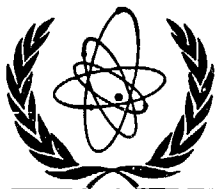XA9128096.

INTERNATIONAL ATOMIC ENERGY AGENCY

NUCLEAR DATA SERVICES

(Rev. 0) .

DOCUMENTATION SERIES OF THE IAEA NUCLEAR DATA SECTION

Decay Data for Detector Efficiency Calibration

Documentation of the GAMDEC DBaseIII Data Base

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Abstract: This report describes the DBaseIII-Plus data files and programs which make up the GAMDEC data base, and the reports produced from this data base.

January 1989

Decay Data Base for Detector Efficiency Calibration

Decay data for detector efficiency calibration consists of three separate data types: half-lives, gamma-ray energies and emission probabilities, and X-ray energies and emission probabilities. The Agency's compilation of these data, which are recommended by the CRP on Gamma-ray Standards for Efficiency Calibration of Detectors (1987-1989), comprises data for 36 individual isotopes. These data are to be included in the INDC/NEANDC 1989 Standards File which is also intended to be published in the ADNDT journal.

The output from the NDS decay data base for detector efficiency calibration consists of the following reports:

- the values of the half-lives of the pertinent radionuclides,
- the list of references for the half-life report,
- the values of the gamma-ray energies and emission probabilities,
- the list of references for the gamma-ray data,
- the values of the X-ray energies and emission probabilities, and
- the list of references for the X-ray data.

These reports are produced by DBaseIII-Plus programs written specifically for this purpose using data which have been compiled in dedicated IAEA/NDS DBaseIII files.

Half-life Data

The half-life data are retrieved from the compilation of the basic IAEA/NDS isotopic properties data file 1BIP.DBF. The data pertinent to the detector calibration standards are tagged in the dedicated logical field GST. The program used to print the half-life report is LIVESGST.PRG. As it is desirable to have the data printed in ZA order, the 1BIP file is indexed on ZA, index file 1ZASORT.NDX.

The LIVESGST program consists of the main LIVESGST program (<u>Attachment 1</u>) and three subroutines: subroutine STRIP1 (<u>Attachment 2</u>), designed to strip all trailing zeroes from the half-live values, subroutine STRIP2 (<u>Attachment 3</u>) designed to strip all trailing zeroes from the half-life uncertainty values, and the ADDZEROG subroutine (<u>Attachment 4</u>) designed to add trailing zeroes to those values of the half-life or half-life uncertainties in order to match the number of significant figures in the half-life and its uncertainty.

The references to the half-life report are retrieved from the ϕREF.DBF file, which contains all references associated with the stored decay data. The references pertinent to the half-life data are tagged in the logical field LST, and the file is indexed alphabetically on the reference acronym field REF, index file ϕREFNDX.NDX. The reference list is produced by the ϕREFLST.PRG program (<u>Attachment 5</u>).

The output from the LIVESGST and ϕREFLST programs is shown in <u>Attachment 6</u>.

Gamma-Ray and X-Ray Data

These data are retrieved from the compilation of decay gamma-ray energies and emission probabilities stored in the IAEA/NDS data file 2GDECAY.DBF (see documentation report IAEA-NDS-111). The data recommended to be used as detector calibration standards are tagged in the logical field ST2. The file

is indexed on ZA in the index file 2GZASORT.NDX. The program used to print the recommended gamma-ray energies and emission probabilities is 2EGPGZST.PRG (see <u>Attachment 7</u>), and the one used to print the recommended X-ray energies and emission probabilities is 2EXPXZST.PRG (see <u>Attachment 8</u>).

The references to the gamma-ray and X-ray reports are produced from the ∲REF file, using programs ∲REFGST.PRG and ∲REFXST (see <u>Attachments 9 and 10</u>) for gamma-rays and x-rays respectively. The pertinent references are tagged in the GST and XST logical fields respectively.

The output from the 2EGPGZST and 2EXPXZST programs and the associated reference lists are shown in <u>Attachment 11</u> and <u>Attachment 12</u>.

Implementation

The input data and programs for this database are available on PC diskette from the IAEA Nuclear Data Section, titled GAMDEC (December 1988).

The programs can be run on all IBM PCs and compatibles using the DBaseIII-Plus applications program. The INPUT/BROWSE and OUTPUT options of this data-base are menu-driven; to start the program use the command DO GAMDEC.

Please note that the decay data given in these listings are shown primarily as examples; do not take these data as final or as recommended values. Please consult the updated files, or later publications for the decay data recommended to be used for gamma-ray detector efficiency calibration.

