=0.
01320 U236(I)=0.
01330 U238(I)=0.
01340 PU238(I)=0.
01350 PU239(I)=0.
01360 PU240(I)=0.
01370 PU241(I)=0.
```

```
01380 PU242(I)=0.
01390 AM241(I)=0.
01400 PURE(I)=0.
01410 390 CONTINUE
01420C     CALCULATE INITIAL  ATOMIC WEIGHT OF PU FROM ISOTOPIC
01430 P1=PU(1)*2.380496
01440 P2=PU(2)*2.390522
01450 P3=PU(3)*2.400538
01460 P4=PU(4)*2.410569
01470 P5=PU(5)*2.420588
01430 AW=P1+P2+P3+P4+P5
01490C     SET IN HALF LIVES IN YEARS
01500 T(1)=87.8
01510 T(2)=24390.
01520 T(3)=6540.
01530 T(4)=14.7
01540 T(5)=387000.
01550C      GENERATE DELTA TIME
01560 DO 400 I=L,M
01570 A=I-K
01580 TIM(I)=A/12.
01590 400 CONTINUE
01600C      SET INITIAL VALUES
01610 SPU(K)=PUI
01620 SU(K)=UG
01630 AM241(K)=GAM
01640 PURE(K)=PUI
01650C      CALCULATE GROW-IN AND DECAY
01660 PUI=PUI/100.
01670 DO 410 I=L,M
01680 R=-(ALOG(2.)*TIM(I))
01690 E1=1.-EXP(R/T(1))
01700 E2=1.-EXP(R/T(2))
01710 E3=1.-EXP(R/T(3))
01720 E4=1.-EXP(R/T(4))
01730 E5=1.-EXP(R/T(5))
01740 U234(I)=2340410.*PU(1)*E1/AW
01750 U235(I)=2350439.*PU(2)*E2/AW
01760 U236(I)=2360456.*PU(3)*E3/AW
01770 U238(I)=2380508.*PU(5)*E5/AW
01780 AM241(I)=2410568.*PU(4)*E4/AW+GAM
01790 PU238(I)=2380496.*PU(1)*E1/AW
01800 PU239(I)=2390522.*PU(2)*E2/AW
01810 PU240(I)=2400538.*PU(3)*E3/AW
01820 PU241(I)=2410569.*PU(4)*E4/AW
01830 PU242(I)=2420588.*PU(5)*E5/AW
01840 SU(I)=U234(I)+U235(I)+U236(I)+U238(I)+UG
01850 SPU(I)=PU238(I)+PU239(I)+PU240(I)+PU241(I)+PU242(I)
01860C     AT THIS POINT SPU IS PU DECREASE IN UG--CONVERT TO G/TOTAL G
01870 S=PUI*(1E6-SPU(I))
01880 SS=1E6-(PUI*(SPU(I)-PU241(I)-SU(I)))
01890 PURE(I)=100.*S/SS
01900 410 CONTINUE
01910C     READY FOR OUTPUT
01920 PRINT 420
01930 420 FORMAT(//////////)
01940 PRINT 430
01950 430 FORMAT(*SAMPLE INFORMATION   ATOM PERCENT INPUT DATA*)
01960 PRINT 120,(ITIT(I),I=1,8)
01970 PRINT 120,(COM1(I),I=1,8)
01980 PRINT 120,(COM2(I),I=1,8)
01990 PRINT 120,(COM3(I),I=1,8)
02000 PRINT 440,DATE,YEAR
02010 440 FORMAT(///,*DATE ANALYZED-- MONTH-YEAR*,F3.0,*-*,F2.0)
02020 PRINT 450, UG
02030 450 FORMAT(*INITIAL ANALYZED URANIUM *,F6.2,* UG/G*)
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```
02040 PRINT 460,GAM
02050 460 FORMAT(*INITIAL ANALYZED AMERICIUM *,F6.2,* UG/G*)
02060 PRINT 470,PUI
02070 470 FORMAT(*INITIAL ANALYZED PLUTONIUM PURITY *,F9.4,* PERCENT*)
02080 PRINT 480,(PU(I),T(I),I=1,5)
