Use of ICRU-37/NBS Collision Stopping Powers in the EGS4 System.

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Abstract

An option has been added to the PEGS4 code in the EGS4 System for the Monte Carlo simulation of radiation transport. This option allows the user to input an arbitrary density-effect corrrection for use in calculating electron and positron collision stopping powers. A data base containing the relevant density-effect corrections for a large number of the materials in ICRU Report 37, as generated by the NBS (NIST) program EPSTAR (S.M. Seltzer, 1988), has been created. In conjunction with the code EPSTAR, one can therefore implement the latest electron/positron collision stopping powers for any material.

1 Introduction

The EGS4 system of codes does Monte Carlo simulations of the radiation transport of electrons and positrons in any material[1]. Part of the system is a stand alone code called PEGS4 which creates the necessary electron and photon data sets for use by EGS4 when doing the simulation. One important cross section is the collision stopping power for electrons or positrons. PEGS4 includes a large collection of data which allows the calculation of the collision stopping power for an arbitrary material. Aside from straightforward parameters such as the atomic number and material density, there are two more complex material-dependent physical parameters needed. These are the mean excitation energy I and the density-effect correction δ. The standard version of PEGS4 includes a table of I values for all elements (see section 2.13 of the EGS4 documentation[1]). These values are from the work of Berger and Seltzer at NBS[2] and have been adopted by the ICRU in their Report 37[3]. For a compound or mixture, PEGS4 determines the mean excitation by the standard procedure of taking a weighted average of the log of the I values of the elements in the compound. For an arbitrary material PEGS4 determines the density-effect correction using a formula due to Sternheimer and Peierls [4] which depends only on simple physical parameters plus the value of I for the material.

PEGS4 also contains an internal data base for 73 selected elements and materials for which both the I-value and Sternheimer *et als.* [5] parameterization of the density-effect correction used in ICRU Report 37 are included. Thus for these 73 materials, PEGS4 uses close to, but not exactly what is in ICRU Report 37. This is because the ICRU Report calculates the density-effect correction individually at each tabulated energy whereas the Sternheimer *et al.* five-parameter fit is just that, a fit to those data points. Figure 1 presents a comparison of the ratio to the ICRU values of the collision stopping powers calculated by PEGS4 for water using either the general formula of Sternheimer and Peierls to calculate the density-effect correction, or the tabulated five-parameter fit to the density-effect correction, and for comparison, the "old" (1964) standard values from Berger and Seltzer [6]. The differences between the stopping powers using the "best" fit values in PEGS4 and the ICRU values are quite small ($\leq$0.5%) but in some situations (e.g. the calculation of stopping-power ratios) this variation could introduce some uncertainty. Figure 2 presents a comparison of the density-effect corrections for water as presented in ICRU Report 37 and from the Sternheimer *et als* fit used in PEGS4. It is these small differences which cause the differences seen in Figure 1. The purpose of the present work was to allow PEGS4 to utilize an arbitrary density-effect correction.