List of Attachments

1. Listing of program LIVESGST

2. Listing of subroutine STRIP1, called by LIVESGST

3. Listing of subroutine STRIP2, called by LIVESGST

4. Listing of subroutine ADDZEROG, called by LIVESGST

5. Listing of program ФREFLST

6. Reports produced by LIVESGST and ФREFLST

7. Listing of program 2EGPGZST

8. Listing of program 2EXPXZST

9. Listing of program ФREFGST

10. Listing of program REFXST

11. Reports produced by 2EGPGZST and ФREFGST

12. Reports produced by 2EXPXZST and ФREFXST

```
*The LIVESGST program is designed to list the half lives
*of radionuclides whose half-lives can be expressed with exponents
*The input for this report is the 1BIP data file in the ISOTOPES
*subdirectory. A.Lorenz. April 1988
************************************************%***********************
SET DATE ANSI
SET TALK OFF
SET ECHO OFF
CLEAR ALL
CLEAR
SET DEVICE TO PRINT
SET PRINT ON
?CHR(27) + "C" + CHR(72)   && Set page length to 72
SET PRINT OFF
**********************************************************************
STORE "0" TO MLIFE
STORE "0" TO LERR
STORE "0" TO TOTLEN
STORE "0" TO PARTLEN
STORE "0" TO RITLEN
STORE "0" TO ERRLEN
STORE "0" TO EPARTLEN
STORE "0" TO ERITLEN
STORE "0" TO DIGIT1
STORE "0" TO DIGIT2
**********************************************************************
STORE 54 TO tline
STORE 0 TO pagenum
USE 1BIP INDEX 1ZASORT
GO TOP
DO WHILE .NOT. EOF()
LOCATE FOR GST              && Select recommended GST values only
DO WHILE GST .AND. .NOT. EOF()
**********************************************************************
    IF tline >53
        STORE 1 TO tline
        @ tline+1,64  SAY DATE()
            SET PRINT ON
            ??CHR(27) + CHR(69)
            @ tline+3,13 SAY "Half-Lives of Radionuclides Used for ;
Detector Calibration"
            @ tline+4,13 SAY REPLICATE("-",57)
            ??CHR(27) + CHR(70)
            SET PRINT OFF
        @ tline+5,22 SAY "Decay"
        @ tline+5,29 SAY "-------"
        @ tline+5,37 SAY "Half-life"
        @ tline+5,47 SAY "---------"
        @ tline+6,11 SAY "Nuclide"
        @ tline+6,22 SAY "Mode"
        @ tline+6,29 SAY "Value"
        @ tline+6,36 SAY "Uncertainty"
        @ tline+6,48 SAY "Exponent"
        @ tline+6,57 SAY "Units"
        @ tline+6,63 SAY "Reference"
        @ tline+7,11 SAY REPLICATE("-",61)
    ENDIF
**********************************************************************
```

```
DO STRIP1
*****************************************************************
IF LIFE_ERR # 0.00000
*****************************************************************
DO STRIP2
*****************************************************************
*The next command checks if the values of LIFE and LIFE_ERR
*do not have any decimals; if they don't, the ADDLIVE9
*routine is skipped.
STORE AT(".",LERR) TO DOT
IF DOT # 0
*****************************************************************
DO ADDZEROG   && Restores zeroes to match significant figures
*****************************************************************
ENDIF
*******************************
    @ tline+9,10 SAY NUCLIDES
    @ tline+9,23 SAY MODE    .
    @ tline+9,26 SAY LSM
    @ tline+9,29 SAY MLIFE
    @ tline+9,37 SAY "+-"
    @ tline+9,40 SAY LERR
    @ tline+9,48 SAY EXP
*****************************************************************
ELSE
    @ tline+9,10 SAY NUCLIDES
    @ tline+9,23 SAY MODE
    @ tline+9,26 SAY LSM
    @ tline+9,29 SAY MLIFE
    @ tline+9,48 SAY EXP
ENDIF
*****************************************************************
    DO CASE
        CASE UNIT ='Y'
          STORE "Years" TO MUNIT
        CASE UNIT ='H'
          STORE "Hours" TO MUNIT
        CASE UNIT ='D'
          STORE "Days" TO MUNIT
        CASE UNIT ='M'
          STORE "Minutes" TO MUNIT
        CASE UNIT ='S'
          STORE "Seconds" TO MUNIT
    ENDCASE
*****************************************************************
    @ tline+9,57 SAY MUNIT
    @ tline+9,65 SAY LIFEREF
    tline=tline+1
CONTINUE
ENDDO
ENDDO
EJECT
CLOSE ALL
```

```
*The STRIP1 program is called by te LIVES programs and is designed
*to strip all trailing zeroes from the LIFE values
*A.Lorenz. April 1988
******************************************************************
STORE 'O' TO Z1
STORE 'OO' TO Z2
STORE 'OOO' TO Z3
STORE 'OOOO' TO Z4
STORE 'OOOOO' TO Z5
STORE STR(LIFE,10,5) TO RLIFE
STORE LTRIM(RLIFE) TO PLIFE
STORE RIGHT(PLIFE,5) TO SLIFE
STORE RIGHT(SLIFE,1) TO M1        && select last decimal only
STORE RIGHT(SLIFE,2) TO M2        && select last 2 decimals only
STORE RIGHT(SLIFE,3) TO M3        && select last 3 decimals only
STORE RIGHT(SLIFE,4) TO M4        && select last 4 decimals only
STORE RIGHT(SLIFE,5) TO M5        && select all last 5 decimals
STORE AT(".",PLIFE) TO C
STORE C+1 TO K
STORE C-1 TO CM1
******************************************************************
      IF M1=Z1
         STORE LEFT(SLIFE,4) TO MLIFED4
         STORE STUFF(PLIFE,K,5,MLIFED4) TO MLIFE
      ELSE    && IF M1 IS NOT Z1
         STORE PLIFE TO MLIFE
      ENDIF
      *********************************************
      IF M2=Z2
         STORE LEFT(SLIFE,3) TO MLIFED3
         STORE STUFF(PLIFE,K,5,MLIFED3) TO MLIFE
      ENDIF
      *********************************************
      IF M3=Z3
         STORE LEFT(SLIFE,2) TO MLIFED2
         STORE STUFF(PLIFE,K,5,MLIFED2) TO MLIFE
      ENDIF
      ***********************************************
     ·IF M4=Z4
         STORE LEFT(SLIFE,1) TO MLIFED1
         STORE STUFF(PLIFE,K,5,MLIFED1) TO MLIFE
  ***********************************************
      IF M5=Z5
         STORE SUBSTR(PLIFE,1,CM1) TO MLIFE
      ENDIF
****************************************************
RETURN