02090 480 FORMAT(*INITIAL PLUTONIUM ISOTOPIC AND CORRESPONDING HALF-LIFE*,
02100+/,*238 PU*,F9.5,2X,F7.1,/,*239 PU*,F9.5,2X,F7.1,/,*240 PU*,F9.5,2X,
02110+F7.1,/,*241 PU*,F9.5,2X,F7.1,/,*242 PU*,F9.5,2X,F8.1,///)
02120 PRINT 490 ,AW
02130 490 FORMAT(*CALCULATED INITIAL ATOMIC WEIGHT OF PLUTONIUM*,F12.6,//)
02140 550 IF(K2.EQ.1) 560,610
02150 560 PRINT 570,(ITIT(I),I=1,8)
02160 570 FORMAT(10/,*U 234 GROW-IN IN UG/G*,//,8A10,//)
02170 CALL OUTP(U234,M,YEAR)
02180 PRINT 580,(ITIT(I),I=1,8)
02190 580 FORMAT(10/,*U 235 GROW-IN IN UG/G*,//,8A10,//)
02200 CALL OUTP(U235,M,YEAR)
02210 PRINT 590,(ITIT(I),I=1,8)
02220 590 FORMAT(10/,*U 236 GROW-IN IN UG/G*,//,8A10,//)
02230 CALL OUTP(U236,M,YEAR)
02240 PRINT 600,(ITIT(I),I=1,8)
02250 600 FORMAT(10/,*U 238 GROW-IN IN UG/G*,//,8A10,//)
02260 CALL OUTP(U238,M,YEAR)
02270 610 IF(K3.EQ.1) 620,640
02280 620 PRINT 630,(ITIT(I),I=1,8)
02290 630 FORMAT(10/,*TOTAL URANIUM GROW-IN IN UG/G*,//,8A10,//)
02300 CALL OUTP(SU,M,YEAR)
02310 640 IF(K4.EQ.1) 650,680
02320 650 PRINT 670,(ITIT(I),I=1,8)
02330 670 FORMAT(10/,*TOTAL AMERICIUM GROW-IN IN UG/G*,//,8A10,//)
02340 CALL OUTP(AM241,M,YEAR)
02350 680 IF(K5.EQ.1) 690,710
02360 690 PRINT 700,(ITIT(I),I=1,8)
02370 700 FORMAT(10/,*PLUTONIUM PURITY OF RCTM IN PERCENT*,//,8A10,//)
02380 CALL PUOUT(PURE,YEAR,Y)
02390 710 IF(K6.EQ.1) 720,770
02400 720 PRINT 740,(ITIT(I),I=1,8)
02410 740 FORMAT(10/,*VARIATION OF PLUTONIUM ISOTOPIC*,//,8A10,//,
02420+*MO YR   238 PU      239 PU      240 PU      241 PU      242 PU*,
02430+*      AT. WT.*)
02440C     CALCULATE ATOMS OF PU FOR ATOM % AND NEW ATOMIC WEIGHT
02450 D1=DATE+1.
02460 Y1=YEAR
02470 LINE=1
02480 DO 750 I=L,M
02490 S=0.
02500 PUA=PU(1)*(EXP(-ALOG(2.)*TIM(I)/T(1)))
02510 PUB=PU(2)*(EXP(-ALOG(2.)*TIM(I)/T(2)))
02520 PUC=PU(3)*(EXP(-ALOG(2.)*TIM(I)/T(3)))
02530 PUD=PU(4)*(EXP(-ALOG(2.)*TIM(I)/T(4)))
02540 PUE=PU(5)*(EXP(-ALOG(2.)*TIM(I)/T(5)))
02550 S=PUA+PUB+PUC+PUD+PUE
02560 PUA=PUA*100./S
02570 PUB=PUB*100./S
02580 PUC=PUC*100./S
02590 PUD=PUD*100./S
02600 PUE=PUE*100./S
02610 G1=2.380495*PUA
02620 G2=2.390522*PUB
02630 G3=2.40054*PUC
02640 G4=2.410567*PUD
02650 G5=2.420587*PUE
02660 AWT=G1+G2+G3+G4+G5
02670 PRINT 760,D1,Y1,PUA,PUB,PUC,PUD,PUE,AWT
02680 760 FORMAT(F2.0,X,F2.0,6(F10.6,2X))
02690 LINE=LINE+1
```

```
02700 IF(LINE.GT.50)900,751
02710 900 PRINT 740,(ITIT(I),I=1,8)
02720 LINE=1
02730 751 D1=D1+1.