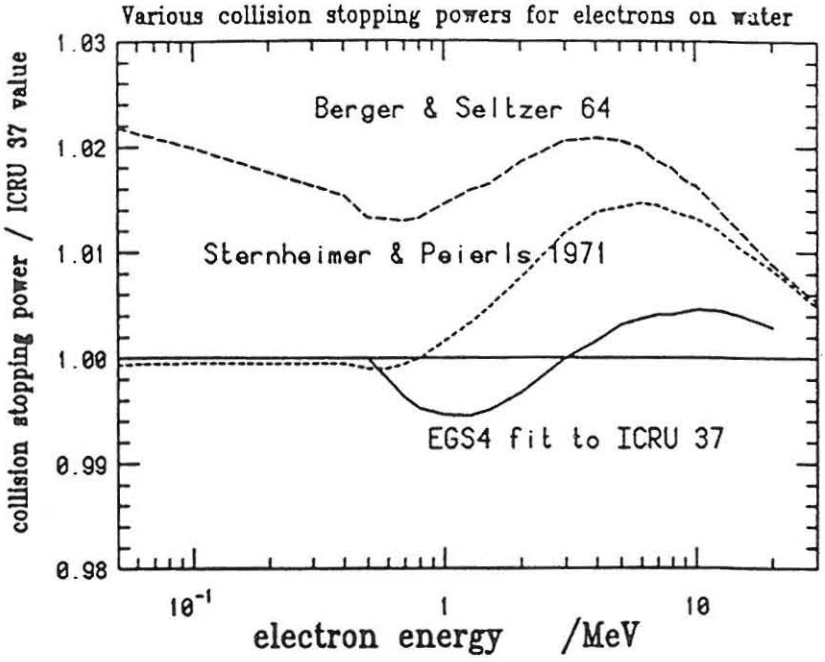

Figure 1: Comparison of collision stopping powers calculated using different density-effect corrections. Results are plotted as ratios to the values in ICRU Report 37.

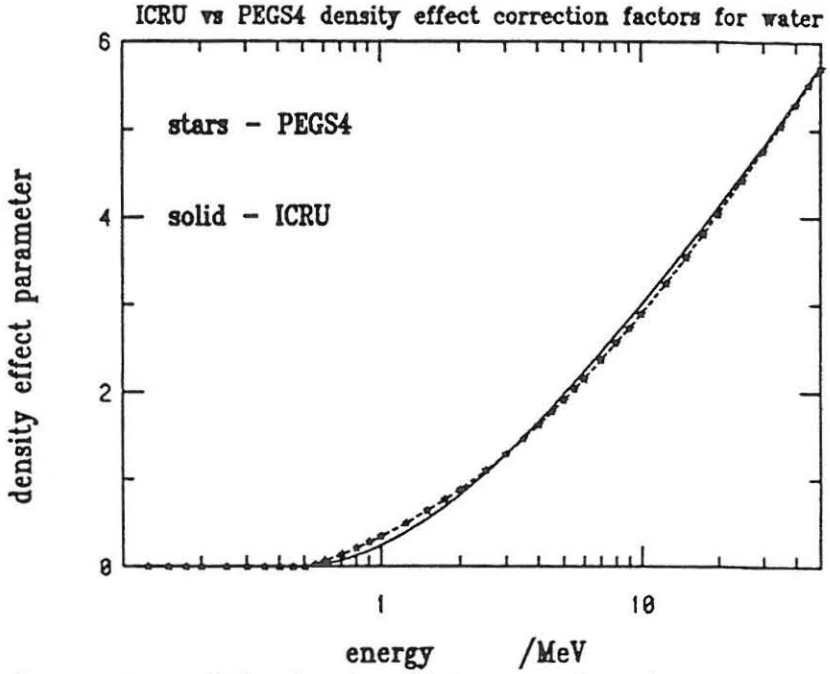

Figure 2: Comparison of the density-effect corrections for water as used in the default PEGS4 code (stars, dashed line) and as presented in ICRU Report 37(solid curve).

2 Changes to PEGS4

All changes have been implemented so that a standard input file, as defined in the EGS4 documentation[1], will produce the same results as in the original version of PEGS4. To invoke the new option, the following must be done:

- In the user's input file, the ENER option must come before the MIXT, ELEM or COMP options (so an internal check on energy limits is valid).
- In the input file, in the ELEM, MIXT or COMP options, set a new flag called EPSTFL to have a value of 1. This instructs PEGS4 to read in a file containing the density-effect correction as a function of energy for the material being studied.
- Assign to FORTRAN unit 20, an input file for the density-effect correction which has the following format:
  - Title line ($\leq$ 80 characters)
  - NDATA, IEV, RHO, NE, (Z(I),FW(I),I=1,NE)
    where
    * NDATA is the number of data points to follow($\leq$ 150),
    * IEV is the mean value of I in eV for the material (real format). This overrides any other value in PEGS4.
    * RHO is the density for which these density effect corrections apply. This is forced to equal the value used in the rest of PEGS4 within 1%.
    * NE is the number of elements in the material being input.
    * (Z(I),FW(I)) are the atomic number and fractional weight of this element in the material being input. These must match the composition being used in the rest of PEGS4 within a 1% tolerance.
  - ENERGY(I), DELTA(I), I = 1, NDATA
    where
    * ENERGY(I) and DELTA(I) are the energies and density-effect corrections at these energies. The energies are *kinetic* energies in MeV. The energy range spanned by the data set should exceed the values for which calculations are to be done. If the energies requested are not covered, a message is printed and the calculation carries on after setting the lower or upper energy to the minimum or maximum required in the code (i.e. one effectively extrapolates the lowest or highest energies input to those needed - this could be wrong in extreme cases!!).