```

```
*The STRIP2 program is called by the LIVES programs and is
*designed to strip all trailing zeroes from LIFE_ERR values
*A.Lorenz. April 1988
******************************************************************
STORE 'O' TO Z1
STORE 'OO' TO Z2
STORE 'OOO' TO Z3
STORE 'OOOO' TO Z4
STORE 'OOOOO' TO Z5
*******************************************
 STORE STR(LIFE_ERR,10,5) TO RERR
 STORE LTRIM(RERR) TO PERR
 STORE RIGHT(PERR,5) TO SERR
 STORE RIGHT(SERR,1) TO N1
 STORE RIGHT(SERR,2) TO N2
 STORE RIGHT(SERR,3) TO N3
 STORE RIGHT(SERR,4) TO N4
 STORE RIGHT(SERR,5) TO N5
 STORE AT(".",PERR) TO C1
 STORE C1+1 TO C2
 STORE C1-1 TO CM1
******************************************************************
    IF N1=Z1
       STORE LEFT(SERR,4) TO NERR4
       STORE STUFF(PERR,C2,5,NERR4) TO LERR
    ELSE
       STORE PERR TO LERR
    ENDIF
    *******************************************
    IF N2=Z2
       STORE LEFT(SERR,3) TO NERR3
       STORE STUFF(PERR,C2,5,NERR3) TO LERR
    ENDIF
    *******************************************
    IF N3=Z3
       STORE LEFT(SERR,2) TO NERR2
       STORE STUFF(PERR,C2,5,NERR2) TO LERR
    ENDIF
    ***********************************************
    IF N4=Z4
       STORE LEFT(SERR,1) TO NERR1
       STORE STUFF(PERR,C2,5,NERR1) TO LERR
    ENDIF
    ***********************************************
    IF N5=Z5
       STORE SUBSTR(PERR,1,CM1) TO LERR
    ENDIF
******************************************************************
RETURN
```

```
*The ADDZEROG program extension is called by the LIVESGST
*program to add trailing zeroes to those values
*of MLIFE and LERR where their number of decimals are not equal.
*A. Lorenz.  April 1988.
***************************************************************
STORE LEN(MLIFE) TO TOTLEN
STORE AT(".",MLIFE) TO PARTLEN
STORE (TOTLEN - PARTLEN) TO RITLEN
***********************************
STORE LEN(LERR) TO ERRLEN
STORE AT(".",LERR) TO EPARTLEN
STORE (ERRLEN - EPARTLEN) TO ERITLEN
*************************************
IF RITLEN # ERITLEN
   DO CASE
      CASE RITLEN > ERITLEN
         STORE (RITLEN - ERITLEN) TO DIGIT1
            DO CASE
               CASE DIGIT1 = 1
                  STORE (LERR + "0") TO LERR
               CASE DIGIT1 = 2
                  STORE (LERR + "00") TO LERR
               CASE DIGIT1 = 3
                  STORE (LERR + "000") TO LERR
               CASE DIGIT1 = 4
                  STORE (LERR + "0000") TO LERR
               CASE DIGIT1 = 5
                  STORE (LERR + "00000") TO LERR
            ENDCASE
*************************************************************
      CASE ERITLEN > RITLEN
        STORE (ERITLEN - RITLEN) TO DIGIT2
            DO CASE
               CASE DIGIT2 = 1
                  STORE (MLIFE + "0") TO MLIFE
               CASE DIGIT2 = 2
                  STORE (MLIFE + "00") TO MLIFE
               CASE DIGIT2 = 3
                  STORE (MLIFE + "000") TO MLIFE
               CASE DIGIT2 = 4
                  STORE (MLIFE + "0000") TO MLIFE
               CASE DIGIT2 = 5
                  STORE (MLIFE + "00000") TO MLIFE
            ENDCASE
   ENDCASE
  ENDIF
ENDIF
RETURN
*************************************************************
```

```
*The OREFLST program is designed to produce a listing of references
*for the half-lives report for gamma ray standards for detector
*calibration produced by the LIVESGST program using the OREF file
*A.Lorenz, November 1988
**************************************************************
SET DATE ANSI
SET TALK OFF
SET ECHO OFF
CLEAR ALL      .
CLEAR
SET DEVICE.TO PRINT
SET PRINT ON
?CHR(27) + "C" + CHR(72)
SET PRINT OFF
**************************************************************
STORE 59 TO tline
STORE 0 TO pagenum
USE OREF
set index to OREFNDX
GO TOP
DO WHILE .NOT. EOF()
LOCATE FOR LST
DO WHILE LST .AND. .NOT. EOF()
**************************************************************
    IF tline >58
        STORE 1 TO tline
        STORE pagenum+1 TO pagenum
        @ tline  ,65  SAY "Page"+STR(Pagenum,2)
        @ tline+1,65  SAY DATE()
            SET PRINT ON
            ??CHR(27) + CHR(69)
            @ tline+3,32 SAY "References"
            @ tline+4,32 SAY "----------"
            ??CHR(27) + CHR(70)
            SET PRINT OFF
        tline=7
    ENDIF
**************************************************************
    @ tline  ,5 SAY REF
    DO CASE
        CASE AUTHOR2 ="                   "
        @ tline,15 SAY TRIM(AUTHOR1)
        CASE AUTHOR3 ="                   "
        @ tline,15 SAY TRIM(AUTHOR1)+", "+TRIM(AUTHOR2)
        CASE AUTHOR4 ="                   "  .
        @ tline,15 SAY TRIM(AUTHOR1)+", "+TRIM(AUTHOR2)+", "+;
TRIM(AUTHOR3)
        CASE AUTHOR4 #"                   "
        @ tline,15 SAY TRIM(AUTHOR1)+", "+TRIM(AUTHOR2)+", "+;
TRIM(AUTHOR3)+", "+TRIM(AUTHOR4)
    ENDCASE
**************************************************************
STORE SPACE(50) TO TLA
STORE SPACE(50) TO TLB
STORE TRIM(TITLE) TO TL
STORE LEN(TL) TO LTL
STORE GSNUM TO NUM
IF NUM # " "
    @tline+1,5 SAY "("+NUM+")"
ENDIF
**************************************************************
```

```
DO CASE
   CASE LTL < 50
            @ tline+1.15 SAY TL
            @ tline+2.15 SAY TRIM(REFERENCE)
   CASE LTL > 49
      X=50
         DO WHILE SUBSTR(TL.X.1) # " "
         X=X-1
         ENDDO
      STORE TRIM(SUBSTR(TL.1.X)) TO TLA
      STORE TRIM(SUBSTR(TL,X+1)) TO TLB
            @ tline+1.15 SAY TLA
            @ tline+2.15 SAY TLB
            @ tline+3.15 SAY TRIM(REFERENCE)
ENDCASE
********************************************************************
   tline=tline+5
CONTINUE
ENDDO
ENDDO
CLOSE ALL
EJECT
```