02740 IF(D1.EQ.13.)765,750
02750 765 D1=1.
02760 Y1=Y1+1.
02770 750 CONTINUE
02780 770 PRINT 420
02790 PRINT 780
02800 780 FORMAT(*IF NEW SAMPLE DESIRED, TYPE 1 - IF DIFFERENT OUTPUTS*,/,
02810++OF SAME DATA IS DESIRED, TYPE 2 - TYPE ZERO TO END*)
02820 READ 260,K7
02830 IF(K7.EQ.0)1000,790
02840 790 IF(K7.EQ.1)101,800
02850 800 IF(K7.EQ.2)320,1000
02860 1000 CONTINUE
02870 END
02880 SUBROUTINE OUTP(A,B,C)
02890 DIMENSION A(300)
02900 INTEGER B
02910 PRINT 100
02920 100 FORMAT(*YEAR  JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG*,
02930+*   SEP   OCT   NOV   DEC*)
02940 D=C+1900.
02950 IF(A(B).GT.999.)140,150
02960 140 DO 160 I=1,B,12
02970 N=I+11
02980 PRINT 170,D,(A(J),J=I,N)
02990 170 FORMAT(F4.0,2X,12(F5.0,X))
03000 160 D=D+1
03010 GO TO 180
03020 150 DO 120 I=1,B,12
03030 N=I+11
03040 PRINT 130,D,(A(J),J=I,N)
03050 130 FORMAT(F4.0,2X,12(F5.1,X))
03060 120 D=D+1.
03070 180 D=0.0
03080 RETURN
03090 END
03100 SUBROUTINE PUOUT(A,B,C)
03110 DIMENSION A(300)
03120 E=1900.+B+C-1.
03130 F=B+1900.
03140 I=1
03150 150 F1=F+1
03160 F2=F+2
03170 F3=F+3
03180 F4=F+4
03190 PRINT 100,F,F1,F2,F3,F4
03200 100 FORMAT(5/,*MONTH*,2X,F4.0,4(11X,F4.0))
03210 D=1.
03220 160 PRINT 130,D,A(I),A(I+12),A(I+24),A(I+36),A(I+48)
03230 130 FORMAT(F2.0,4X,F8.4,4(6X,F8.4))
03240 D=D+1.
03250 I=I+1
03260 IF(D.EQ.13)140,160
03270 140 D=1.
03280 I=I+48
03290 F=F+5.
03300 IF(F.GE.E)170,150
03310 170 F=0.