- Run PEGS4

The output data file from PEGS4 will have the same format as in the original (with some minor additions on the second line which do *not* affect EGS4). The only real difference is that the density-effect correction used to calculate the collision stopping powers for electrons and positrons will be those from the input file on unit 20.

Appendix A presents a differences comparison showing all the changes made in PEGS4 to implement these changes. Note that almost all new variables have been introduced with EPST or EPS in the name.

When we input a table of density-effect correction factors from ICRU Report 37, the resulting unrestricted collision stopping powers, output by PEGS4 with the IUNRST=1 option turned on, are the same as those in ICRU Report 37 within 0.01%. Similarily, the ratio of the restricted collision stopping powers to the unrestricted collision stopping powers were checked against Table 7.1 of ICRU Report 37 and found to agree within ± 1 in the last digit.

3 Data Sets from EPSTAR/ICRU 37

In principle, the option described in this report can be used to input any arbitrary density effect for use in calculating the electron and positron collision stopping power. The data set is interpolated linearly, so that not a great deal of data is needed. However, what spurred this work was the availability of the PC-based EPSTAR/ESPA programs written by Steven Seltzer of NBS[7]. These programs can generate the entire data base available in ICRU Report 37 (they are the programs which generated the data base), or they can do *ab initio* calculations for an arbitrary material. We have run these codes for a variety of compounds and elements which appear in ICRU Report 37 and have put the density-effect correction data into two files. These data are available on a floppy disk or via bitnet. The elements/compounds included are listed below, along with the first few lines of that part of the data file which specifies the density effect for that material in the format described above. To make a file which is suitable for use as input to PEGS4 one just extracts the data of interest from the larger files.

File **COMPOUNDS.DEL**

```
A-150 TISSUE-EQUIVALENT PLASTIC
        113   65.10000       1.127000                6
 1 0.101327  6 0.775501  7 0.035057  8 0.052316  9 0.017422 20 0.018378
```

```
 AIR, DRY (NEAR SEA LEVEL)
         113   85.66600       1.2047900E-03          4
  6 0.000124  7 0.755267  8 0.231781 18 0.012827


C-552 AIR-EQUIVALENT PLASTIC
         113   86.79900       1.760000               5
  1 0.024680  6 0.501611  8 0.004527  9 0.465209 14 0.003973

 CARBON DIOXIDE
         113   85.00000       1.8421200E-03          2
  6 0.272916  8 0.727084

 FERROUS AMMONIUM SULFATE (STANDARD FRICKE) DOSIMETER SOLUTION
         113   76.31200       1.024000               7
  1 0.108366  7 0.000027  8 0.878913 11 0.000022 16 0.012582 17 0.000035
 26 0.000055

LITHIUM FLUORIDE
         113   94.00000       2.635000               2
  3 0.267585  9 0.732415

 NYLON, TYPE 6 AND TYPE 6/6
         113   63.90000       1.140000               4
  1 0.097976  6 0.636856  7 0.123779  8 0.141389

 POLYETHYLENE
         113   57.40000       0.9400000              2
  1 0.143711  6 0.856289

 POLYMETHYL METHACRYLATE, "LUCITE", "PERSPEX", "PLEXIGLAS"
         113   74.00000       1.190000               3
  1 0.080538  6 0.599848  8 0.319614

 POLYSTYRENE
         113   68.70000       1.060000               2
  1 0.077418  6 0.922582

 SODIUM IODIDE
         113   452.0090       3.667000               2
 11 0.153373 53 0.846627

 WATER, LIQUID
         113   75.00000       1.000000               2
  1 0.111894  8 0.888106
```

```
WATER VAPOR
        113   71.60000       7.5618201E-04          2
 1 0.111894  8 0.888106
```