Half-Lives of Radionuclides Used for Detector Calibration

Nuclide	Decay Mode	Value	Uncertainty	Exponent	Units	Reference
11-Na-022	EC	950.8	+- 0.9		Days	CH8701
11-Na-024	B-	0.62356	+- 0.00017		Days	CH8701
21-Sc-046	B-	83.79	+- 0.04		Days	CH8701
24-Cr-051	EC	27.706	+- 0.007		Days	CH8701
25-Mn-054	EC	312.3	+- 0.4		Days	CH8701
26-Fe-055	EC	999	+- 8		Days	CH8701
27-Co-056	EC	77.35	+- 0.23		Days	CH8701
27-Co-057	EC	271.79	+- 0.09		Days	CH8701
27-Co-058	EC	70.86	+- 0.07		Days	CH8701
27-Co-060	B-	1925.5	+- 0.5		Days	CH8701
30-Zn-065	EC	244.26	+- 0.26		Days	CH8701
34-Se-075	EC	119.64	+- 0.24		Days	CH8701
38-Sr-085	EC	64.849	+- 0.004		Days	CH8701
39-Y -088	EC	106.630	+- 0.025		Days	CH8701
41-Nb-093m	IT	5.89	+- 0.05	E+03	Days	CH8701
41-Nb-094	B-	7.3	+- 0.9	E+06	Days	CH8701
41-Nb-095	B-	34.975	+- 0.007		Days	CH8701
48-Cd-109	EC	462.6	+- 0.7		Days	CH8701
49-In-111	EC	2.8047	+- 0.0005		Days	CH8701
50-Sn-113	EC	115.09	+- 0.04		Days	CH8701
51-Sb-125	B-	1007.7	+- 0.6		Days	CH8701
53-I -125	EC	59.6	+- 0.5		Days	CH8701
55-Cs-134	B-	754.28	+- 0.22		Days	CH8701
55-Cs-137	B-	1.105	+- 0.004	E+04	Days	CH8701
56-Ba-133	EC	3862	+- 15		Days	CH8701
58-Ce-139	EC	137.640	+- 0.023		Days	CH8701
63-Eu-152	EC	4933	+- 11		Days	CH8701
63-Eu-154	B-	3136.8	+- 2.9		Days	CH8701
63-Eu-155	B-	1.77	+- 0.05	E+03	Days	CH8701
79-Au-198	B-	2.6943	+- 0.0008		Days	CH8701
80-Hg-203	B-	46.595	+- 0.013		Days	CH8701
83-Bi-207	EC	1.16	+- 0.07	E+04	Days	CH8701
90-Th-228	A	698.7	+- 0.7		Days	IAEA86
93-Np-239	B-	2.355	+- 0.004		Days	IAEA86
95-Am-241	A	1.580	+- 0.002	E+05	Days	IAEA86
95-Am-243	A	2.690	+- 0.008	E+06	Days	CH8701

References

CH8701   Christmas,P., Debertin,K., Woods,M.J.
(GS/037)   Half-Life Data for Calibration Nuclides:
            Formulation and Application of Evaluated Criteria
            Private Communication (1987). Report RS 11/2/07