03320 RETURN
03330 END
```

```
SAMPLE INFORMATION   ATOM PERCENT INPUT DATA
EXAMPLE CALCULATION FOR 10 YEAR DECAY PERIOD
THIS IS FAIRLY TYPICAL OF PLUTONIUM METAL MATERIALS
THE INITIAL PURITY HAS BEEN SET TO 100% FOR THE SAKE OF CLARITY
THE INITIAL ASSAYED AMOUNTS OF URANIUM AND AMERICIUM HAVE BEEN ASSUMED TO 0


DATE ANALYZED-- MONTH-YEAR  1-76
INITIAL ANALYZED URANIUM   0.   UG/G
INITIAL ANALYZED AMERICIUM   0.   UG/G
INITIAL ANALYZED PLUTONIUM PURITY    1.0000 PERCENT
INITIAL PLUTONIUM ISOTOPIC AND CORRESPONDING HALF-LIFE
238 PU   .00300     87.8
239 PU 97.61700  24390.0
240 PU  2.32400   6540.0
241 PU   .05400     14.7
242 PU   .00200  387000.0


CALCULATED INITIAL ATOMIC WEIGHT OF PLUTONIUM  239.076590
```

```
PU DECAY TABLE GENERATOR
ALL INPUT VALUES MUST EITHER BE TERMINATED BY A DECIMAL, OR
CONTAIN A DECIMAL. THE EXCEPTIONS ARE THE OUTPUT SELECTIONS
AND THE ANALYSIS DATE
INPUT SAMPLE NAME--UP TO 80 CHRS
? EXAMPLE CALCULATION FOR 10 YEAR DECAY PERIOD
INPUT UP TO 3 LINES OF COMMENTS OR 3 SPACE-BAR RETURNS
? THIS IS FAIRLY TYPICAL OF PLUTONIUM METAL MATERIALS
? THE INITIAL PURITY HAS BEEN SET TO 100% FOR THE SAKE OF CLARITY
? THE INITIAL ASSAYED AMOUNTS OF URANIUM AND AMERICIUM HAVE BEEN ASSUMED TO 0
INPUT DATE ANALYZED AS MMYY
? 0176
INPUT PU ISOTOPIC DISTRIBUTION AS ATOM PERCENTS
PU238
? .003
PU239
? 97.617
PU 240
? 2.324
PU241
? .054
PU242
? .002
INPUT INITIAL ANALYZED TOTAL URANIUM CONTENT IN UG/G
? 0.
INPUT INITIAL ANALYZED AMERICIUM CONTENT IN UG/G
? 0.
INPUT INITIAL ANALYZED PLUTONIUM CONTENT IN PERCENT
? 100.
INPUT NUMBER OF YEARS TO BE COVERED IN THE TABLES AS YY.
THE DECIMAL IS REQUIRED, AND NOT MORE THAN 25 YEARS MAY BE USED
? 10.
INPUT A 1 FOR EACH OUTPUT OPTION DESIRED. A ZERO GIVE
NO OUTPUT FOR THAT TABLE
INDIVIDUAL URANIUM ISOTOPE GROW-IN IN UG
? 1
TOTAL URANIUM GROW-IN IN UG
? 1
TOTAL AMERICIUM GROW-IN IN UG
? 1
PLUTONIUM PURITY IN % DUE TO DECAY
? 1
PU ISOTOPIC DISTRIBUTION AS ATOM % FOR ALL PU ISOTOPES
? 1
```

U 234 GROW-IN IN UG/G

EXAMPLE CALCULATION FOR 10 YEAR DECAY PERIOD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1976	0.	.0	.0	.1	.1	.1	.1	.1	.2	.2	.2	.2
1977	.2	.3	.3	.3	.3	.3	.3	.4	.4	.4	.4	.4
1978	.5	.5	.5	.5	.5	.6	.6	.6	.6	.6	.6	.7
1979	.7	.7	.7	.7	.8	.8	.8	.8	.8	.9	.9	.9
1980	.9	.9	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1
1981	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3
1982	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.6
1983	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.8	1.8
1984	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.9	2.0	2.0	2.0
1985	2.0	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2
1986	2.2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

U 235 GROW-IN IN UG/G

EXAMPLE CALCULATION FOR 10 YEAR DECAY PERIOD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1976	0.	2.3	4.5	6.8	9.1	11.4	13.6	15.9	18.2	20.5	22.7	25.0
1977	27.3	29.5	31.8	34.1	36.4	38.6	40.9	43.2	45.5	47.7	50.0	52.3
1978	54.5	56.8	59.1	61.4	63.6	65.9	68.2	70.5	72.7	75.0	77.3	79.5
1979	81.8	84.1	86.4	88.6	90.9	93.2	95.5	97.7	100.0	102.3	104.5	106.8
1980	109.1	111.4	113.6	115.9	118.2	120.5	122.7	125.0	127.3	129.5	131.	134.1
