```
======================================================================= Sixpak
                                                                        Sixpak
     PROGRAM SIXPAK                                                     Sixpak
     ==============                                                     Sixpak
     VERSION 92-1 (JANUARY 1992)                                        Sixpak
     VERSION 92-2 (FEBRUARY 1992)*INCREASED CORE ALLOCATION TO          Sixpak
                                  ACCOMMODATE JEF AND EFF EVALUATIONS.  Sixpak
     VERSION 92-3 (APRIL 1992)    *ADDED ADDITIONAL DATA TESTS.         Sixpak
     VERSION 92-4 (SEPT. 1992)    *CORRECTED KALBACH-MANN CALCULATIONS. Sixpak
                                  *FOR PHOTON PRODUCTION OUTPUT MF=12   Sixpak
                                   (MULTIPLICITY), MF=14 (ISOTROPIC     Sixpak
                                   ANGULAR DISTRIBUTIONS) AND MF=15     Sixpak
                                   (SPECTRA) - PREVIOUSLY ONLY MF=15.   Sixpak
                                  *FIRST ORDER CORRECTIONS TRANSFORMING  Sixpak
                                   CENTER-OF-MASS SPECTRA TO LAB SYSTEM  Sixpak
                                   FOR OUTPUT IN MF=5                   Sixpak
                                  *CORRECTED ISOTROPIC ANGULAR          Sixpak
                                   DISTRIBUTION FLAG (LI)               Sixpak
     VERSION 94-1 (JANUARY 1994) *VARIABLE ENDF/B INPUT DATA FILENAME   Sixpak
                                   TO ALLOW ACCESS TO FILE STRUCTURES    Sixpak
                                   (WARNING - INPUT PARAMETER FORMAT     Sixpak
                                   HAS BEEN CHANGED)                    Sixpak
                                  *CLOSE ALL FILES BEFORE TERMINATING    Sixpak
                                   (SEE, SUBROUTINE ENDIT)              Sixpak
                                  *INCREASED MAXIMUM TABLE SIZE FROM     Sixpak
                                   2000 TO 6000.                        Sixpak
     VERSION 96-1 (JANUARY 1996) *COMPLETE RE-WRITE                     Sixpak
                                  *IMPROVED COMPUTER INDEPENDENCE        Sixpak
                                  *ALL DOUBLE PRECISION                 Sixpak
                                  *ON SCREEN OUTPUT                     Sixpak
                                  *UNIFORM TREATMENT OF ENDF/B I/O      Sixpak
                                  *IMPROVED OUTPUT PRECISION            Sixpak
     VERSION 99-1 (MARCH 1999)    *CORRECTED CHARACTER TO FLOATING       Sixpak
                                   POINT READ FOR MORE DIGITS           Sixpak
                                  *UPDATED TEST FOR ENDF/B FORMAT        Sixpak
                                   VERSION BASED ON RECENT FORMAT CHANGE Sixpak
                                  *GENERAL IMPROVEMENTS BASED ON         Sixpak
                                   USER FEEDBACK                        Sixpak
     VERSION 99-2 (JUNE 1999)     *ASSUME ENDF/B-VI, NOT V, IF MISSING   Sixpak
                                   MF=1, MT-451.                        Sixpak
     VERS. 2000-1 (FEBRUARY 2000)*GENERAL IMPROVEMENTS BASED ON         Sixpak
                                   USER FEEDBACK                        Sixpak
     VERS. 2002-1 (JANUARY 2002) *CORRECTED ANGULAR DISTRIBUTION (MF=4) Sixpak
                                   OUTPUT TO INSURE USED FIELDS ARE 0    Sixpak
                  (MAY 2002)     *OPTIONAL INPUT PARAMETERS             Sixpak
                  (NOV. 2002)    *EXTENDED TO ALLOW CHARGED PARTICLE    Sixpak
                                   ANGULAR DISTRIBUTION IN MF=4 -       Sixpak
                                   WARNING - STRICTLY SPEAKING THIS IS   Sixpak
                                   NOT LEGAL, SINCE MF=4 IS SUPPOSED TO  Sixpak
                                   BE USED ONLY FOR NEUTRON ANGULAR      Sixpak
                                   DISTRIBUTIONS - BUT WHERE MT MAKES    Sixpak
                                   IT OBVIOUS THAT THE OUTGOING PARTICLE Sixpak
                                   IS NOT A NEUTRON HOPEFULLY IT WILL    Sixpak
                                   NOT CAUSE A PROBLEM IF MF=4 IS USED   Sixpak
                                   FOR CHARGED PARTICLES.               Sixpak
     VERS. 2004-1 (MARCH 2004)    *ADDED INCLUDE FOR COMMON              Sixpak
                                  *INCREASED MAXIMUM TABLE SIZE FROM     Sixpak
                                   6,000 TO 12,000.                     Sixpak
                                  *ADDED DUMMY A FOR ELEMENTS           Sixpak
                                  *CORRECTED OUTPUT INTERPOLATON LAWS    Sixpak
     VERS. 2007-1 (JAN.  2007)    *CHECKED AGAINST ALL ENDF/B-VII.       Sixpak
                                  *INCREASED MAXIMUM TABLE SIZE FROM     Sixpak
                                   12,000 TO 120,000.                   Sixpak
     VERS. 2007-2 (DEC.  2007)    *72 CHARACTER FILE NAMES.              Sixpak
     VERS. 2010-1 (Apr.  2010)    *General update based on user feedback Sixpak
     VERS. 2011-1 (May   2011)    *Added MF/MT=9/5 yield output starting Sixpak
                                   from  MF/MT=6/5 distributions.       Sixpak
                                  *Increased maximum Legendre order from Sixpak
                                   30 to 1,000 - WARNING - using more    Sixpak
                                   than 30 results in NONSENSE = NOISE!! Sixpak
     VERS. 2012-1 (Oct.  2012)    *Increased max. point count to 500,000 Sixpak
```