File ELEMENTS.DEL

```
CARBON, GRAPHITE (2.265 g/cm3)
        113   78.00000       2.265000               1
 6 1.000000

CARBON, GRAPHITE (1.700 g/cm3)
        113   78.00000       1.700000               1
 6 1.000000

ALUMINUM
        113   166.0000       2.698900               1
13 1.000000

SILICON
        113   173.0000       2.330000               1
14 1.000000

IRON
        113   286.0000       7.874000               1
26 1.000000

COPPER
        113   322.0000       8.960000               1
29 1.000000

GERMANIUM
        113   350.0000       5.323000               1
32 1.000000

TUNGSTEN
        113   727.0000       19.30000               1
74 1.000000

GOLD
        113   790.0000       19.32000               1
79 1.000000

LEAD
        113   823.0000       11.35000               1
82 1.000000
```

```
URANIUM
        113    889.9990        18.95000                1
92 1.000000
```

4 The Distribution Files

The following files are available on a PC floppy.

PEGS4.MOR

This is the current NRC version. It therefore includes the upgrade described in PIRS177 [8] to allow ICRU 37 radiative stopping powers to be used by PEGS4. It also includes two patches: one to correct an error in calculating the density effect for gases not at NTP (i.e. for GASP non-zero: see SPINIT, error was pointed out by Prof. Kamae in Tokyo, via Hideo Hirayama); the second to correct some errors in SPTOTE(P) when IUNRST=2, 3 or 4 were used in the PLOT or CALL option.

COMPOUNDS.DEL

The file of deltas described above for a set of compounds.

ELEMENTS.DEL

The file of deltas described above for a set of elements.

5 Acknowledgements

We wish to thank Stephen Seltzer of NBS for sending a copy of his PC program EPSTAR which calculates the ICRU 37 density-effect corrections for an arbitrary material.