IAEA86   Lorenz,A.(Ed)
            Decay Data of the Transactinium Nuclides
            IAEA Technical Report No.261 (1986)

```
*The 2EGPGZST program is designed to list the energies and
*emission probabilities of gamma rays used for detector
*calibration which was prepared for the INDC/NEANDC
*Standards File 1989.  The input used for this report
*is the 2GDECAY data file in the ISOTOPE subdirectory.
*The information printed by this program displays the EG and
*PG values ordered by energy for each individual radionuclide.
*A.Lorenz. August 1988
************************************************************
SET DATE ANSI
SET STEP OFF
SET TALK OFF
SET ECHO OFF
SET DEBUG OFF
CLEAR ALL
CLEAR
SET DEVICE TO PRINT
SET PRINT ON
?CHR(27) + "C" + CHR(72)
SET PRINT OFF
************************************************************
STORE 54 TO tline
STORE 0 TO pagenum
ZAM='        '    && Value of previous ZA field
************************************************************
USE 2GDECAY INDEX 2GZASORT
REINDEX
GO TOP
DO WHILE .NOT. EOF()
LOCATE FOR ST2
DO WHILE ST2 .AND. .NOT. EOF()
************************************************************
    IF tline >53
        STORE 1 TO tline
        STORE pagenum+1 TO pagenum
        @ tline  ,60 SAY "Page"+STR(Pagenum,2)
        @ tline+1,60 SAY DATE()
        SET PRINT ON
        ??CHR(27) + CHR(69)
        @ tline+3,10 SAY "Gamma Ray Standards: Energies "
        @ tline+3,40 SAY "and Emission Probabilities"
        @ tline+4,10 SAY REPLICATE('-',56)
        ??CHR(27) + CHR(70)
        SET PRINT OFF
        @ tline+5,42 SAY "Emission"
        @ tline+6,13 SAY "Nuclide"
        @ tline+6,24 SAY "Energy (keV)"
        @ tline+6,41 SAY "Probability"
        @ tline+6,55 SAY "Reference"
        @ tline+7,12 SAY REPLICATE("-",52)
    ENDIF
************************************************************
```

```
IF ZA=ZAM
   tline=tline+1
ELSE
   tline=tline+2
   STORE ZA TO ZAM
ENDIF
***************************************************
   STORE LOWER(SUBSTR(NUCLIDE,5,1)) TO MM
   @ tline+8, 12 SAY STUFF(NUCLIDE,5,1,MM)
   @ tline+8, 24 SAY ENERGY
   @ tline+8, 41 SAY EMIS_PROB
   @ tline+8, 57 SAY REFERENCE
*********************************************************************
CONTINUE
ENDDO
ENDDO
EJECT
```

```
*The 2EXPXZST program is designed to list the energies and
*emission probabilities of X-rays used for detector
*calibration which was prepared for the INDC/NEANDC
*Standards File 1989.  The input used for this report
*is the 2GDECAY data file in the ISOTOPE subdirectory.
*The information printed by this program displays the EX and
*PX values ordered by energy for each individual radionuclide.
*A.Lorenz. September 1988
**************************************************************
SET DATE ANSI
SET STEP OFF
SET TALK OFF
SET ECHO OFF
SET DEBUG OFF
CLEAR ALL
CLEAR
SET DEVICE TO PRINT
SET PRINT ON
?CHR(27) + "C" + CHR(72)
SET PRINT OFF
**************************************************************
STORE 54 TO tline
STORE 0 TO pagenum
ZAM='          '     && Value of previous ZA field
**************************************************************
USE 2GDECAY INDEX 2GZASORT
REINDEX
GO TOP
DO WHILE .NOT. EOF()
LOCATE FOR X2
DO WHILE X2 .AND. .NOT. EOF()
**************************************************************
   IF tline >53
      STORE 1 TO tline
      STORE pagenum+1 TO pagenum
      @ tline  ,60 SAY "Page"+STR(Pagenum,2)
      @ tline+1,60 SAY DATE()
         SET PRINT ON
         ??CHR(27) + CHR(69)
         @ tline+3,12 SAY "X-Ray Standards: Energies "
         @ tline+3,38 SAY "and Emission Probabilities"
         @ tline+4,12 SAY REPLICATE('-',52)
         ??CHR(27) + CHR(70)
         SET PRINT OFF
      @ tline+5,42 SAY "Emission"
      @ tline+6,13 SAY "Nuclide"
      @ tline+6,24 SAY "Energy (keV)"
      @ tline+6,41 SAY "Probability"
      @ tline+6,55 SAY "Reference"
      @ tline+7,12 SAY REPLICATE("-",52)
   ENDIF
**************************************************************
IF ZA=ZAM
  tline=tline+1
ELSE
  tline=tline+2
  STORE ZA TO ZAM
ENDIF
*******************************************
```

```
IF X3
   SET PRINT ON
   ??CHR(27) + CHR(69)
      STORE LOWER(SUBSTR(NUCLIDE,5,1)) TO NN
      @ tline+8, 12 SAY STUFF(NUCLIDE,5,1,NN)
      @ tline+8, 24 SAY ENERGY
      @ tline+8, 41 SAY EMIS_PROB
      @ tline+8, 57 SAY REFERENCE
   ??CHR(27) + CHR(70)
   SET PRINT OFF
ELSE
      STORE LOWER(SUBSTR(NUCLIDE,5,1)) TO MM
      @ tline+8, 12 SAY STUFF(NUCLIDE,5,1,MM)
      @ tline+8, 24 SAY ENERGY
      @ tline+8, 41 SAY EMIS_PROB
      @ tline+8, 57 SAY REFERENCE
ENDIF
****************************************************************
CONTINUE
ENDDO
ENDDO
EJECT
CLOSE ALL
```

```
*The OREFGST program is designed to produce a listing of references
*for the E-gamma/F-gamma report for gamma ray standards for detector
*calibration produced by the 2EGFGZST program. A.Lorenz November 1988.
*************************************************************
SET DATE ANSI
SET TALK OFF
SET ECHO OFF
CLEAR ALL
CLEAR
SET DEVICE TO PRINT
SET PRINT ON
?CHR(27) + "C" + CHR(72)
SET PRINT OFF
*************************************************************
STORE 59 TO tline
STORE 0 TO pagenum
USE OREF
set index to OREFNDX
GO TOP
DO WHILE .NOT. EOF()
LOCATE FOR GST
DO WHILE GST .AND. .NOT. EOF()
*************************************************************
    IF tline >58
        STORE 1 TO tline
        STORE pagenum+1 TO pagenum
        @ tline  ,65  SAY "Page"+STR(Pagenum,2)
        @ tline+1,65  SAY DATE()
            SET PRINT ON
            ??CHR(27) + CHR(69)
            @ tline+3,32 SAY "References"
            @ tline+4,32 SAY "----------"
            ??CHR(27) + CHR(70)
            SET PRINT OFF
        tline=7
    ENDIF
*************************************************************
    @ tline  ,5 SAY REF
    DO CASE
        CASE AUTHOR2 ="                   "
            @ tline,15 SAY TRIM(AUTHOR1)
        CASE AUTHOR3 ="                   "
            @ tline,15 SAY TRIM(AUTHOR1)+", "+TRIM(AUTHOR2)
        CASE AUTHOR4 ="                   "
            @ tline,15 SAY TRIM(AUTHOR1)+", "+TRIM(AUTHOR2)+", "+;
TRIM(AUTHOR3)
        CASE AUTHOR4 #"                   "
            @ tline,15 SAY TRIM(AUTHOR1)+", "+TRIM(AUTHOR2)+", "+;
TRIM(AUTHOR3)+","+TRIM(AUTHOR4)
    ENDCASE
*************************************************************
STORE SPACE(50) TO TLA
STORE SPACE(50) TO TLB
STORE TRIM(TITLE) TO TL
STORE LEN(TL) TO LTL
STORE GSNUM TO NUM
IF NUM # " "
    @tline+1,5 SAY "("+NUM+")".
ENDIF
*************************************************************
```

```
DO CASE
   CASE LTL < 50
            @ tline+1,15 SAY TL
            @ tline+2,15 SAY TRIM(REFERENCE)
   CASE LTL > 49
      X=50
        DO WHILE SUBSTR(TL,X,1) # " "
        X=X-1
        ENDDO
      STORE TRIM(SUBSTR(TL,1,X)) TO TLA
      STORE TRIM(SUBSTR(TL,X+1)) TO TLB
            @ tline+1,15 SAY TLA
            @ tline+2,15 SAY TLB
            @ tline+3,15 SAY TRIM(REFERENCE)
ENDCASE
**********************************************************************
   tline=tline+5
CONTINUE
ENDDO
ENDDO
CLOSE ALL
EJECT
```

```
*The OREFXST program is designed to produce a listing of references
*for the E-X/F-X report for X-ray standards for detector
*calibration produced by the ZEXPXZST program. A.Lorenz November 19E
****************************************************************
SET DATE ANSI
SET TALK OFF
SET ECHO OFF
CLEAR ALL
CLEAR
SET DEVICE TO PRINT
SET PRINT ON
?CHR(27) + "C" + CHR(72)
SET PRINT OFF
****************************************************************
STORE 59 TO tline
STORE 0 TO pagenum
USE OREF
set index to OREFNDX
GO TOP
DO WHILE .NOT. EOF()
LOCATE FOR XST
DO WHILE XST .AND. .NOT. EOF()
****************************************************************
    IF tline >58
        STORE 1 TO tline
        STORE pagenum+1 TO pagenum
        @ tline  ,65  SAY "Page"+STR(Pagenum,2)
        @ tline+1,65  SAY DATE()
            SET PRINT ON
            ??CHR(27) + CHR(69)
            @ tline+3,32 SAY "References"
            @ tline+4,32 SAY "----------"
            ??CHR(27) + CHR(70)
            SET PRINT OFF
        tline=7
    ENDIF
****************************************************************
    @ tline  ,5 SAY REF
    DO CASE
        CASE AUTHOR2 ="                    "
            @ tline,15 SAY TRIM(AUTHOR1)
        CASE AUTHOR3 ="                    "
            @ tline,15 SAY TRIM(AUTHOR1)+", "+TRIM(AUTHOR2)
        CASE AUTHOR4 ="                    "
            @ tline,15 SAY TRIM(AUTHOR1)+", "+TRIM(AUTHOR2)+", "+;
TRIM(AUTHOR3)
        CASE AUTHOR4 #"                    "
            @ tline,15 SAY TRIM(AUTHOR1)+", "+TRIM(AUTHOR2)+", "+;
TRIM(AUTHOR3)+","+TRIM(AUTHOR4)
    ENDCASE
****************************************************************
STORE SPACE(50) TO TLA
STORE SPACE(50) TO TLB
STORE TRIM(TITLE) TO TL
STORE LEN(TL) TO LTL
STORE GSNUM TO NUM
IF NUM # " "
    @tline+1,5 SAY "("+NUM+")"
ENDIF
****************************************************************
```

```
DO CASE
   CASE LTL < 50
            @ tline+1,15 SAY TL
            @ tline+2,15 SAY TRIM(REFERENCE)
   CASE LTL > 49
       X=50
          DO WHILE SUBSTR(TL,X,1) # " "
          X=X-1
          ENDDO
       STORE TRIM(SUBSTR(TL,1,X)) TO TLA
       STORE TRIM(SUBSTR(TL,X+1)) TO TLB
            @ tline+1,15 SAY TLA
            @ tline+2,15 SAY TLB
            @ tline+3,15 SAY TRIM(REFERENCE)
ENDCASE
****************************************************************
   tline=tline+5
CONTINUE
ENDDO
ENDDO
CLOSE ALL
EJECT
```