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                          *Added CODENAME                          Sixpak
                          *32 and 64 bit Compatible                Sixpak
                          *Added ERROR stop                        Sixpak
                          *For photons, combine discrete and       Sixpak
                           continuum into tabulated increasing     Sixpak
                           energy order.                           Sixpak
                          *Check energy output order increasing.   Sixpak
                           Print WARNING if not increasing - do    Sixpak
                           not STOP- stopping would prevent ALL    Sixpak
                           output - the user may not be at all     Sixpak
                           interested in the BAD data, but may     Sixpak
                           be interested in other output data      Sixpak
                           that is o.k.                            Sixpak
VERS. 2015-1 (Jan.  2015)  *Extended OUT9.                          Sixpak
                          *Replaced ALL 3 way IF Statements.       Sixpak
                          *Deleted unused coding.                  Sixpak
VERS. 2017-1 (May   2017)  *Increased max. point to 600,000         Sixpak
                          *Updated based on user feedback          Sixpak
VERS. 2017-2 (Oct.  2017)  *Updated for new P(nu) formats =         Sixpak
                           Recognized and ignored = no MF=5        Sixpak
                           equivalent.                             Sixpak
VERS. 2018-1 (Jan.  2018)  *Updated to skip Nu-Bar Data = there     Sixpak
                           is no double-differential data to       Sixpak
                           process.                                Sixpak
                          *On-linr report for ALL ENDERROR         Sixpak
                                                                   Sixpak
OWNED, MAINTAINED AND DISTRIBUTED BY                               Sixpak
-----------------------------------                                Sixpak
THE NUCLEAR DATA SECTION                                           Sixpak
INTERNATIONAL ATOMIC ENERGY AGENCY                                 Sixpak
P.O. BOX 100                                                       Sixpak
A-1400, VIENNA, AUSTRIA                                            Sixpak
EUROPE                                                             Sixpak
                                                                   Sixpak
ORIGINALLY WRITTEN BY                                              Sixpak
---------------------------------                                  Sixpak
Dermott E. Cullen                                                  Sixpak
                                                                   Sixpak
PRESENT CONTACT INFORMATION                                        Sixpak
---------------------------                                        Sixpak
Dermott E. Cullen                                                  Sixpak
1466 Hudson Way                                                    Sixpak
Livermore, CA 94550                                                Sixpak
U.S.A.                                                             Sixpak
Telephone  925-443-1911                                            Sixpak
E. Mail    RedCullen1@Comcast.net                                  Sixpak
Website    RedCullen1.net/HOMEPAGE.NEW                             Sixpak
                                                                   Sixpak
COLLABORATION                                                      Sixpak
================================================================== Sixpak
DEVELOPED IN COLLABORATION WITH,                                   Sixpak
                                                                   Sixpak
*THE NATIONAL NUCLEAR DATA CENTER, BROOKHAVEN NATIONAL LAB         Sixpak
                                                                   Sixpak
*THE NUCLEAR DATA SECTION, IAEA, VIENNA, AUSTRIA                   Sixpak
                                                                   Sixpak
*CENTRO TECNICO AEROSPACIAL, SAO JOSE DOS CAMPOS, BRAZIL           Sixpak
                                                                   Sixpak
AS A PART OF AN INTERNATIONAL PROJECT ON THE EXCHANGE OF           Sixpak
NUCLEAR DATA                                                       Sixpak
                                                                   Sixpak
ACKNOWLEDGEMENT (VERSION 92-1)                                     Sixpak
================================================================== Sixpak
THE AUTHOR THANKS SOL PEARLSTEIN (BROOKHAVEN NATIONAL LAB) FOR     Sixpak
SIGNIFICANTLY CONTRIBUTING TOWARD IMPROVING THE ACCURACY AND       Sixpak
COMPUTER INDEPENDENCE OF THIS CODE - THANKS, SOL                   Sixpak
                                                                   Sixpak
ACKNOWLEDGEMENT (VERSION 92-4)                                     Sixpak
================================================================== Sixpak
THE AUTHOR THANKS BOB MACFARLANE (LOS ALAMOS) FOR SUGGESTING HOW   Sixpak
TO PROPERLY OUTPUT THE PHOTON PRODUCTION DATA TO PUT IT INTO        Sixpak
```

EXACTLY THE FORM NEEDED FOR USE IN PROCESSING CODES. Sixpak

Sixpak

THE AUTHOR THANKS CHRIS DEAN (WINFRITH) FOR POINTING OUT ERRORS Sixpak
IN THE EARLIER TREATMENT OF THE KALBACH-MANN FORMALISM AND IN Sixpak
THE DEFINITION OF THE ISOTROPIC ANGULAR DISTRIBUTION FLAG (LI). Sixpak

Sixpak

AUTHORS MESSAGE Sixpak
========== Sixpak
THE COMMENTS BELOW SHOULD BE CONSIDERED THE LATEST DOCUMENTATION Sixpak
INCLUDING ALL RECENT IMPROVEMENTS. PLEASE READ ALL OF THESE Sixpak
COMMENTS BEFORE IMPLEMENTING AND USING THESE CODES. Sixpak

Sixpak

AT THE PRESENT TIME WE ARE ATTEMPTING TO DEVELOP A SET OF COMPUTER Sixpak
INDEPENDENT PROGRAMS THAT CAN EASILY BE IMPLEMENTED ON ANY ONE Sixpak
OF A WIDE VARIETY OF COMPUTERS. IN ORDER TO ASSIST IN THIS PROJECT Sixpak
IT WOULD BE APPECIATED IF YOU WOULD NOTIFY THE AUTHOR OF ANY Sixpak
COMPILER DIAGNOSTICS, OPERATING PROBLEMS OR SUGGESTIONS ON HOW TO Sixpak
IMPROVE THIS PROGRAM. HOPEFULLY, IN THIS WAY FUTURE VERSIONS OF Sixpak
THIS PROGRAM WILL BE COMPLETELY COMPATIBLE FOR USE ON YOUR Sixpak
COMPUTER. Sixpak

Sixpak

PURPOSE Sixpak
========== Sixpak
1) CHECK ALL DOUBLE-DIFFERENTIAL DATA (MF=6) Sixpak

Sixpak

2) OUTPUT EQUIVALENT MF = 4, 5, 12, 14 AND 15 DATA. Sixpak

Sixpak

DATA CHECKING Sixpak
========== Sixpak
ALL OF THE ENDF/B-VI MF=6 DATA IS CHECKED - FOR DETAILS SEE BELOW. Sixpak

Sixpak

THE MF=6 DATA IS NOT CORRECTED AND OUTPUT IN THE ENDF/B FORMAT. Sixpak
IT IS MERELY CHECKED. IF ERRORS ARE FOUND IT IS UP TO THE USER Sixpak
TO TAKE CORRECTIVE ACTION ON THE MF=6 DATA. Sixpak

Sixpak

IN CONTRAST WHEN PROBLEMS ARE FOUND IN DATA WHICH WILL BE OUTPUT Sixpak
IN THE ENDF/B FORMAT (MF=4, 5, 12, 14 AND 15), WHENEVER POSSIBLE Sixpak
CORRECTIVE ACTION WILL BE TAKEN. Sixpak

Sixpak

FURTHER CHECKS AND CORRECTIONS Sixpak
========== Sixpak
ONCE THE DATA HAS BEEN OUTPUT IN MF = 4, 5, 12, 14 AND 15 FORMATS Sixpak
FURTHER CORRECTIVE ACTION CAN BE TAKEN AS FOLLOWS, Sixpak

Sixpak

PROGRAM LEGEND Sixpak
========== Sixpak
CAN BE USED TO CORRECT ANGULAR DISTRIBUTIONS WHICH ARE NEGATIVE, Sixpak
TO CONVERT FROM LEGENDRE COEFFICIENTS TO TABULATED ANGULAR Sixpak
DISTRIBUTIONS AND GENERALLY PERFORM MORE EXTENSIVE TESTS OF Sixpak
ALL MF=4 DATA. Sixpak

Sixpak

PROGRAM EVALPLOT Sixpak
========== Sixpak