Appendix A

Changes Introduced into PEGS4.MOR

```
 ************
File SYS$SYSDEVICE:  NEW_PEGS4.MOR;9
    2   "PLAYED WITH AT NRC NOV 1988 TO GET DENSITY EFFECT  "
******
File SYS$SYSDEVICE:  OLD_PEGS4.MOR;8
    2   "!COMMENTS;"
************
************
File SYS$SYSDEVICE:  NEW_PEGS4.MOR;9
  255   "***EPSTAR      NRCC ADDITION, NOV 1988                                 "
  256   "-------------------------------------------------------------------"
  257   REPLACE {;COMIN/EPSTAR/;} WITH
  258      {;INTEGER EPSTFL;CHARACTER*1 EPSTTL(80);INTEGER ZEPST;
  259        COMMON/EPSTAR/EPSTEN(150),EPSTD(150),EPSTFL,EPSTTL,NEPST,IEPST,
  260        NELEPS,ZEPST(20),WEPST(20),IAPRIM;}
  261
  262       "THIS COMMON IS USED FOR OPTION WHICH READS IN DENSITY EFFECT "
  263       "CORRECTION IN SPINIT AND CALCULATES USING IT IN SPIONB       "
  264       "THE FLAG EPSTFL IS READ UNDER NAMELIST INPUT, AND DEFAULTS   "
  265       "   TO ZERO IN THE BLOCK DATA. SET TO UNITY TO USE THE OPTION "
  266       "PEGS USES THE I-VALUE IN THE DENSITY INPUT FILE              "
  267       "VARIOUS CHECKS ARE DONE TO ENSURE THE DENSITY CORRECTION     "
  268       "   CORRESPONDS TO THE MATERIAL DEFINITION IN PEGS            "
  269       "THE ENERGY TABLE READ IN IS ASSUMED TO BE KINETIC ENERGY IN  "
  270       "   MEV BUT IS CONVERTED TO TOTAL ENERGY BY THE CODE.         "
  271       "THE ENERGY OPTION MUST BE USED IN PEGS PRIOR TO THE MIXT,COMP"
  272       "   OR ELEM OPTIONS TO ALLOW ALL THE CHECKS TO WORK PROPERLY. "
  273       "NELEPS IS THE NUMBER OF ELEMENTS IN THE MATERIAL             "
  274       "ZEPST(I) (INTEGER), WEPST(I) ARE THE Z VALUE AND FRACTION    "
  275       "   BY WEIGHT OF THE I-TH ELEMENT IN THE DATA FILE.           "
  276
  277   "-------------------------------------------------------------------"
  278   "*** FUNCS                                                          "
******
File SYS$SYSDEVICE:  OLD_PEGS4.MOR;8
  247   "*** FUNCS                                                          "
************
************
File SYS$SYSDEVICE:  NEW_PEGS4.MOR;9
  540       PHPAIR,PHCONS,PWLFIN,RAYLEI,RSLTS,THRESH,EPSTAR/;"MODNOV 23,1988"
  541   REAL XP(4),WASAV(20);
******
File SYS$SYSDEVICE:  OLD_PEGS4.MOR;8
  510       PHPAIR,PHCONS,PWLFIN,RAYLEI,RSLTS,THRESH/;
  511   REAL XP(4),WASAV(20);
************
************
File SYS$SYSDEVICE:  NEW_PEGS4.MOR;9
  569       EI,ISUB,GASP,IUNRST,IRAYL,AFACT,SK,XO,X1,IEV,CBAR,ISSB,EPSTFL,
  570       IAPRIM;
  571   "                        MOD NOV 23,1988                        ======="
  572   NAMELIST/PWLFNM/EPE,ZTHRE,ZEPE,NIPE,NALE,EPG,ZTHRG,ZEPG,NIPG,NALG,
******
File SYS$SYSDEVICE:  OLD_PEGS4.MOR;8
  539       EI,ISUB,GASP,IUNRST,IRAYL,AFACT,SK,XO,X1,IEV,CBAR,ISSB;