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Gamma

Gamma Ray Standards: Energies and Emission Probabilities

Nuclide	Energy (keV)	Emission Probability	Reference
11-Na-022	1274.542(7)	0.9995(2)	IAEA83
11-Na-024	1368.633(6)	0.99994(2)	IAEA83
11-Na-024	2754.030(14)	0.99881(8)	IAEA83
21-Sc-046	889.277(3)	0.999836(16)	YO8001
21-Sc-046	1120.545(4)	0.999871(12)	YO8001
24-Cr-051	320.084(1)	0.0986(7)	NI8801
25-Mn-054	834.843(6)	0.999746(25)	YO8001
27-Co-056	846.764(6)	0.99923(7)	IAEA83
27-CO-056	1037.844(4)	0.1409(6)	IAEA83
27-Co-056	1175.099(8)	0.0227(2)	IAEA83
27-Co-056	1238.287(6)	0.670(7)	IAEA83
27-Co-056	1360.206(6)	0.0426(2)	IAEA83
27-Co-056	1771.350(15)	0.1549(5)	IAEA83
27-Co-056	2015.179(11)	0.0303(4)	IAEA83
27-Co-056	2034.759(11)	0.0776(4)	YO8001
27-Co-056	2598.460(10)	0.1695(6)	IAEA83
27-Co-056	3201.954(14)	0.0318(8)	IAEA83
27-Co-056	3253.417(14)	0.0764(20)	IAEA83
27-Co-056	3272.998(14)	0.018(1)	IAEA83
27-Co-056	3451.154(13)	0.0093(3)	IAEA83
27-Co-056	3548.18(12)	0.0019(1)	IAEA83
27-Co-057	14.4119(4)	0.0960(8)	BA8701
27-Co-057	122.0612(15)	0.8560(17)	BA8701
27-Co-057	136.4730(15)	0.1068(8)	BA8701
27-Co-058	810.772(7)	0.9945(1)	BA8701
27-Co-060	1173.238(4)	0.9989(2)	IAEA83
27-Co-060	1332.502(5)	0.999816(15)	IAEA83
30-Zn-065	1115.546(4)	0.5071(33)	NI8801
34-Se-075	66.0523(9)	0.0112(3)	NI8701
34-Se-075	96.7344(10)	0.0342(6)	NI8701
34-Se-075	121.1171(14)	0.171(3)	NI8701
34-Se-075	136.0008(6)	0.582(8)	NI8701
34-Se-075	198.6053(32)	0.0148(3)	NI8701
34-Se-075	264.6580(17)	0.585(5)	NI8701
34-Se-075	279.5431(22)	0.2484(23)	NI8701
34-Se-075	303.9249(15)	0.01312(22)	NI8701
34-Se-075	400.6593(13)	0.1140(25)	NI8701
38-Sr-085	514.009(12)	0.984(4)	IAEA83
39-Y -088	898.042(4)	0.941(5)	CO8702
39-Y -088	1836.063(13)	0.9936(5)	CO8702

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Gamma Ray Standards: Energies and Emission Probabilities