VERSION 92-1 AND LATER VERSIONS CAN PLOT ALL OF THE MF=4, 5 AND 15 Sixpak
DATA OUTPUT BY THIS CODE. EARLIER VERSIONS CAN PLOT MF=4 AND 5. Sixpak
GRAPHICS IS AN EXCELLENT WAY TO CHECK THIS DATA. Sixpak

Sixpak

PROGRAM PLOTTAB Sixpak
========== Sixpak
THIS IS A GENERAL PLOTTING PROGRAM AND THERE IS AN INTERFACE IN Sixpak
THIS CODE TO PRODUCE OUTPUT FOR ANY MF=6 DATA IN THE PLOTTAB Sixpak
INPUT FORMAT. THIS PROGRAM CAN BE USED TO CHECK ALL OF THE MF=6 Sixpak
DATA AS WELL AS THE EQUIVALENT MF=4, 5, 12, 14 AND 15 DATA - AS Sixpak
WELL AS COMPARING THE ORIGINAL MF=6 AND EQUIVALENT DATA. Sixpak

Sixpak

DATA OUTPUT Sixpak
========== Sixpak
THE ENDF/B MF=4, 5, 12, 14 AND 15 FORMATS ONLY ALLOW FOR NEUTRONS Sixpak
INCIDENTS Sixpak

Sixpak

THE ENDF/B MF=4 AND 5 FORMATS ONLY ALLOW FOR NEUTRONS OUTGOING. Sixpak

THE ENDF/B MF=12, 14 AND 15 ONLY ALLOWS FOR PHOTONS OUTGOING.

THESE ARE THE ONLY COMBINATIONS OF DATA OUTPUT BY THIS CODE.

ALL OTHER COMBINATIONS OF INCIDENT AND OUTGOING PARTICLES ARE CHECKED, BUT THE RESULTS CANNOT BE OUTPUT IN THE ENDF/B FORMAT. HOWEVER, USING THE PLOTTAB INTERFACE BUILT INTO THIS CODE THIS DATA CAN, AND HAS BEEN, OUTPUT AND CHECKED.

THE NEUTRON DATA IN MF=4 CAN BE IN THE FORM OF EITHER TABULATED ANGULAR DISTRIBUTIONS OR LEGENDRE COEFFICIENTS.

THE NEUTRON (MF=5) OR PHOTON (MF=15) SPECTRA ARE BOTH IN EXACTLY THE SAME FORMAT = ARBITRARY TABULATED FUNCTIONS - ENDF/B OPTION LF=1.

ENDF/B DATA OUTPUT ORDER
==========

ENDF/B DATA IS OUTPUT IN ASCENDING MAT, MF, MT ORDER. IN ORDER TO ALLOW THIS PROGRAM TO PRODUCE ALL OUTPUT IN A SINGLE PASS THROUGH THE MF=6 DATA, OUTPUT FOR EACH (MAT, MT) IS OUTPUT TO SEPERATE FILES FOR MF=4, 5, 12, 14 AND 15.

FOR SUBSEQUENT USE THE ENDF/B FORMATTED DATA OUTPUT BY THIS CODE CAN BE MERGED TOGETHER USING PROGRAM MERGER (CONTAIN THE AUTHOR OF THIS CODE FOR A COPY OF MERGER), E.G., MERGE MF=12, 14 AND 15 DATA IN ORDER TO THEN CALCULATE PHOTON PRODUCTION DATA OR MF=4 AND 5 CAN BE MERGED TOGETHER TO CALCULATE NEUTRON TRANSFER - OR ALL OF THEM CAN BE MERGED TOGETHER TO PERFORM NEUTRON AND PHOTON CALCULATIONS.

CORRELATED (MF=6) VS. UNCORRELATED (MF=4 AND 5) DATA
==========

THE ENDF/B DOUBLE DIFFERENTAL = CORRELATED - DATA IN MF=6 REPRESENTS DATA IN THE FORM,

$$F(E,EP,COS) = SIG(E)*Y(E)*G0(E,EP)*F(E,EP,COS)$$

SIG(E) = MF=3 CROSS SECTIONS
Y(E) = YIELD (MULTIPLICITY)
G0(E,EP) = ENERGY SPECTRUM
F(E,EP,COS) = ANGULAR DISTRIBUTION

IN A SITUATION WHERE YOU HAVE MONOENERGETIC AND MONODIRECTIONAL NEUTRONS INCIDENT YOU WILL BE ABLE TO OBSERVE CORRELATION EFFECTS IN THE NEUTRON SPECTRUM AND ANGULAR DISTRIBUTION.

EVEN IN SITUATIONS WHERE YOU HAVE A NARROW SPECTRUM OF NEUTRONS THAT ARE HIGHLY DIRECTIONALLY ORIENTED YOU MAY BE ABLE TO OBSERVE THESE CORRELATION EFFECTS, E.G., A NARROW 14 MEV FUSION SOURCE INCIDENT ON THE FIRST WALL OF A CTR DEVICE.

FOR SUCH SITUATIONS USE OF THE CORRELATED (MF=6) DATA IS REQUIRED IN CALCULATIONS.

HOWEVER, IN MANY APPLICATIONS WHERE THERE IS A BROAD SPECTRUM OF NEUTRONS AND THE NEUTRON FLUX IS NOT HIGHLY DIRECTIONALLY ORIENTED, THE NEUTRON MULTIPLICATION, SPECTRUM AND ORIENTATION CAN BE FAIRLY ACCURATELY CALCULATED WITHOUT CONSIDERING CORRELATION EFFECTS.

THE UNCORRELATED DATA PRODUCED BY THIS CODE REPLACES THE CORRELATED DATA,

$$F(E,EP,COS) = SIG(E)*Y(E)*G0(E,EP)*F(E,EP,COS)$$

BY THE UNCORRELATED DATA,

$$F(E,EP,COS) = SIG(E)*Y(E)*G0(E,EP)*F0(E,COS)$$

BY INTEGRATING G0(E,EP)*F(E,EP,COS) OVER SECONDARY ENERGY (EP) Sixpak
TO DEFINE AN AVERAGE ANGULAR DISTRIBUTION, F0(E,COS). Sixpak
Sixpak
WHAT IS LOST IN THIS PROCESS IS THE CORRELATION BETWEEN EP AND COS Sixpak
SO THAT IN A TRANSPORT CALCULATION ALL MOMENTS OF THE FLUX WILL Sixpak
HAVE THE SAME SPECTRUM, G0(E,EP) AND EACH WILL BE EFFECTED BY THE Sixpak
AVERAGE ANGULAR DISTRIBUTION. Sixpak
Sixpak
FOR APPLICATIONS TO HIGH ENERGY FUSION APPLICATIONS CORRELATED Sixpak
DATA SHOULD BE USED. HOWEVER, FOR LOWER ENERGY APPLICATIONS, Sixpak
SUCH AS FISSION REACTORS, IT SHOULD BE ADEQUATE TO USE THE Sixpak
UNCORRELATED DATA - IN THIS CASE THE MOST IMPORTANT EFFECT Sixpak
WILL BE THE OVERALL NEUTRON MULTIPLICATION AND SPECTRUM. Sixpak
Sixpak
AN IMPORTANT CONSIDERATION IN DESIGNING THIS PROGRAM IS THAT Sixpak
MANY COMPUTER CODES - DATA PROCESSING AND TRANSPORT CODES - Sixpak
CANNOT USE THE CORRELATED (MF=6) DATA - NOR ARE THEY INTENDED Sixpak
FOR HIGH ENERGY USE. FOR THESE CODES THE UNCORRELATED DATA Sixpak
PRODUCED BY THIS CODE SHOULD BE ADEQUATE TO MEET THEIR NEEDS. Sixpak
Sixpak
WARNING - IT CANNOT BE STRESSED ENOUGH THAT THE OUTPUT OF THIS Sixpak
CODE SHOULD ONLY BE USED FOR LOW ENERGY APPLICATIONS - FAILURE Sixpak
TO HEED THIS WARNING CAN LEAD TO COMPLETELY UNRELIABLE RESULTS. Sixpak
Sixpak
ENDF/B FORMAT Sixpak
========== Sixpak
THIS PROGRAM ONLY USES THE ENDF/B BCD OR CARD IMAGE FORMAT (AS Sixpak
OPPOSED TO THE BINARY FORMAT) AND CAN HANDLE DATA IN ANY VERSION Sixpak
OF THE ENDF/B FORMAT (I.E., ENDF/B-I, II,III, IV, V OR VI FORMAT). Sixpak
Sixpak
IT IS ASSUMED THAT THE DATA IS CORRECTLY CODED IN THE ENDF/B Sixpak
FORMAT AND NO ERROR CHECKING IS PERFORMED. IN PARTICULAR IT IS Sixpak
ASSUMED THAT THE MAT, MF AND MT ON EACH LINE IS CORRECT. SEQUENCE Sixpak
NUMBERS (COLUMNS 76-80) ARE IGNORED ON INPUT, BUT WILL BE Sixpak
CORRECTLY OUTPUT ON ALL LINES. THE FORMAT OF SECTION MF=1, MT=451 Sixpak
AND ALL SECTIONS OF MF=6 MUST BE CORRECT. THE PROGRAM SKIPS ALL Sixpak
OTHER SECTIONS OF DATA AND AS SUCH IS INSENSITIVE TO THE FORMAT Sixpak
OF ALL OTHER SECTIONS. Sixpak
Sixpak
CONTENTS OF OUTPUT Sixpak
========== Sixpak
5 ENDF/B FORMATTED OUTPUT FILES ARE PRODUCED FOR NEUTRON INCIDENT Sixpak
DATA, Sixpak
Sixpak
1) ENDFB.MF4 - ANGULAR DISTRIBUTIONS AND LEGENDRE COEFFICIENTS Sixpak
FOR NEUTRONS Sixpak
2) ENDFB.MF5 - TABULATED NEUTRON ENERGY SPECTRA Sixpak
3) ENDFB.M12 - PHOTON EMISSION MULTIPLICITY Sixpak
4) ENDFB.M14 - PHOTON EMISSION ANGULAR DISTRIBUTIONS (ALWAYS Sixpak
ISOTROPIC) Sixpak
5) ENDFB.M15 - TABULATED PHOTON EMISSION SPECTRA Sixpak
Sixpak
EMITTED PARTICLE YIELD Sixpak
========== Sixpak
NEUTRONS Sixpak
======== Sixpak
IN MF=6 THE YIELD FOR EACH REACTION IS THE ACTUAL MULTIPLICITY OF Sixpak
THE REACTION, E.G., (N,2N) = 2. IN USING MF=4 AND 5 DATA THE Sixpak
ENDF/B CONVENTION IS THAT THE MULTIPLICITY IS IMPLIED BY THE Sixpak
MT NUMBER, E.G., MT=16 = (N,2N) = 2. Sixpak
Sixpak
THE ONLY EXCEPT IN ENDF/B-VI IS MT=201 = TOTAL NEUTRON PRODUCTION Sixpak
WHERE AN ACTUAL ENERGY DEPENDENT YIELD IS INCLUDED IN MF=6. Sixpak
HOWEVER, IN THIS CASE THE MF=3 CROSS SECTION INCLUDES THE Sixpak
MULTIPLICITY (S. PEARLSTEIN, PRIVATE COMMUNICATION, JAN. 1992), Sixpak
SIG(MT=201) = 2*SIG(N,2N)+3*SIG(N,3N).....ETC. Sixpak
Sixpak
SO THAT FOR ALL ENDF/B-VI DATA AS OF JANUARY 1992 THE MF=4 AND 5 Sixpak
DATA OUTPUT BY THIS CODE CAN BE USED IN CONJUNCTION WITH THE MF=3 Sixpak
CROSS SECTIONS - WITHOUT ANY REFERENCE TO THE MF=6 YIELD. Sixpak
Sixpak

PHOTONS Sixpak
======= Sixpak
UNLIKE THE NEUTRONS WHERE WITH ONLY ONE EXCEPTION (MT=201) THE Sixpak
MF=6 YIELD IS ENERGY INDEPENDENT, IN THE CASE OF PHOTON EMISSION Sixpak
ALMOST ALL OF THE PHOTONS HAVE AN ENERGY DEPENDENT YIELD. Sixpak
Sixpak
THIS PROGRAM WILL OUTPUT THE PHOTON MULTIPLICITY IN MF=12 AND Sixpak
INDICATE THAT THERE IS A NORMALIZED DISTRIBUTION IN MF=15 Sixpak
(LF=1 IN MF=12). Sixpak
Sixpak
THIS PROGRAM WILL OUTPUT THE NORMALIZED PHOTON SPECTRA IN MF=15. Sixpak
CONTINUOUS ENERGY SPECTRA AND DISCRETE PHOTONS WILL ALL BE OUTPUT Sixpak
AS NORMALIZED SPECTRA. Sixpak
Sixpak
THIS PROGRAM WILL ALSO OUTPUT MF=14 PHOTON ANGULAR DISTRIBUTION Sixpak
DATA, ALWAYS USING THE ISOTROPIC FLAG TO MINIMIZE OUTPUT. Sixpak
Sixpak