1981	136.4	138.6	140.9	143.2	145.5	147.7	150.0	152.3	154.5	156.8	159.1	161.4
1982	163.6	165.9	168.2	170.4	172.7	175.0	177.3	179.5	181.8	184.1	186.4	188.6
1983	190.9	193.2	195.4	197.7	200.0	202.3	204.5	206.8	209.1	211.4	213.6	215.9
1984	218.2	220.4	222.7	225.0	227.3	229.5	231.8	234.1	236.3	238.6	240.9	243.2
1985	245.4	247.7	250.0	252.3	254.5	256.8	259.1	261.3	263.6	265.9	268.2	270.4
1986	272.7	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

U 236 GROW-IN IN UG/G

EXAMPLE CALCULATION FOR 10 YEAR DECAY PERIOD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1976	0.	.2	.4	.6	.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2
1977	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.9	4.1	4.3	4.5	4.7
1978	4.9	5.1	5.3	5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.9	7.1
1979	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5
1980	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.8	12.0
1981	12.2	12.4	12.6	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.2	14.4
1982	14.6	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	16.8
1983	17.0	17.2	17.4	17.6	17.8	18.0	18.2	18.4	18.6	18.8	19.0	19.2
1984	19.4	19.6	19.9	20.1	20.3	20.5	20.7	20.9	21.1	21.3	21.5	21.7
1985	21.9	22.1	22.3	22.5	22.7	22.9	23.1	23.3	23.5	23.7	23.9	24.1
1986	24.3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

U 238 GROW-IN IN UG/G

EXAMPLE CALCULATION FOR 10 YEAR DECAY PERIOD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1976	0.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1977	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1978	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1979	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1980	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1981	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1982	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1983	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1984	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1985	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1986	.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TOTAL URANIUM GROW-IN IN UG/G

EXAMPLE CALCULATION FOR 10 YEAR DECAY PERIOD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1976	0.	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	24.9	27.4
1977	29.9	32.4	34.9	37.4	39.9	42.4	44.9	47.4	49.9	52.4	54.9	57.4
1978	59.9	62.4	64.9	67.4	69.8	72.3	74.8	77.3	79.8	82.3	84.8	87.3
1979	89.8	92.3	94.8	97.3	99.8	102.3	104.8	107.3	109.8	112.2	114.7	117.2
1980	119.7	122.2	124.7	127.2	129.7	132.2	134.7	137.2	139.7	142.2	144.7	147.2
1981	149.7	152.1	154.6	157.1	159.6	162.1	164.6	167.1	169.6	172.1	174.6	177.1
1982	179.6	182.1	184.6	187.1	189.5	192.0	194.5	197.0	199.5	202.0	204.5	207.0
1983	209.5	212.0	214.5	217.0	219.5	222.0	224.5	226.9	229.4	231.9	234.4	236.9
1984	239.4	241.9	244.4	246.9	249.4	251.9	254.4	256.9	259.4	261.8	264.3	266.8
1985	269.3	271.8	274.3	276.8	279.3	281.8	284.3	286.8	289.3	291.8	294.3	296.7
1986	299.2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TOTAL AMERICIUM GROW-IN IN UG/G

EXAMPLE CALCULATION FOR 10 YEAR DECAY PERIOD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1976	0.	2.1	4.3	6.4	8.5	10.6	12.7	14.8	16.8	18.9	21.0	23.0