  540   NAMELIST/PWLFNM/EPE,ZTHRE,ZEPE,NIPE,NALE,EPG,ZTHRG,ZEPG,NIPG,NALG,
************
************
```

```
File SYS$SYSDEVICE:  NEW_PEGS4.MOR;9
  940          PHPAIR,PMCONS,PWLFIN,RADLEN,RAYLEI,SPCOMM,RSLTS,THRESH,EPSTAR/;
  941   "                                  MOD NOV 22 1988            ======="
  942
******
File SYS$SYSDEVICE:  OLD_PEGS4.MOR;8
  908          PHPAIR,PMCONS,PWLFIN,RADLEN,RAYLEI,SPCOMM,RSLTS,THRESH/;
  909
**************
**************
File SYS$SYSDEVICE:  NEW_PEGS4.MOR;9
 1185
 1186   "DATA FOR EPSTAR"
 1187   DATA EPSTFL/0/,IEPST/1/,IAPRIM/0/;
 1188
 1189   END; "END OF BLOCK DATA"
******
File SYS$SYSDEVICE:  OLD_PEGS4.MOR;8
 1152   END; "END OF BLOCK DATA"
**************
**************
File SYS$SYSDEVICE:  NEW_PEGS4.MOR;9
 2256   COMIN/PMCONS,SPCOMM,DERCON,MOLVAR,MIXDAT,ELEMTB,LSPION,EPSTAR,THRESH/;
 2257   "                                    MOD NOV 23,1988    ================"
 2258
 2259   REAL IMEV;
 2260   TOLN10=2.0*ALOG(10.0);IM=-100;
 2261
 2262   IF(EPSTFL < 0 | EPSTFL > 1) [EPSTFL = 0;"ERROR ON INPUT, IGNORE"]
 2263   "ABOVE IS NRCC MOD DEC 1988"
 2264
 2265   IF(EPSTFL=0)["DEFAULT TO STANDARD PEGS4 METHODS"
 2266
******
File SYS$SYSDEVICE:  OLD_PEGS4.MOR;8
 2144   COMIN/PMCONS,SPCOMM,DERCON,MOLVAR,MIXDAT,ELEMTB,LSPION/;
 2145   REAL IMEV;
 2146   TOLN10=2.0*ALOG(10.0);
 2147
**************
**************
File SYS$SYSDEVICE:  NEW_PEGS4.MOR;9
 2395   ]"END OF EPSTFL=0 BLOCK"
 2396
 2397   ELSE[ "EPSTFL=1 BLOCK  I.E. READ IN THE INPUT FROM THE DENSITY"
 2398        "INPUT FILE"
 2399
 2400   READ(20,:A:)EPSTTL;::A:  FORMAT(80A1);
 2401   READ(20,*) NEPST,IEV,EPSTRH,NELEPS,(ZEPST(I),WEPST(I),I=1,NELEPS);
 2402   READ(20,*) (EPSTEN(I),EPSTD(I),I=1,NEPST);
 2403
 2404   IF(NEPST>150)[OUTPUT NEPST;
 2405   (//' *****NEPST=',I4,' IS GREATER THAN THE 150 ALLOWED');STOP;]
 2406   "CONVERT TO TOTAL ENERGIES"
 2407   DO I=1,NEPST[EPSTEN(I) = EPSTEN(I) + RM;]
 2408   IMEV = IEV*1.E-06;
 2409
 2410   "CHECK THAT WE HAVE COVERED ENERGY RANGES NEEDED"
 2411   IF( AE < EPSTEN(1))[OUTPUT EPSTEN(1),AE;
 2412   (//' ****LOWEST ENERGY INPUT FOR DENSITY EFFECT IS',1PE10.3/
 2413   T20,'WHICH IS HIGHER THAN THE VALUE OF AE=',1PE10.3,' MEV'/
 2414   ' ***IT HAS BEEN SET TO AE***'//);EPSTEN(1) = AE;]
 2415   IF( UE > EPSTEN(NEPST))[ OUTPUT EPSTEN(NEPST),UE;
 2416   (//' ****HIGHEST ENERGY INPUT FOR DENSITY EFFECT IS',1PE10.3/
 2417   T20,'WHICH IS LOWER THAN THE VALUE OF UE=',1PE10.3,' MEV'/
 2418   ' ***IT HAS BEEN SET TO UE***'//);EPSTEN(NEPST) = UE;]
```

```
 2419
 2420   "DO A CHECK ON THE COMPOSITION AND DENSITY TO INSURE THE RIGHT DELTA"
 2421   "HAS BEEN PICKED UP. ALLOW A TOLERANCE OF 1 PERCENT ERROR ON THE"
 2422   "COMPOSITION BY WEIGHT."
 2423
 2424   ICHECK=0; "FLAG GETS SET TO UNITY IF THE COMPOSITION DOES NOT MATCH"