WARNING OF ENERGY DEPENDENT YIELD Sixpak
================================= Sixpak
THIS PROGRAM WILL PRINT A WARNING MESSAGE IF A SECTION OF DATA Sixpak
BEING OUTPUT IN THE ENDF/B FORMAT HAS AN ENERGY DEPENDENT MF=6 Sixpak
YIELD AND THE EMITTED PARTICLE IS A NEUTRON - SINCE THE ENDF/B Sixpak
CONVENTION IS THAT FOR EACH MT NUMBER THE MULTIPLICITY IS IMPLIED Sixpak
WE DO NOT EXPECT AN ENERGY DEPENDENT MULTIPLICITY FOR NEUTRON Sixpak
EMISSION. Sixpak
Sixpak
USING THE OUTPUT Sixpak
== Sixpak
NOTE, THAT IN USING THIS DATA, STARTING FROM THE RELATIONSHIP, Sixpak
Sixpak
F(E,EP,COS) = SIG(E)*Y(E)*G0(E,EP)*F0(E,COS) Sixpak
Sixpak
USING THE ENDF/B CONVENTION THAT THE MULTIPLICITY IS EITHER Sixpak
IMPLIED BY THE MT NUMBER (E.G., MT=16 = N,2N - MULTIPLICITY = 2) Sixpak
OR INCLUDED IN THE CROSS SECTION (E.G., MT=201 = TOTAL NEUTRON Sixpak
PRODUCTION) ALL THE INFORMATION REQUIRED FOR A CALCULATION IS Sixpak
AVAILABLE IN, Sixpak
Sixpak
MF=3 - SIG(E) Sixpak
MF=4 - F0(E,COS) - FOR OUTGOING NEUTRONS Sixpak
MF=5 - G0(E,EP) - FOR OUTGOING NEUTRONS Sixpak
MF=12 - Y(E) - FOR OUTGOING PHOTONS Sixpak
MF=14 - F0(E,COS) - FOR OUTGOING PHOTONS (ALWAYS ISOTROPIC) Sixpak
MF=15 - G0(E,EP) - FOR OUTGOING PHOTONS Sixpak
Sixpak
DOCUMENTATION Sixpak
== Sixpak
ONLY SECTIONS OF MF=4, 5, 12, 14, 15 ARE OUTPUT ON A ENDF/B FILE. Sixpak
THE ONLY DOCUMENTATION IS THE ENDF/B TAPE LABEL (FIRST RECORD OF Sixpak
EACH FILE) WHICH IDENTIFIES THE DATA AS SIXPAK OUTPUT. Sixpak
Sixpak
REACTION INDEX Sixpak
== Sixpak
THIS PROGRAM DOES NOT USE THE REACTION INDEX WHICH IS GIVEN IN Sixpak
SECTION MF=1, MT=451 OF EACH EVALUATION. Sixpak
Sixpak
SECTION SIZE Sixpak
== Sixpak
ALL OF THE DATA IN ENDF/B-VI, MF=6 ARE QUITE SMALL TABLES. AS SUCH Sixpak
THIS PROGRAM ONLY ALLOWS TABLES OF UP TO 12000 POINTS (12,000 X, Sixpak
Y VALUES). THIS SIZE IS MORE THAN ADEQUATE TO HANDLE ALL OF THE Sixpak
CURRENT ENDF/B-VI DATA, AND IT CAN BE EASILY INCREASED TO HANDLE Sixpak
ANY NEWER DATA AS IT BECOMES AVAILABLE. Sixpak
Sixpak
PLEASE CONTACT THE AUTHOR IF YOU HAVE AN EVALUATION WHICH EXCEEDS Sixpak
THIS LIMIT. Sixpak
Sixpak
SELECTION OF DATA Sixpak
== Sixpak
THE PROGRAM SELECTS DATA TO BE PROCESSED BASED ON MAT/MT RANGES Sixpak
(MF=6 ASSUMED). THIS PROGRAM ALLOWS UP TO 100 MAT/MT RANGES TO BE Sixpak

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SPECIFIED BY INPUT PARAMETERS. THE PROGRAM WILL ASSUME THAT THE    Sixpak
ENDF/B TAPE IS IN MAT ORDER. THE PROGRAM WILL TERMINATE EXECUTION  Sixpak
WHEN A MAT IS FOUND THAT IS ABOVE ALL REQUESTED MAT RANGES.        Sixpak
                                                                   Sixpak
PROGRAM OPERATION                                                  Sixpak
================================================================== Sixpak
EACH SECTION (MT) OF MF=6 DATA IS SUBDIVIDED INTO SUBSECTIONS -    Sixpak
ONE SUBSECTION FOR EACH EMITTED PARTICLE.                          Sixpak
                                                                   Sixpak
EACH SUBSECTION OF DATA IS CONSIDERED SEPARATELY. EACH SUBSECTION  Sixpak
OF ENDF/B MF=6 DATA TO PROCESS IS IN THE FORM,                     Sixpak
                                                                   Sixpak
F(E,EP,COS) = SIG(E)*Y(E)*G0(E,EP)*F(E,EP,COS)                     Sixpak
                                                                   Sixpak
SIG(E)      = MF=3 CROSS SECTIONS                                  Sixpak
Y(E)        = YIELD (MULTIPLICITY)                                 Sixpak
G0(E,EP)    = ENERGY SPECTRUM                                      Sixpak
F(E,EP,COS) = ANGULAR DISTRIBUTION                                 Sixpak
                                                                   Sixpak
G0(E,EP) = 1 WHEN INTEGRATED OVER EP (SECONDARY ENERGY)            Sixpak
G0(E,EP)*F(E,EP,COS) = 1 WHEN INTEGRATED OVER EP AND COS           Sixpak
                                                                   Sixpak
THIS PROGRAM WILL DEFINE THE ZEROTH ORDER MOMENTS OF THE           Sixpak
ENERGY AND ANGULAR DISTRIBUTIONS,                                  Sixpak
                                                                   Sixpak
G0(E,EP)  = G0(E,EP)*F(E,EP,COS) INTEGRATED OVER COS               Sixpak
F0(E,COS) = G0(E,EP)*F(E,EP,COS) INTEGRATED OVER EP                Sixpak
                                                                   Sixpak
FOR NEUTRON INDUCED REACTIONS THE ENDF/B FORMATTED OUTPUT WILL BE  Sixpak
                                                                   Sixpak
F0(E,COS)- IN ENDFB.MF4 FOR NEUTRONS OUT OF A REACTION             Sixpak
G0(E,EP) - IN ENDFB.MF5 FOR NEUTRONS OUT OF A REACTION             Sixpak
         - IN ENDFB.M15 FOR PHOTONS OUT OF A REACTION              Sixpak
                                                                   Sixpak
FOR NEUTRONS INCIDENT AND NEUTRONS EMITTED THIS DATA WILL BE       Sixpak
OUTPUT IN MF=4 AND 5 FORMATS.                                      Sixpak
                                                                   Sixpak
FOR NEUTRONS INCIDENT AND PHOTONS EMITTED THIS DATA WILL BE        Sixpak
OUTPUT IN MF=15 FORMAT - THE SPECTRA ARE OUTPUT AND THE            Sixpak
ANGULAR DISTRIBUTION IS IGNORED.                                   Sixpak
                                                                   Sixpak
ALL PHOTON EMISSION IN THE ENDF/B-VI LIBRARY AS OF JANUARY 1992    Sixpak
IS ISOTROPIC AND AS SUCH NO DISTRIBUTION OF PHOTON ANGULAR         Sixpak
DISTRIBUTIONS NEED BE OUTPUT - IT IS ALWAYS ISOTROPIC.             Sixpak
                                                                   Sixpak
FOR ALL OTHER COMBINATIONS INCIDENT AND EMITTED PARTICLES          Sixpak
THERE WILL BE NO ENDF/B FORMATTED OUTPUT.                          Sixpak
                                                                   Sixpak
VARIATIONS FROM ENDF/B MANUAL                                      Sixpak
================================================================== Sixpak
LAW=1, LANG=2 = KALBACH-MANN                                       Sixpak
============================                                       Sixpak
FOR THE DISTRIBUTIONS,                                             Sixpak
                                                                   Sixpak
F(MU,E,EP) = G0(E,EP)*A*(COSH(MU*A)+R(E,EP)*SINH(MU*A))            Sixpak
                                                                   Sixpak
G0(E,EP) = 1 - WHEN INTEGRATED OVER EP.                            Sixpak
                                                                   Sixpak
A*(COSH(MU*A)+R(E,EP)*SINH(MU*A)) = 2 - WHEN INTEGRATD OVER MU     Sixpak
                                                                   Sixpak
THIS MEANS AS DEFINED IN THE ENDF/B MANUAL THE DISTRIBUTIONS       Sixpak
ARE NORMALIZED TO 2, INSTEAD OF 1. IN ORDER TO OBTAIN CORRECTLY    Sixpak
NORMALIZED DISTRIBUTIONS THE DISTRIBUTION SHOULD BE DEFINED        Sixpak
TO INCLUDE A FACTOR OF 1/2 MULTIPLYING THE ANGULAR PART OF         Sixpak
THE DISTRIBUTION.                                                  Sixpak
                                                                   Sixpak
F(MU,E,EP) = G0(E,EP)*0.5*A*(COSH(MU*A)+R(E,EP)*SINH(MU*A))        Sixpak
                                                                   Sixpak
THIS IS THE FORM USED IN THIS CODE                                 Sixpak
                                                                   Sixpak
LAW=1, ND NOT 0 = DISCRETE SECONDARY ENERGY DISTRIBUTION           Sixpak
```