Nuclide	Energy (keV)	Emission Probability	Reference
41-Nb-094	702.645(6)	0.9979(5)	HE8801
41-Nb-094	871.119(4)	0.9986(5)	HE8801
41-Nb-095	765.807(6)	0.9981(3)	HE8802
48-Cd-109	88.0341(11)	0.0365(6)	IAEA83
49-In-111	171.28(3)	0.902(3)	IAEA83
49-In-111	245.35(4)	0.949(2)	IAEA83
51-Sb-125	176.334(11)	0.069(1)	CO8702
51-Sb-125	380.435(20)	0.0151(2)	CO8702
51-Sb-125	427.889(15)	0.294(3)	CO8702
51-Sb-125	463.383(15)	0.1042(10)	CO8702
51-Sb-125	600.557(18)	0.178(2)	CO8702
51-Sb-125	606.641(19)	0.0500(7)	CO8702
51-Sb-125	635.895(20)	0.113(10)	CO8702
51-Sb-125	671.409(20)	0.0181(3)	CO8702
53-I -125	35.4919(5)	0.0667(5)	CO8702
55-Cs-134	475.34(13)	0.0152(4)	YO8701
55-Cs-134	563.23(2)	0.0836(5)	YO8701
55-Cs-134	569.32(2)	0.1540(9)	YO8701
55-Cs-134	604.69(2)	0.9763(6)	YO8701
55-Cs-134	795.84(1)	0.8550(6)	YO8701
55-Cs-134	801.93(2)	0.0867(5)	YO8701
55-Cs-134	1038.555(20)	0.00987(6)	YO8701
55-Cs-134	1167.92(2)	0.01788(10)	YO8701
55-Cs-134	1365.16(2)	0.03005(17)	YO8701
55-Cs-134m	11.28(2)	0.0094(9)	IAEA83
55-Cs-137	661.660(3)	0.851(2)	CO8801
56-Ba-133	53.16	0.02161(18)	BA8701
56-Ba-133	79.62	0.0255(7)	JE8801
56-Ba-133	81.00	0.3411(28)	BA8701
56-Ba-133	276.40	0.07147(30)	BA8701
56-Ba-133	302.86	0.1830(6)	BA8701
56-Ba-133	356.02	0.6194(14)	BA8701
56-Ba-133	383.85	0.08905(29)	BA8701
58-Ce-139	165.857(6)	0.7999(10)	IAEA83
63-Eu-152	121.7824(4)	0.2842(18)	HE8601
63-Eu-152	244.6989(10)	0.0748(7)	HE8601
63-Eu-152	344.2811(19)	0.2660(11)	HE8601
63-Eu-152	411.117(7)	0.02241(17)	HE8601
63-Eu-152	443.990(6)	0.03116(22)	HE8601
63-Eu-152	778.925(13)	0.1305(4)	HE8601
63-Eu-152	867.	0.0422(6)	HE8601

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Gamma Ray Standards: Energies and Emission Probabilities

Nuclide	Energy (keV)	Emission Probability	Reference
63-Eu-152	964.031(35)	0.1468(7)	HE8601
63-Eu-152	1086.	0.1014(2)	HE8601
63-Eu-152	1112.116(17)	0.1359(3)	HE8601
63-Eu-152	1408.011(14)	0.2092(9)	HE8601
63-Eu-154	123.071(11)	0.410(5)	YO8701
63-Eu-154	247.930(1)	0.0695(9)	YO8701
63-Eu-154	401.258(14)	0.00171(14)	YO8701
63-Eu-154	591.762(5)	0.0500(6)	YO8701
63-Eu-154	692.425(4)	0.01810(22)	YO8701
63-Eu-154	723.305(5)	0.2028(24)	YO8701
63-Eu-154	873.190(5)	0.1227(14)	YO8701
63-Eu-154	996.262(6)	0.1050(12)	YO8701
63-Eu-154	1004.725(7)	0.1817(21)	YO8701
63-Eu-154	1274.436(6)	0.349(4)	YO8701
79-Au-198	411.8044(11)	0.9557(47)	NI8801
80-Hg-203	279.1967(12)	0.8148(8)	HE8803
83-Bi-207	569.702(2)	0.9774(3)	IAEA83
83-Bi-207	1063.662(4)	0.740(3)	IAEA83
83-Bi-207	1770.237(10)	0.0687(4)	IAEA83
90-Th-228	84.373(3)	0.0122(3)	CO8801
90-Th-228	131.613(4)	0.00127(7)	CO8801
90-Th-228	166.411(4)	0.00107(4)	CO8801
90-Th-228	215.984(5)	0.0026(1)	CO8801
95-Am-241	59.537(1)	0.359(4)	BA8801
95-Am-243	43.53(15)	0.0593(13)	IAEA86
95-Am-243	74.67(15)	0.682(14)	IAEA86
95-Am-243	86.79(15)	0.00338(7)	IAEA86
95-Am-243	142.18(15)	0.0012(1)	IAEA86

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References

BA8601   Bambynek,W.
            Evaluation of the Am241 Half-Life
            IAEA Technical Report No.261, p.127

BA8701   Barta,T., Erbeszkorn,L., Jedlovszky,R.,Zsinka,A.
(GS/024)   Revised Evaluation of the Gamma Photon Emission
            Probabilities of Co57, Co58 and Ba133
            Private Communication (1987)

BA8801   Bambynek,W.
(GS/031)   Measurement of the 59.5 KeV Gamma Ray Emission
            Probability in the Am241 Decay
            Private Communication (1988).

CO8702   Coursol,N.
(GS/015)   Evaluation of E-gamma/P-gamma of Y88, I125, Sb125
            and Cs137
            Internal LMRI Report DAMRI/87/50/NC/MJ (March 1987)

CO8801   Coursol,N.
(GS/034)   Evaluation of the E-gamma/P-gamma of Nb93m,
            Th228, and Cs137
            LMRI Private Communication (1988)

HE8601   Helmer,R.
(GS/001)   Preliminary Evaluation of P-gamma Values from the
            Decay of Eu152
            Private Communication (1986)

HE8801   Helmer,R.
(GS/028)   Decay of Nb94 Evaluation
            Private Communication (1988)

HE8802   Helmer,R.
(GS/029)   Decay of Nb95 Evaluation
            Private Communication (1988)

HE8803   Helmer,R.
(GS/030)   Decay of Hg203 Evaluation
            Private Communication (1988)

IAEA83   Lorenz,A.
            Decay Data for Radionuclides Used as Calibration
            Standards
            IAEA Technical Report No.227 (1983), page 89

IAEA86   Lorenz,A.(Ed)
            Decay Data of the Transactinium Nuclides
            IAEA Technical Report No.261 (1986)

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References

JE8801   Jedlovszki,R., et,al.
(GS/033)   Measurement of the 76.6 keV Gamma Photon Emission
            Probability of Ba133
            Private communication (1988)

NI8701   Nichols,A.L.
(GS/013)   X- and Gamma-ray Standards for Detector
            Calibration: Evaluation of Specific Decay Data
            Private Communication (1987)

NI8801   Nichols,A.L.
(GS/027)   X- and Gamma-ray Standards for Detector
            Calibration: Re-evaluation of Specific Decay Data
            Private communication (1988)

YO8001   Yoshizawa,Y., et al.
            Evaluation of Gamma-ray Intensities
            Report JEARI-M 8811 (Also INDC(JPN)-50/G(1980))