1977	25.1	27.1	29.1	31.2	33.2	35.2	37.2	39.2	41.2	43.1	45.1	47.0
1978	49.0	50.9	52.9	54.8	56.7	58.6	60.5	62.4	64.3	66.2	68.1	70.0
1979	71.8	73.7	75.5	77.4	79.2	81.0	82.8	84.6	86.4	88.2	90.0	91.8
1980	93.6	95.4	97.1	98.9	100.6	102.4	104.1	105.8	107.5	109.3	111.0	112.7
1981	114.4	116.0	117.7	119.4	121.1	122.7	124.4	126.0	127.7	129.3	130.9	132.6
1982	134.2	135.8	137.4	139.0	140.6	142.2	143.7	145.3	146.9	148.4	150.0	151.5
1983	153.1	154.6	156.1	157.7	159.2	160.7	162.2	163.7	165.2	166.7	168.1	169.6
1984	171.1	172.6	174.0	175.5	176.9	178.4	179.8	181.2	182.6	184.1	185.5	186.9
1985	188.3	189.7	191.1	192.5	193.8	195.2	196.6	198.0	199.3	200.7	202.0	203.4
1986	204.7	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PLUTONIUM PURITY OF RCTM IN PERCENT

EXAMPLE CALCULATION FOR 10 YEAR DECAY PERIOD

MONTH	1976	1977	1978	1979	1980
1	100.0000	99.9945	99.9891	99.9838	99.9787
2	99.9995	99.9940	99.9887	99.9834	99.9782
3	99.9991	99.9936	99.9882	99.9830	99.9778
4	99.9986	99.9931	99.9878	99.9825	99.9774
5	99.9982	99.9927	99.9873	99.9821	99.9770
6	99.9977	99.9922	99.9869	99.9817	99.9765
7	99.9972	99.9918	99.9865	99.9812	99.9761
8	99.9968	99.9913	99.9860	99.9808	99.9757
9	99.9963	99.9909	99.9856	99.9804	99.9753
10	99.9959	99.9904	99.9851	99.9800	99.9749
11	99.9954	99.9900	99.9847	99.9795	99.9744
12	99.9950	99.9896	99.9843	99.9791	99.9740

MONTH	1981	1982	1983	1984	1985
1	99.9736	99.9686	99.9637	99.9589	99.9542
2	99.9732	99.9682	99.9633	99.9586	99.9538
3	99.9728	99.9678	99.9629	99.9582	99.9535
4	99.9723	99.9674	99.9625	99.9578	99.9531
5	99.9719	99.9670	99.9621	99.9574	99.9527
6	99.9715	99.9666	99.9617	99.9570	99.9523
7	99.9711	99.9662	99.9613	99.9566	99.9519
8	99.9707	99.9658	99.9609	99.9562	99.9515
9	99.9703	99.9654	99.9605	99.9558	99.9511
10	99.9699	99.9650	99.9601	99.9554	99.9508
11	99.9694	99.9646	99.9597	99.9550	99.9504
12	99.9690	99.9641	99.9593	99.9546	99.9500

VARIATION OF PLUTONIUM ISOTOPIC

EXAMPLE CALCULATION FOR 10 YEAR DECAY PERIOD

MO	YR	238 PU	239 PU	240 PU	241 PU	242 PU	AT. WT.
2	76	.002998	97.617223	2.323990	.053788	.002000	239.076590
3	76	.002996	97.617446	2.323981	.053578	.002000	239.076586
4	76	.002994	97.617667	2.323971	.053368	.002000	239.076581
5	76	.002992	97.617888	2.323961	.053159	.002000	239.076577
6	76	.002990	97.618108	2.323951	.052951	.002000	239.076573
7	76	.002988	97.618327	2.323941	.052743	.002000	239.076569
8	76	.002986	97.618545	2.323932	.052537	.002000	239.076564
9	76	.002984	97.618763	2.323922	.052331	.002000	239.076560
10	76	.002982	97.618980	2.323912	.052126	.002000	239.076556
11	76	.002980	97.619196	2.323902	.051922	.002000	239.076552
12	76	.002979	97.619411	2.323892	.051718	.002000	239.076548
1	77	.002977	97.619625	2.323882	.051516	.002000	239.076544
2	77	.002975	97.619839	2.323872	.051314	.002000	239.076539
3	77	.002973	97.620052	2.323862	.051113	.002000	239.076535
4	77	.002971	97.620264	2.323852	.050913	.002000	239.076531
5	77	.002969	97.620475	2.323842	.050713	.002000	239.076527
6	77	.002967	97.620686	2.323832	.050515	.002000	239.076523
7	77	.002965	97.620896	2.323822	.050317	.002000	239.076519