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=========================================================          Sixpak
THE ENDF/B MANUAL SAYS THESE ARE FLAGGED WITH NEGATIVE ENERGIES.   Sixpak
IN ENDF/B-VI ALL OF THESE HAVE POSITIVE ENERGY. THIS CODE DOES     Sixpak
NOT CONSIDER THE ENDF/B-VI DATA TO BE IN ERROR.                    Sixpak
                                                                   Sixpak
WITH THE CONVENTION ACTUALLY USED IN ENDF/B-VI ALL SECONDARY       Sixpak
ENERGIES SHOULD BE NON-NEGATIVE AND IN ASCENDING ENERGY ORDER      Sixpak
FOR EACH INCIDENT ENERGY.                                          Sixpak
                                                                   Sixpak
FROM THE ENDF/B MANUAL IT IS NOT OBVIOUS WHAT G0(E,EP) SHOULD BE   Sixpak
FOR DISCRETE PHOTONS - PHYSICALLY THIS IS A DELTA FUNCTION. IN     Sixpak
ENDF/B-VI IT IS ENTERED AS 1.0 = INTERPRETING IT AS INTEGRATED     Sixpak
OVER SECONDARY ENERGY - IN WHICH CASE THE DELTA FUNCTION = 1.0.    Sixpak
                                                                   Sixpak
LIMITATIONS                                                        Sixpak
================================================================== Sixpak
CHECKING DATA                                                      Sixpak
================================================================== Sixpak
THIS PROGRAM CHECKS ALL ENDF/B-VI MF=6 DATA. THE FOLLOWING CHECKS  Sixpak
ARE PERFORMED.                                                     Sixpak
                                                                   Sixpak
PARAMETERS                                                         Sixpak
==========                                                         Sixpak
ALL PARAMETERS ARE CHECKED FOR CONSISTENCY. IF PARAMETERS ARE      Sixpak
NOT CONSISTENT THE PROGRAM MAY NOT BE ABLE TO PERFORM THE          Sixpak
FOLLOWING TESTS AND WILL MERELY SKIP A SECTION OF DATA.            Sixpak
                                                                   Sixpak
INTERPOLATION LAWS                                                 Sixpak
==================                                                 Sixpak
ALL INTEGRATIONS ARE PERFORMED USING THE INTERPOLATION LAW GIVEN   Sixpak
FOR SECONDARY ENERGY AND/OR COSINE. INTEGRATIONS ARE NOT           Sixpak
PERFORMED OVER INCIDENT - ONLY INTEGRATION OVER SECONDARY ENERGY   Sixpak
AND/OR COSINE ARE PERFORMED AT EACH INCIDENT ENERGY. THEREFORE     Sixpak
THE INTERPOLATION LAW FOR INCIDENT ENERGY IS NOT USED BY THIS      Sixpak
CODE.                                                              Sixpak
                                                                   Sixpak
ALL INTERPOLATION LAWS ARE CHECKED. ALL DATA ASSOCIATED WITH       Sixpak
INTERPOLATION LAWS ARE CHECKED, E.G., NO NON-NEGATIVE VALUES       Sixpak
REQUIRING LOG INTERPOLATION. IN ORDER TO PERFORM REQUIRED          Sixpak
INTEGRALS OVER COS AND EP IT IS IMPERATIVE THAT THE INTERPOLATION  Sixpak
LAWS BE COMPATIBLE WITH THE DATA.                                  Sixpak
                                                                   Sixpak
ENDF/B-VI ALLOWS NEW INTERPOLATION LAWS FOR CORRESPONDING POINT    Sixpak
AND UNIT BASE TRANSFORMATION INTERPOLATION. NONE OF THESE NEW      Sixpak
INTERPOLATION LAWS ARE USED IN THE ENDF/B-VI LIBRARY AS OF         Sixpak
JANUARY 1992 TO INTERPOLATE IN SECONDARY ENERGY OR COSINE.         Sixpak
THEREFORE THIS PROGRAM CAN PERFORM ALL OF THE REQUIRED INTEGRALS   Sixpak
OVER SECONDARY ENERGY AND/OR COSINE USING ONLY THE OLDER           Sixpak
INTERPOLATION CODES. THIS PROGRAM ONLY PERFORMS INTEGRALS FOR      Sixpak
EACH INCIDENT ENERGY, SO THAT INTERPOLATION IN INCIDENT ENERGY     Sixpak
IS NOT PERFORMED BY THIS PROGRAM.                                  Sixpak
                                                                   Sixpak
NEW INTERPOLATION SCHEMES ARE USED FOR INCIDENT ENERGY - FOR       Sixpak
EXAMPLE, CORRESPONDING POINT INTERPOLATION IS SPECIFIED TO ALLOW   Sixpak
INTERPOLATION IN G0(E,EP) TO SIMULATE CASES WHERE THE INPUT ENERGY Sixpak
LIMIT IS DEFINED BY E-EP = A DIAGONAL CURVE ACROSS (E,EP) SPACE.   Sixpak
THIS INTERPOLATION CODE CANNOT BE SPECIFIED IN THE MF=5 OUTPUT     Sixpak
OF THIS CODE - MF=5 ONLY ALLOWS THE OLDER INTERPOLATION LAWS       Sixpak
INT=1 THROUGH 5. THEREFORE THIS PROGRAM WILL USE THE CLOSEST       Sixpak
CORRESPONDING INTERPOLATION CODE FOR OUTPUT TO MF=5. FOR USE       Sixpak
WHERE THE OUTPUT OF THIS CODE = LOW ENERGY APPLICATIONS - THIS     Sixpak
SHOULD HAVE LITTLE EFFECT ON RESULTS.                              Sixpak
                                                                   Sixpak
FOR CONSISTENCY WITH EARLIER VERSIONS OF ENDF/B IN CREATING THE    Sixpak
ENDF/B OUTPUT, IF ANY INPUT INTERPOLATION LAW IS NOT IN THE        Sixpak
RANGE 1-5, IT WILL FIRST BE TESTED TO SEE IF MOD(10) IT IS         Sixpak
IN THIS RANGE, FINALLY IF EVEN THIS DOESN'T WORK IT IS SET         Sixpak
EQUAL TO 2 (LINEARLY INTERPOLATION). THIS METHOD WILL EFFECTIVELY  Sixpak
REPLACE CORRESPONDING POINT AND UNIT BASE TRANSFORMATION BY THE    Sixpak
CLOSEST RELATED INTERPOLATION LAW 1 THROUGH 5 - AGAIN NOTE, AS     Sixpak
OF JANUARY 1992 NONE OF THESE NEW LAWS ARE USED IN ENDF/B-VI. IF   Sixpak
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THIS MUST BE DONE FOR INTERPOLATION IN SECONDARY ENERGY OR COSINE  Sixpak
AN ERROR MESSAGE WILL BE PRINTED - SINCE THIS WOULD EFFECT THE     Sixpak
ACCURACY OF THE INTEGRALS PERFORMED BY THIS PROGRAM. IF THIS MUST  Sixpak
BE DONE FOR INCIDENT ENERGY NO MESSAGE IS PRINTED - SINCE THIS     Sixpak
WILL NOT EFFECT THE ACCURACY OF THE INTEGRALS PERFORMED BY THIS    Sixpak
PROGRAM.                                                           Sixpak
                                                                   Sixpak
SPECTRA AND ANGULAR DISTRIBUTIONS                                  Sixpak
================================                                   Sixpak
ALL SPECTRA AND ANGULAR DISTRIBUTIONS ARE CHECKED TO INSURE        Sixpak
THEY ARE NORMALIZED AND DO NOT INCLUDE ANY NEGATIVE VALUES.        Sixpak
                                                                   Sixpak
LEGENDRE COEFFICIENTS                                              Sixpak
=====================                                              Sixpak
THE NORMALIZATION, F0, CANNOT BE NEGATIVE.                         Sixpak
                                                                   Sixpak
LEGENDRE COEFFICIENTS IN NORMAL FORM ARE CHECKED TO INSURE         Sixpak
THEY ARE IN THE RANGE -1 TO +1 = THE LEGENDRE EXPANSION OF A       Sixpak
DELTA FUNCTION AT COS=+1 OR -1 - COEFFICIENTS SHOULD NOT           Sixpak
EXCEED WHAT YOU GET FROM A DELTA FUNCTION.                         Sixpak
                                                                   Sixpak
ANGULAR DISTRIBUTIONS ARE CHECKED AT COS = -1, 0 AND +1.           Sixpak
                                                                   Sixpak
CREATING ENDF/B OUTPUT                                             Sixpak
=================================================================  Sixpak
THIS PROGRAM CAN CREATE EQUIVALENT MF =4, 5, 12, 14, 15 DATA FOR   Sixpak
ALL OF THE DATA INCLUDED IN ENDF/B-VI AS OF JANUARY 1992, EXCEPT   Sixpak
FOR 1 SECTION OF LAW=6 DATA (SEE DETAILS BELOW).                   Sixpak
                                                                   Sixpak
THIS PROGRAM HAS NOT BEEN TESTED ON OTHER DATA LIBRARIES, E.G.,    Sixpak
JEF, JENDL, ETC.                                                   Sixpak
                                                                   Sixpak
THE PROGRAM HAS THE FOLLOWING LIMITATION AS FAR AS CREATING        Sixpak
ENDF/B FORMATTED OUTPUT.                                           Sixpak
                                                                   Sixpak
ISOTROPIC PHOTON EMISSION                                          Sixpak