YO8701   Yoshizawa,Y., Inoue,H., Iwata,Y.
(GS/017)   Evaluation of Gamma-Ray Emission Probabilities
            for Co56, Sr85, In111, Cs134, and Eu154
            Private Communication (1987)

X-Ray Standards: Energies and Emission Probabilities

Nuclide	Energy (keV)	Emission Probability	Reference
11-Na-022	0.848	0.00053(6)	BR8601
11-Na-022	0.849	0.00106(11)	BR8601
23-V -049	4.51	0.179(11)	BA8401
23-V -049	4.93	0.024(2)	BA8401
24-Cr-051	4.95	0.201(6)	BA8401
24-Cr-051	5.43	0.027(1)	BA8401
25-Mn-054	5.41	0.226(4)	BA8401
25-Mn-054	5.95	0.030(1)	BA8401
26-Fe-055	5.89	0.249(5)	BA8401
26-Fe-055	6.49	0.034(2)	BA8401
27-Co-056	6.391	0.073(4)	BR8601
27-Co-056	6.404	0.144(7)	BR8601
27-Co-056	7.058	0.0258(13)	BR8601
27-Co-057	6.40	0.510(2)	BA8401
27-Co-057	7.06	0.069(3)	BA8401
30-Zn-065	8.04	0.341(6)	BA8401
30-Zn-065	8.91	0.046(1)	BA8401
34-Se-075	10.53	0.489(30)	BA8401
34-Se-075	10.544	0.324(15)	BR8601
34-Se-075	11.72	0.076(6)	BA8401
35-Br-082	12.598	0.0014(7)	BR8601
35-Br-082	12.651	0.0027(13)	BR8601
35-Br-082	14.109	0.0006(3)	BR8601
35-Br-082	14.408	0.000052(24	BR8601
38-Sr-085	13.38	0.500(8)	BA8401
38-Sr-085	14.98	0.087(8)	BA8401
39-Y -088	14.14	0.513(8)	BA8401
39-Y -088	15.86	0.092(2)	BA8401
48-Cd-109	22.10	0.821(18)	BA8401
48-Cd-109	25.01	0.173(7)	BA8401
49-In-111	23.11	0.684((20)	BA8401
49-In-111	26.18	0.145(6)	BA8401
53-I -125	27.38	0.134(30)	BA8401
53-I -125	31.12	0.250(8)	BA8401
55-Cs-134	31.817	0.00243(6)	BR8601
55-Cs-134	32.194	0.00447(11)	BR8601
55-Cs-134	36.357	0.00124(3)	BR8601

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X-Ray Standards: Energies and Emission Probabilities

Nuclide	Energy (keV)	Emission Probability	Reference
55-Cs-134	37.450	0.000313(9)	BR8601
55-Cs-134m	30.625	0.090(3)	BR8601
55-Cs-134m	30.973	0.167(6)	BR8601
55-Cs-134m	34.967	0.0456(16)	BR8601
55-Cs-134m	36.006	0.111(4)	BR8601
55-Cs-137	32.06	0.0566(18)	BA8401
55-Cs-137	36.36	0.0107(4)	BA8401
55-Cs-137	37.45	0.0027(1)	BR8601
56-Ba-133	30.85	0.980(16)	BA8601
56-Ba-133	34.9	0.184(7)	BA8401
56-Ba-133	36.0	0.046(2)	BA8401
58-Ce-139	33.30	0.639(17)	BA8401
58-Ce-139	37.98	0.153(5)	BA8401
63-Eu-152	39.91	0.591(12)	BA8401
63-Eu-152	42.75	0.00648(22)	BA8401
63-Eu-152	46.0	0.149(3)	BA8401
63-Eu-152	48.65	0.00141(5)	BA8401
63-Eu-152	50.214	0.00035(1)	BA8401
63-Eu-154	42.309	0.0736(25)	BR8601
63-Eu-154	42.996	0.0132(5)	BR8601
63-Eu-154	48.652	0.0390(13)	BR8601
63-Eu-154	50.214	0.0118(5)	BR8601
79-Au-198	9.980	0.00508(24)	BR8601
79-Au-198	11.918	0.0053(3)	BR8601
79-Au-198	68.893	0.00804(23)	BR8601
79-Au-198	70.818	0.0137(4)	BR8601
79-Au-198	80.124	0.00481(14)	BR8601
79-Au-198	82.780	0.00131(4)	BR8601
80-Hg-203	10.259	0.0236(10)	BR8601
80-Hg-203	12.305	0.0236(14)	BR8601
80-Hg-203	70.832	0.038(2)	BA8401
80-Hg-203	72.873	0.064(2)	BA8401
80-Hg-203	82.574	0.022(1)	BA8401
80-Hg-203	84.865	0.0063(3)	BA8401
83-Bi-207	9.185	0.0075(7)	BR8601
83-Bi-207	10.451	0.0958(15)	BR8601
83-Bi-207	11.349	0.00184(11)	BR8601
83-Bi-207	12.699	0.140(10)	BR8601
83-Bi-207	14.914	0.0265(25)	BR8601
83-Bi-207	72.803	0.226(12)	BA8401
83-Bi-207	74.969	0.382(20)	BA8401
83-Bi-207	84.789	0.130(10)	BA8401
83-Bi-207	87.632	0.039(3)	BA8401
95-Am-241	11.871	0.0086(3)	BA8401

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X-Ray Standards: Energies and Emission Probabilities

Nuclide	Energy (keV)	Emission Probability	Reference
95-Am-241	13.927	0.133(4)	BA8401
95-Am-241	17.611	0.194(6)	BA8401
95-Am-241	20.997	0.049(2)	BA8401
95-Am-241	97.066	0.00126(11)	BR8601
95-Am-141	101.059	0.00201(17)	BR8601
95-Am-241	113.944	0.00074(6)	BR8601
95-Am-241	117.891	0.000249(22)	BR8601

References

BA8401
(GS/016)   Bambynek,W.
           Emission Probabilities of Selected X-Rays for
           Radionuclides Used as Detector Calibration Standards
           Internal CBNM Report GE/R/RN/18/84 (November 1984)

BR8601   Browne,E., Firestone,R., Shirley,V.S.(Ed)
           Table of Radioactive Isotopes
           John Wiley & Sons (1986)