8	77	.002963	97.621105	2.323812	.050120	.002000	239.076515
9	77	.002961	97.621313	2.323802	.049923	.002000	239.076511
10	77	.002959	97.621521	2.323792	.049728	.002000	239.076507
11	77	.002957	97.621728	2.323782	.049533	.002000	239.076503
12	77	.002955	97.621934	2.323772	.049339	.002000	239.076499
1	78	.002953	97.622139	2.323762	.049146	.002000	239.076495
2	78	.002951	97.622344	2.323752	.048953	.002000	239.076491
3	78	.002949	97.622547	2.323742	.048761	.002000	239.076487
4	78	.002948	97.622751	2.323731	.048570	.002000	239.076483
5	78	.002946	97.622953	2.323721	.048380	.002000	239.076479
6	78	.002944	97.623155	2.323711	.048191	.002000	239.076476
7	78	.002942	97.623356	2.323701	.048002	.002000	239.076472
8	78	.002940	97.623556	2.323690	.047814	.002000	239.076468
9	78	.002938	97.623755	2.323680	.047626	.002000	239.076464
10	78	.002936	97.623954	2.323670	.047440	.002000	239.076460
11	78	.002934	97.624152	2.323660	.047254	.002000	239.076456
12	78	.002932	97.624349	2.323649	.047069	.002000	239.076453
1	79	.002930	97.624546	2.323639	.046885	.002000	239.076449
2	79	.002928	97.624742	2.323629	.046701	.002000	239.076445
3	79	.002926	97.624937	2.323618	.046518	.002000	239.076441
4	79	.002925	97.625132	2.323608	.046336	.002000	239.076438
5	79	.002923	97.625325	2.323597	.046154	.002000	239.076434
6	79	.002921	97.625519	2.323587	.045973	.002000	239.076430
7	79	.002919	97.625711	2.323576	.045793	.002000	239.076426
8	79	.002917	97.625903	2.323566	.045614	.002000	239.076423
9	79	.002915	97.626094	2.323556	.045435	.002000	239.076419
10	79	.002913	97.626284	2.323545	.045257	.002000	239.076415
11	79	.002911	97.626474	2.323535	.045080	.002000	239.076412
12	79	.002909	97.626663	2.323524	.044903	.002000	239.076408
1	80	.002907	97.626851	2.323514	.044727	.002000	239.076405
2	80	.002905	97.627039	2.323503	.044552	.002000	239.076401
3	80	.002904	97.627226	2.323492	.044378	.002000	239.076397

VARIATION OF PLUTONIUM ISOTOPIC

EXAMPLE CALCULATION FOR 10 YEAR DECAY PERIOD

MO	YR	238 PU	239 PU	240 PU	241 PU	242 PU	AT. WT.
4	80	.002902	97.627412	2.323482	.044204	.002000	239.076394
5	80	.002900	97.627598	2.323471	.044031	.002000	239.076390
6	80	.002898	97.627783	2.323461	.043858	.002000	239.076387
7	80	.002896	97.627967	2.323450	.043686	.002000	239.076383
8	80	.002894	97.628151	2.323439	.043515	.002000	239.076380
9	80	.002892	97.628334	2.323429	.043345	.002000	239.076376
10	80	.002890	97.628516	2.323418	.043175	.002000	239.076373
11	80	.002888	97.628698	2.323407	.043006	.002000	239.076369
12	80	.002887	97.628879	2.323397	.042837	.002001	239.076366
1	81	.002885	97.629059	2.323386	.042670	.002001	239.076362
2	81	.002883	97.629239	2.323375	.042502	.002001	239.076359
3	81	.002881	97.629418	2.323364	.042336	.002001	239.076355
4	81	.002879	97.629597	2.323354	.042170	.002001	239.076352
5	81	.002877	97.629775	2.323343	.042005	.002001	239.076349
6	81	.002875	97.629952	2.323332	.041840	.002001	239.076345
7	81	.002873	97.630129	2.323321	.041676	.002001	239.076342
8	81	.002871	97.630305	2.323310	.041513	.002001	239.076338
9	81	.002870	97.630480	2.323300	.041350	.002001	239.076335
10	81	.002868	97.630655	2.323289	.041188	.002001	239.076332