=========================                                          Sixpak
FOR PHOTON EMISSION THE DISTRIBUTIONS ARE ASSUMED TO BE ISOTROPIC  Sixpak
AND ONLY THE MULTIPLICITY IS OUTPUT IN MF=12, ISOTROPIC ANGULAR    Sixpak
DISTRIBUTIONS IN MF=14 AND THE SPECTRA IN MF=15. ALL ENDF/B-VI     Sixpak
MF=6 DATA AS OF JANUARY 1992 INCLUDE ONLY ISOTROPIC PHOTON         Sixpak
EMISSION - SO THAT THIS IS NOT A LIMITATION ON TRANSLATING         Sixpak
ENDF/B-VI DATA.                                                    Sixpak
                                                                   Sixpak
EITHER TABULATED OR LEGENDRE COEFFICIENTS                          Sixpak
=========================================                          Sixpak
FOR LAW=2 THE REPRESENTATION, EITHER TABULATED OR LEGENDRE         Sixpak
COEFFICIENTS, CAN BE SPECIFIED FOR EACH INCIDENT ENERGY.           Sixpak
                                                                   Sixpak
IN ORDER TO OBTAIN CORRECT ENDF/B OUTPUT THE REPRESENTATION        Sixpak
MUST BE THE SAME FOR ALL INCIDENT ENERGIES = MF=4 DATA CAN ONLY     Sixpak
BE TABULATED OR LEGENDRE OVER THE ENTIRE ENERGY RANGE.             Sixpak
                                                                   Sixpak
YIELD AND OUTPUT NORMALIZATION                                     Sixpak
==============================                                     Sixpak
THE YIELD INCLUDED WITH EACH SECTION OF DATA IS NOT USED FOR       Sixpak
OUTPUT FOR NEUTRONS, BUT IS INCLUDED IN THE OUTPUT FOR PHOTONS.    Sixpak
IN ALL CASES THE ANGULAR DISTRIBUTIONS AND SPECTRA OUTPUT ARE      Sixpak
NORMALIZED TO UNITY.                                               Sixpak
                                                                   Sixpak
LAW=0                                                              Sixpak
=====                                                              Sixpak
NO OUTPUT - INCIDENT NEUTRON - EMITTED PHOTON OR NEUTRON           Sixpak
            REACTIONS ARE NOT EXPECTED.                            Sixpak
                                                                   Sixpak
LAW=1                                                              Sixpak
=====                                                              Sixpak
FOR EACH INCIDENT ENERGY DISCRETE AND CONTINUOUS EMISSION SPECTRA  Sixpak
CANNOT BE MIXED TOGETHER - THEY MUST BE ALL EITHER DISCRETE OR     Sixpak
CONTINUOUS. IF DISCRETE EMISSION IS GIVEN ONLY 1 SECONDARY         Sixpak
ENERGY (NEP=1) MAY BE GIVEN = A NORMALIZED DISTRIBUTION FOR A      Sixpak
```

SINGLE DISCRETE EMISSION ENERGY. ALL OF THE ENDF/B-VI DATA AS OF JANUARY 1992 CONFORM TO THESE LIMITATIONS.

SINCE THE FLAG NA, TO INDICATE ISOTROPIC DISTRIBUTIONS, IS ONLY GIVEN FOR EACH SECONDARY ENERGY (EP) THE PROGRAM CANNOT DECIDE IN ADVANCE WHETHER OR NOT THE DISTRIBUTION WILL BE ISOTROPIC AT ALL INCIDENT ENERGIES. THEREFORE ISOTROPIC DISTRIBUTIONS WILL BE OUTPUT EITHER: LANG = 1 - AS 1 LEGENDRE COEFFICIENT = 0.0 OR LANG = NOT 1 - AS A 2 POINT ANGULAR DISTRIBUTION AT COS = -1.0 AND +1.0 WITH BOTH VALUES EQUAL TO 0.5 (A NORMALIZED ISOTROPIC DISTRIBUTION).

DISCRETE PHOTONS ARE OUTPUT IN MF=15 AS 3 POINT DISTRIBUTIONS WITH SECONDARY ENERGY POINTS AT EP-DEP, EP, EP+DEP, WHERE DEP=0.001*EP. THE VALUES AT EP-DEP AND EP+DEP ARE 0.0, AND AT EP THE VALUE IS 1000.0/EP TO NORMALIZE THE DISTRIBUTION.

LAW=2
=====
NO LIMITATION ON REPRESENTATIONS.

LAW=3
=====
NO LIMITATION ON REPRESENTATIONS.

LAW=4
=====
NO OUTPUT - INCIDENT NEUTRON - EMITTED PHOTON OR NEUTRON REACTIONS ARE NOT EXPECTED.

LAW=5
=====
NO OUTPUT - INCIDENT NEUTRON - EMITTED PHOTON OR NEUTRON REACTIONS ARE NOT EXPECTED.

LAW=6
=====
NO OUTPUT - ENDF/B-VI ONLY INCLUDES 1 SECTION OF THIS TYPE OF DATA FOR (N,D) 2N,P.

LAW=7
=====
FOR EACH INCIDENT ENERGY THE REPRESENTATION MUST BE EITHER,

1) SQUARE = FOR EACH INCIDENT COSINE EXACTLY THE SAME SECONDARY ENERGIES.

2) LINEAR = FOR EACH INCIDENT COSINE THE INTERPOLATION LAW BETWEEN SECONDARY ENERGIES MUST BE LINEAR.

THESE 2 PRESENTATIONS ARE THE ONLY ONES PRESENTED IN ENDF/B-VI AS OF JANUARY 1992 - SO THIS PROGRAM CAN TRANSLATED ALL LAW=7 DATA FOR ENDF/B-VI.

LABORATORY VS. CENTER-OF-MASS SYSTEM
====================================

IN MANY CASES PEOPLE ASSUME THAT FOR HEAVY (HIGH ATOMIC WEIGHT) MATERIALS THE CENTER-OF-MASS AND LAB SYSTEMS ARE ALMOST IDENTICAL, SINCE IN THIS CASE THE CENTER-OF-MASS ENERGY WILL BE MUCH SMALLER THAN THE INCIDENT ENERGY. FOR A PROCESS SUCH AS ELASTIC SCATTERING WHERE FOR HEAVY MATERIALS THE SECONDARY ENERGY, EP, WILL ALWAYS BE A LARGE FRACTION OF THE INCIDENT ENERGY, THIS ASSUMPTION IS VALID. HOWEVER, FOR THE TYPICAL REACTIONS INCLUDED IN MF=6 THIS IS NOT ALWAYS TRUE - IN MANY OF THESE CASES THE SECONDARY ENERGY CAN EXTEND ALL THE WAY DOWN TO ZERO, AND IN PARTICULAR IT CAN BE SMALL COMPARED TO THE CENTER-OF-MASS ENERGY - WHICH MAKES THE TRANSFORMATION FROM CENTER-OF-MASS TO LAB IMPORTANT. THEREFORE GENERALLY TO TREAT MF=6 DATA WE MUST CONSIDER THIS TRANSFORMATION.

THE FOLLOWING DISCUSSING ONLY APPLIES TO SPECTRA THAT MAY BE OUTPUT IN MF=5 = ONLY DATA FOR NEUTRONS INCIDENT AND EMITTED -

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IN PARTICULAR THE FOLLOWING DEFINITIONS ARE NOT GENERAL - THEY     Sixpak
ARE ONLY VALID FOR INCIDENT AND EMITTED NEUTRONS.                  Sixpak
                                                                   Sixpak
DOUBLE DIFFERENTIAL DATA IN MF=6 MAY BE GIVEN IN EITHER THE LAB    Sixpak
OR C.M. SYSTEM. SIMILARLY ANGULAR DISTRIBUTIONS IN MF=4 MAY BE     Sixpak
GIVEN IN EITHER THE LAB OR C.M. SYSTEM. IN CONTRAST ENERGY         Sixpak
SPECTRA IN MF=5 CAN ONLY BE GIVEN IN THE LABORATORY SYSTEM.        Sixpak
                                                                   Sixpak
THE ANGULAR DISTRIBUTIONS OUTPUT BY THIS CODE IN MF=4 ARE IN THE   Sixpak
SAME SYSTEM IN WHICH THEY ARE GIVEN IN MF=6 - EITHER LAB OR        Sixpak
CENTER-OF-MASS SYSTEM.                                             Sixpak
                                                                   Sixpak
THE ENERGY SPECTRA OUTPUT BY THIS CODE IN MF=5 MUST BE IN THE LAB  Sixpak
SYSTEM - THIS IS THE ONLY ALLOWED FORM FOR MF=5 DATA.              Sixpak
                                                                   Sixpak
FOR MF=6 SPECTRA GIVEN IN THE LAB SYSTEM THIS MERELY REQUIRES      Sixpak
COPYING THE GIVEN SPECTRA TO MF=5 OUTPUT.                          Sixpak
                                                                   Sixpak
FOR MF=6 SPECTRA GIVEN IN THE CENTER-OF-MASS SYSTEM ONLY FIRST     Sixpak
ORDER CORRECTIONS IN THE SPECTRA AND USED AND THEY ARE THEN        Sixpak
OUTPUT IN MF=5 AS IN THE LAB SYSTEM - THE FIRST ORDER CORRECTIONS  Sixpak
ARE DESCRIBED BELOW.                                               Sixpak
                                                                   Sixpak
DEFINING,                                                          Sixpak
MM      = CENTER OF MASS MOTION                                    Sixpak
CM      = OUTGOING (EMITTED) PARTICLE IN CENTER OF MASS            Sixpak
LAB     = OUTGOING (EMITTED) PARTICLE IN LAB                       Sixpak
THETA   = CM SCATTERING ANGLE RELATIVE TO INCIDENT DIRECTION       Sixpak
COS(CM) = COSINE OF THE CM SCATTERING ANGLE                        Sixpak
                                                                   Sixpak
FOR NEUTRONS INCIDENT WITH AN ENERGY, E, AND THEREFORE A SPEED,    Sixpak
                                                                   Sixpak
VN(E) = 2*SQRT(E)/MASS(IN)                                         Sixpak
                                                                   Sixpak
THE CENTER-OF-MASS SPEED IS GIVEN BY,                              Sixpak
                                                                   Sixpak
V(MM) = VN(E)/(1 + A)                                              Sixpak
                                                                   Sixpak
AND THE CENTER OF MASS ENERGY BY,                                  Sixpak
                                                                   Sixpak
E(MM) = 1/2*MASS(IN)*V(MM)**2                                      Sixpak
      = 1/2*MASS(IN)*VN(E)**2/(1 + A)**2                           Sixpak
      = E/(1 + A)**2                                               Sixpak
                                                                   Sixpak
FOR DISTRIBUTIONS GIVEN IN MF=6 IN THE CM, THE SPEED, V(CM),       Sixpak
SHOULD BE VECTORIALLY ADDED TO THAT OF OUTGOING PARTICLES TO       Sixpak
DEFINE THE OUTGOING PARTICLES LAB VELOCITY, AND IN TURN IT'S       Sixpak
ENERGY,                                                            Sixpak
                                                                   Sixpak
V(LAB)*COS(LAB) = V(MM) + V(CM)*COS(CM)                            Sixpak
V(LAB)*SIN(LAB) =         V(CM)*SIN(CM)                            Sixpak
                                                                   Sixpak
V(LAB)**2 = V(MM)**2 + V(CM)**2 + 2*COS(CM)*V(MM)*V(CM)            Sixpak
                                                                   Sixpak
EP(LAB)   = 0.5*MASS(OUT)*V(LAB)**2                                Sixpak
                                                                   Sixpak
          = E(MM) + EP(CM) + 2*COS(CM)*SQRT(E(MM)*EP(CM))          Sixpak
                                                                   Sixpak
WE CAN ALSO DEFINE THE REVERSE TRANSFORMATION USING,               Sixpak
                                                                   Sixpak
V(CM)*COS(CM) = V(LAB)*COS(LAB) - V(MM)                            Sixpak
V(CM)*SIN(CM) = V(LAB)*SIN(LAB)                                    Sixpak
                                                                   Sixpak
V(CM)**2 = V(MM)**2 + V(LAB)**2 - 2*COS(LAB)*V(MM)*V(LAB)          Sixpak
                                                                   Sixpak
EP(CM)   = 0.5*MASS(OUT)*V(CM)**2                                  Sixpak
                                                                   Sixpak
          = E(MM) + EP(LAB) - 2*COS(LAB)*SQRT(E(MM)*EP(LAB))       Sixpak
                                                                   Sixpak
WE CAN DEFINE COS(LAB) FROM THE RELATIONSHIP,                      Sixpak
                                                                   Sixpak
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V(LAB)*COS(LAB) = V(MM) + V(CM)*COS(CM)                                  Sixpak
                                                                        Sixpak
COS(LAB)        =[V(MM) + V(CM)*COS(CM)]/V(LAB)                         Sixpak
                                                                        Sixpak
                 [V(MM) + V(CM)*COS(CM)]                                Sixpak
COS(LAB)        =---------------------------------------------          Sixpak
                 SQRT[V(MM)**2+V(CM)**2+2*COS(CM)*V(MM)*V(CM)]          Sixpak
                                                                        Sixpak
OR COS(CM) FROM THE RELATIONSHIP,                                       Sixpak
                                                                        Sixpak
V(CM)*COS(CM)  = V(LAB)*COS(LAB) - V(MM)                                Sixpak
                                                                        Sixpak
COS(CM)         =[V(LAB)*COS(LAB) - V(MM)]/V(CM)                        Sixpak
                                                                        Sixpak
                 [V(LAB)*COS(LAB) - V(MM)]                              Sixpak
COS(CM)         =-----------------------------------------------        Sixpak
                 SQRT[V(LAB)**2+V(CM)**2-2*COS(LAB)*V(LAB)*V(MM)]       Sixpak
                                                                        Sixpak
THE JACOBIAN CAN BE DEFINED FROM,                                       Sixpak
                                                                        Sixpak
V(LAB)*COS(LAB) = V(MM) + V(CM)*COS(CM)                                 Sixpak
                                                                        Sixpak
J = D[COS(CM)]/D[COS(LAB)] = V(LAB)/V(CM)                               Sixpak
                           = SQRT[EP(LAB)/EP(CM)]                       Sixpak
                                                                        Sixpak
WITH THESE DEFINITIONS OF EP(LAB) AND COS(LAB) IN TERMS OF E(MM),       Sixpak
EP(CM) AND COS(CM) IT IS POSSIBLE TO PERFORM A POINT-BY-POINT           Sixpak
TRANSFORMATION OF DISTRIBUTIONS FROM THE CM TO LAB SYSTEM USING         Sixpak
THESE DEFINITIONS - OR IF WE WISHED WE COULD PERFORM THE REVERSE        Sixpak
TRANSFORMATION USING THE ABOVE RELATIONSHIPS AND THE IDENTITY,          Sixpak
                                                                        Sixpak
F(E,EP(LAB),COS(LAB))*D(COS(LAB))=F(E,EP(CM),COS(CM))*D(COS(CM))        Sixpak
                                                                        Sixpak
THIS IS NOT WHAT WILL BE DONE HERE, SINCE WE WILL ONLY BE               Sixpak
INTERESTED IN THE ZEROTH ORDER MOMENTS OF THESE DISTRIBUTIONS,          Sixpak
BUT WE WILL BE INTERESTED IN DEFINING THOSE MOMENTS IN THE              Sixpak
LAB SYSTEM IN TERMS OF MF=6 SPECTRA GIVEN IN THE CM SYSTEM USING,       Sixpak
                                                                        Sixpak
F(E,EP(LAB),COS(LAB)) = F(E,EP(CM),COS(CM))*J                           Sixpak
                                                                        Sixpak
THE LIMITS OF EP(LAB) ARE DEFINED BY SETTING COS(CM) = +1 OR -1,        Sixpak
                                                                        Sixpak
EP(LAB)   = (SQRT(EP(CM)) + SQRT(E(MM)))**2  FOR COS(CM) = +1           Sixpak
          = (SQRT(EP(CM)) - SQRT(E(MM)))**2  FOR COS(CM) = -1           Sixpak
                                                                        Sixpak
IN THIS FORM WE CAN SEE THAT AS LONG AS THE SECONDARY ENERGY IN         Sixpak
THE CENTER-OF-MASS SYSTEM, EP(CM), IS MUCH LARGER THAN THE              Sixpak
ENERGY OF THE CENTER-OF-MASS, E(MM), THE CENTER-OF-MASS AND LAB         Sixpak
ENERGIES WILL BE ALMOST EQUAL - SIMILARLY FOR THE COSINE, IN            Sixpak
THIS CASE COS(LAB) AND COS(CM) WILL BE ALMOST EQUAL - HOWEVER,          Sixpak
FOR THE MF=6 DATA WE CANNOT ASSUME THAT THIS IS TRUE.                   Sixpak
                                                                        Sixpak
TO FIRST ORDER THE ANGULAR DEPENDENCE CAN BE IGNORED,                   Sixpak
                                                                        Sixpak
EP(LAB)   = E(MM) + EP(CM)                                              Sixpak
                                                                        Sixpak
ALL THIS SAYS IS THAT TO FIRST ORDER THE EFFECT OF TRANSFORMING         Sixpak
FROM THE CM TO LAB SYSTEM IS TO INCREASE THE ENERGY OF THE              Sixpak
EMITTED PARTICLE IN THE CENTER-OF-MASS SYSTEM BY THE ENERGY OF          Sixpak
THE CENTER-OF-MASS TO DEFINE THE LAB ENERGY.                            Sixpak
                                                                        Sixpak
NOT ONLY THE ENERGY, BUT ALSO THE SPECTRA MUST BE TRANSFORMED.          Sixpak
STARTING FROM THE DOUBLE DIFFERENTIAL DATA IN THE LAB SYSTEM,           Sixpak
F(E,EP,COS(LAB)), WE CAN DEFINE THE LAB SCALAR SPECTRUM AS,             Sixpak
                                                                        Sixpak
G0(E,EP) = INTEGRAL F(E,EP,COS(LAB))*D(COS(LAB))                        Sixpak
                                                                        Sixpak
THIS IS THE NORMAL CALCULATION DEFINED ABOVE AND USED FOR DATA          Sixpak
GIVEN IN THE LAB SYSTEM.                                                Sixpak
                                                                        Sixpak
STARTING FROM DATA IN THE CENTER OF MASS SYSTEM F(E,EP,COS(CM)),        Sixpak
```