11	81	.002866	97.630829	2.323278	.041027	.002001	239.076328
12	81	.002864	97.631002	2.323267	.040866	.002001	239.076325
1	82	.002862	97.631175	2.323256	.040706	.002001	239.076322
2	82	.002860	97.631347	2.323245	.040547	.002001	239.076318
3	82	.002858	97.631519	2.323234	.040388	.002001	239.076315
4	82	.002857	97.631690	2.323223	.040230	.002001	239.076312
5	82	.002855	97.631860	2.323212	.040072	.002001	239.076309
6	82	.002853	97.632030	2.323201	.039915	.002001	239.076305
7	82	.002851	97.632199	2.323190	.039759	.002001	239.076302
8	82	.002849	97.632368	2.323179	.039603	.002001	239.076299
9	82	.002847	97.632536	2.323168	.039448	.002001	239.076296
10	82	.002845	97.632703	2.323157	.039293	.002001	239.076293
11	82	.002843	97.632870	2.323146	.039139	.002001	239.076289
12	82	.002842	97.633037	2.323135	.038986	.002001	239.076286
1	83	.002840	97.633202	2.323124	.038833	.002001	239.076283
2	83	.002838	97.633367	2.323113	.038681	.002001	239.076280
3	83	.002836	97.633532	2.323102	.038530	.002001	239.076277
4	83	.002834	97.633696	2.323091	.038379	.002001	239.076274
5	83	.002832	97.633859	2.323080	.038228	.002001	239.076271
6	83	.002830	97.634022	2.323068	.038079	.002001	239.076268
7	83	.002829	97.634184	2.323057	.037929	.002001	239.076264
8	83	.002827	97.634346	2.323046	.037781	.002001	239.076261
9	83	.002825	97.634507	2.323035	.037633	.002001	239.076258
10	83	.002823	97.634667	2.323024	.037485	.002001	239.076255
11	83	.002821	97.634827	2.323013	.037339	.002001	239.076252
12	83	.002819	97.634986	2.323001	.037192	.002001	239.076249
1	84	.002818	97.635145	2.322990	.037047	.002001	239.076246
2	84	.002816	97.635303	2.322979	.036901	.002001	239.076243
3	84	.002814	97.635461	2.322968	.036757	.002001	239.076240
4	84	.002812	97.635618	2.322956	.036613	.002001	239.076237
5	84	.002810	97.635775	2.322945	.036469	.002001	239.076234

VARIATION OF PLUTONIUM ISOTOPIC

EXAMPLE CALCULATION FOR 10 YEAR DECAY PERIOD

MO	YR	238 PU	239 PU	240 PU	241 PU	242 PU	AT. WT.
6	84	.002808	97.635931	2.322934	.036326	.002001	239.076231
7	84	.002807	97.636086	2.322922	.036184	.002001	239.076228
8	84	.002805	97.636241	2.322911	.036042	.002001	239.076225
9	84	.002803	97.636395	2.322900	.035901	.002001	239.076223
10	84	.002801	97.636549	2.322888	.035761	.002001	239.076220
11	84	.002799	97.636703	2.322877	.035620	.002001	239.076217
12	84	.002797	97.636855	2.322866	.035481	.002001	239.076214
1	85	.002796	97.637008	2.322854	.035342	.002001	239.076211
2	85	.002794	97.637159	2.322843	.035203	.002001	239.076208
3	85	.002792	97.637310	2.322831	.035066	.002001	239.076205
4	85	.002790	97.637461	2.322820	.034928	.002001	239.076202
5	85	.002788	97.637611	2.322808	.034791	.002001	239.076199
6	85	.002786	97.637761	2.322797	.034655	.002001	239.076197
7	85	.002785	97.637910	2.322786	.034519	.002001	239.076194
8	85	.002783	97.638058	2.322774	.034384	.002001	239.076191
9	85	.002781	97.638206	2.322763	.034249	.002001	239.076188
10	85	.002779	97.638354	2.322751	.034115	.002001	239.076185
11	85	.002777	97.638501	2.322740	.033981	.002001	239.076183
12	85	.002775	97.638647	2.322728	.033848	.002001	239.076180
1	86	.002774	97.638793	2.322716	.033716	.002001	239.076177