WE CAN USE THE RELATIONSHIP,

F(E,EP,COS(LAB))*D(COS(LAB)) = F(E,EP,COS(CM))*J*D(COS(LAB))

J = SQRT(EP(LAB)/EP(CM)) - THE JACOBIAN

= E(MM)/EP(CM) + 1 + 2*COS(CM)*SQRT(E(MM)/EP(CM))

AS IN THE CASE OF THE ENERGY, IN THIS FORM WE CAN SEE THAT AS LONG AS THE SECONDARY ENERGY IN THE CENTER-OF-MASS SYSTEM, EP(CM), IS LARGE COMPARED TO THE CENTER-OF-MASS ENERGY, E(MM), THE JACOBIAN IS ESSENTIALLY UNITY AND THE CENTER-OF-MASS AND LAB SPECTRA WILL BE VERY SIMILAR - AGAIN, GENERALLY WE CANNOT ASSUME THAT THIS IS TRUE FOR THE MF=6 SPECTRA.

THEREFORE WE CAN ALSO DEFINE THE LAB SCALAR SPECTRUM IN TERMS OF THE CM SPECTRUM IN THE FORM,

G0(E,EP) = INTEGRAL F(E,EP,COS(CM))*J*D(COS(LAB))

CONSISTENT WITH THE ABOVE ASSUMPTION THAT THE ANGULAR DEPENDENCE OF EP(LAB) CAN BE IGNORED THE JACOBIAN WILL NOT BE USED IN PERFORMING THESE INTEGRALS - IN WHICH CASE THE INTEGRAL REDUCES TO EXACTLY THE SAME FORM AS IF THE DATA WERE IN THE LAB SYSTEM.

IT SHOULD BE NOTED THAT SINCE IN THIS CASE THE MF=4 ANGULAR DISTRIBUTIONS ARE GIVEN IN THE CM SYSTEM AND WHEN USED IN ANY APPLICATION THEY WILL BE TRANSFORMED TO THE LAB SYSTEM - WHEN THIS IS DONE THE JACOBIAN WILL BE APPLIED.

IN THIS CODE WHERE WE ARE MOSTLY CONCERNED WITH CONSERVING THE NUMBER OF EMITTED PARTICLES AND AVERAGE ENERGIES THE NEUTRON SPECTRA OUTPUT IN MF=5 WILL NOT BE COMPLETELY CONVERTED TO THE LAB SYSTEM - ONLY FIRST ORDER CORRECTIONS WILL BE INCLUDED BY INCREASING THE EMITTED PARTICLE ENERGY BY THE CENTER OF MASS ENERGY, I.E., FOR A CENTER OF MASS SPECTRUM TABULATED AT CENTER OF MASS ENERGIES EP(CM) THESE WILL ALL BE UNIFORMLY INCREASED BY E(MM) TO ACCOUNT FOR THE CENTER OF MASS MOTION - THE SPECTRA WILL NOT BE MODIFIED BY THE JACOBIAN FACTOR SQRT(EP(LAB)/EP(CM)) SINCE THIS WOULD REQUIRE A DETAILED TRANSFORMATION IN ENERGY AND COS(THETA) SPACE - WHICH IS JUDGED NOT TO BE WORTH PERFORMING WITHIN THE LIMITS OF WHERE THE OUTPUT FROM THIS CODE IS INTENDED TO BE USED.

SINCE THE ANGULAR DISTRIBUTION IS ALWAYS OUTPUT IN THE SAME SYSTEM AS WHICH IT IS GIVEN IN MF=6, NO TRANSFORMATION IS REQUIRED FOR THE MF=4 OUTPUT.

WHEN USED IN LOW ENERGY APPLICATIONS (E.G., FISSION REACTORS) THE HIGH ENERGY SPECTRA PRESENTED IN MF=6 WILL BE MOSTLY IMPORTANT SIMPLY IN CONSERVING PARTICLES, (E.G., AS IN (N,2N)) AND ENERGY AND THE DETAILS OF THE CORRELATION AND GROSS ENERGY SPECTRA WILL NOTE PLAY THAT IMPORTANT A ROLE. IN THIS CASE THE SPECTRA OUTPUT BY THIS PROGRAM IN MF=5 SHOULD BE ADEQUATE.

PLOTTAB FORMATTED OUTPUT

THIS PROGRAM CONTAINS ROUTINES TO PRODUCE OUTPUT THAT CAN BE USED AS INPUT TO THE PLOTTAB CODE TO OBTAIN GRAPHIC RESULTS.

THESE ROUTINES ARE DESIGNED ONLY FOR USE BY THE AUTHOR TO CHECK THIS CODE. USERS ARE ASKED NOT TO ACTIVATE OR TRY TO USE THESE ROUTINES. UNLESS YOU COMPLETELY UNDERSTAND THIS CODE THE RESULTS CAN BE UNRELIABLE IF YOU ACTIVATE THESE ROUTINES.

INPUT FILES

UNIT	DESCRIPTION
2	INPUT LINES (BCD - 80 CHARACTERS/RECORD)
10	ORIGINAL ENDF/B DATA (BCD - 80 CHARACTERS/RECORD)

```
                                                                      Sixpak
OUTPUT FILES                                                          Sixpak
====================================================================  Sixpak
UNIT  DESCRIPTION                                                     Sixpak
----  -----------                                                     Sixpak
   3  OUTPUT REPORT (BCD - 120 CHARACTERS/RECORD)                     Sixpak
  11  ENDF/B DATA MF=4 (BCD - 80 CHARACTERS/RECORD)                   Sixpak
  12  ENDF/B DATA MF=5 (BCD - 80 CHARACTERS/RECORD)                   Sixpak
  14  ENDF/B DATA MF=15 (BCD - 80 CHARACTERS/RECORD)                  Sixpak
  17  ENDF/B DATA MF=12 (BCD - 80 CHARACTERS/RECORD)                  Sixpak
  18  ENDF/B DATA MF=14 (BCD - 80 CHARACTERS/RECORD)                  Sixpak
  15  PLOTTAB INPUT PARAMETERS (BCD - 80 CHARACTERS/RECORD)           Sixpak
  16  PLOTTAB FORMATTED OUTPUT (BCD - 80 CHARACTERS/RECORD)           Sixpak
                                                                      Sixpak
SCRATCH FILES                                                         Sixpak
====================================================================  Sixpak
NONE                                                                  Sixpak
                                                                      Sixpak
OPTIONAL STANDARD FILE NAMES (SEE SUBROUTINE FILIO1 AND FILIO2)       Sixpak
====================================================================  Sixpak
UNIT  FILE NAME                                                       Sixpak
----  ----------                                                      Sixpak
  2   SIXPAK.INP                                                      Sixpak
  3   SIXPAK.LST                                                      Sixpak
 10   ENDFB.IN                                                        Sixpak
 11   ENDFB.MF4                                                       Sixpak
 12   ENDFB.MF5                                                       Sixpak
 14   ENDFB.M15                                                       Sixpak
 17   ENDFB.M12                                                       Sixpak
 18   ENDFB.M14                                                       Sixpak
 15   PLOTTAB.INP                                                     Sixpak
 16   PLOTTAB.CUR                                                     Sixpak
                                                                      Sixpak
                                                                      Sixpak
INPUT PARAMETERS                                                      Sixpak
====================================================================  Sixpak
LINE  COLS.  DESCRIPTION                                              Sixpak
----  -----  -----------                                              Sixpak
   1   1-72  ENDF/B INPUT DATA FILENAME                               Sixpak
             (STANDARD OPTION = ENDFB.IN)                             Sixpak
 2-N   1-6   MINIMUM MAT FOR REQUESTED RANGE                          Sixpak
       9-11  MINIMUM MT FOR REQUESTED RANGE                           Sixpak
      12-17  MAXIMUM MAT FOR REQUESTED RANGE                          Sixpak
      20-22  MAXIMUM MT FOR REQUESTED RANGE                          Sixpak
                                                                      Sixpak
LEAVE THE DEFINITION OF THE FILENAME BLANK - THE PROGRAM WILL         Sixpak
THEN USE THE STANDARD FILENAME (ENDFB.IN).                            Sixpak
                                                                      Sixpak
UP TO 100 MAT/MT RANGES MAY BE SPECIFIED. THE LIST OF RANGES IS       Sixpak
TERMINATED BY A BLANK LINE. IF THE FIRST INPUT LINE IS COMPLETELY     Sixpak
BLANK ALL DATA WILL BE PROCESSED.                                     Sixpak
                                                                      Sixpak
EXAMPLE INPUT NO. 1                                                   Sixpak
-------------------                                                   Sixpak
PROCESS ALL MF=6 DATA ON AN ENDF/B TAPE. USE THE STANDARD INPUT       Sixpak
DATA FILENAME ENDFB.IN IN THIS CASE THE USER CAN EITHER EXPLICITLY    Sixpak
SPECIFY THE FILENAME AND MAT/MT RANGE BY THE FOLLOWING  2 INPUT       Sixpak
LINES,                                                                Sixpak
                                                                      Sixpak
ENDFB.IN                                                              Sixpak
     1    1  9999  999                                               Sixpak
                      (BLANK LINE, TERMINATES REQUEST LIST)           Sixpak
                                                                      Sixpak
OR BY INPUTTING 2 BLANK LINE = PROCESS EVERYTHING.                    Sixpak
                                                                      Sixpak
EXAMPLE INPUT NO. 2                                                   Sixpak
-------------------                                                   Sixpak
PROCESS BE-9, MAT=425, MT=16. READ THE DATA FROM ENDFB6\BE9.          Sixpak
IN THIS CASE THE FOLLOWING 3 INPUT LINES ARE REQUIRED,                Sixpak
                                                                      Sixpak
ENDFBB6\BE9                                                           Sixpak
```

```
   425   16   425   16                                                Sixpak
                     (BLANK LINE, TERMINATES REQUEST LIST)           Sixpak
                                                                     Sixpak
EXAMPLE INPUT NO. 3                                                  Sixpak
------------------                                                   Sixpak
PROCESS ALL MT=16 (N,2N) DATA. THIS CAN BE DONE BY SPECIFYING THE    Sixpak
MAXIMUM MAT RANGE = 1 TO 9999, AND MT=16 FOR THE MINIMUM AND         Sixpak
MAXIMUM MT RANGE. READ THE DATA FROM ENDFB6\K300. IN THIS CASE       Sixpak
CASE THE FOLLOWING 3 INPUT LINES ARE REQUIRED,                       Sixpak
                                                                     Sixpak
ENDFB6\K300                                                          Sixpak
     1   16  9999   16                                              Sixpak
                     (BLANK LINE, TERMINATES REQUEST LIST)           Sixpak
                                                                     Sixpak
====================================================================== Sixpak
```