 2425       TLRNCE=0.01; "TOLERANCE ALLOWED ON FRACTION BY WEIGHT"
 2426
 2427   "FIRST CHECK THAT THE NUMBER OF ELEMENTS ARE THE SAME"
 2428   IF(NELEPS.NE.NE) ICHECK=1;
 2429
 2430   "NOW CHECK THAT THE DENSITIES ARE THE SAME WITHIN TOLERANCE"
 2431   IF( (ICHECK.EQ.0)  .AND.
 2432     ( (EPSTRH.LT.((1.0-TLRNCE)*RHO)) .OR. (EPSTRH.GT.((1.0+TLRNCE)*RHO))
 2433     ) ) ICHECK=1; "DENSITY IS OUT OF RANGE"
 2434   "WE MUST FIRST NORMALIZE THE PEGS FRACTIONS BY WEIGHT TO ENSURE THEY"
 2435   "ARE NORMALIZED TO UNITY"
 2436   EPSTWT = 0.0;DO I=1,NE[ EPSTWT = EPSTWT + RHOZ(I);]
 2437   IF(EPSTWT=0.0)[
 2438   OUTPUT;(//' *****IN SPINIT***SOMETHING WRONG, MOLECULAR WEIGHT OF',
 2439   'MOLECULE IS ZERO (I.E. SUM OF RHOZ)***'//);]
 2440
 2441   IF(ICHECK.EQ.0)[
 2442       IESPEL=0;    "INITIALIZE ESP ELEMENT COUNTER"
 2443       ICHECK=1;    "ASSUME FAILURE"
 2444       LOOP["LOOP OVER ESP COMPONENTS"
 2445           IESPEL=IESPEL+1;
 2446           IPEGEL=0;    "INITIALIZE PEGS ELEMENT COUNTER"
 2447           LOOP["LOOP OVER PEGS COMPONENTS"
 2448               IPEGEL=IPEGEL+1;
 2449               IF(IFIX(Z(IPEGEL)).EQ.ZEPST(IESPEL))[ICHECK=0;EXIT;]
 2450               ]WHILE(IPEGEL.LT.NE);
 2451               IF( (ICHECK.EQ.0) "Z OF ELEMENT MATCHES"
 2452               .AND.
 2453               ( (WEPST(IESPEL).LT.((1.0-TLRNCE)*RHOZ(IPEGEL)/EPSTWT))
 2454                 .OR. (WEPST(IESPEL).GT.((1.0+TLRNCE)*RHOZ(IPEGEL)/EPSTWT))
 2455               ) ) ICHECK=1; "MATCHED ELEMENT BUT WEIGHT FRACTION WRONG"
 2456           ]WHILE(IESPEL.LT.NELEPS);
 2457       ] "END OF TEST FOR ICHECK = 0"
 2458
 2459   IF(ICHECK.EQ.1)[ "PRINT MESSAGE AND STOP"
 2460   OUTPUT;
 2461   ((((/'0*** COMPOSITION IN INPUT DENSITY FILE DOES NOT  MATCH',
 2462   'THAT BEING USED BY PEGS, QUITTING EARLY***'////);
 2463   STOP; " ERRORS DETECTED";
 2464   ]
 2465
 2466
 2467   ]"END OF EPSTFL=1 BLOCK"
 2468
 2469
 2470   SPC1=2.*PI*RO**2*RM*EDEN*RLC;
******
File SYS$SYSDEVICE:  OLD_PEGS4.MOR;8
 2276   SPC1=2.*PI*RO**2*RM*EDEN*RLC;
************
************
File SYS$SYSDEVICE:  NEW_PEGS4.MOR;9
 2478   ELSEIF(IM = -1) [OUTPUT;
 2479   (' STERNHEIMER-SELTZER-BERGER DENSITY EFFECT DATA SUPPLIED BY USER');]
 2480   ELSE[
 2481   OUTPUT EPSTTL;(' DENSITY EFFECT READ IN DIRECTLY:'/T10,80A1);]
 2482   OUTPUT;(1X,64('-')/);
 2483   OUTPUT IEV;(/' ADJUSTED MEAN IONIZATION = ',F8.2,' EV'/1X,38('-')//);
 2484   IF(EPSTFL = 0) [$DUMP IEV,VPLASM,CBAR,X0,X1,SK,AFACT;]
 2485   $DUMP SPC1,SPC2;
```

```
 2486
******
File SYS$SYSDEVICE:  OLD_PEGS4.MOR;8
 2284   ELSE [OUTPUT;
 2285   (' STERNHEIMER-SELTZER-BERGER DENSITY EFFECT DATA SUPPLIED BY USER');]
 2286   OUTPUT;(1X,64('-')/);
 2287   OUTPUT IEV;(/' ADJUSTED MEAN IONIZATION = ',F8.2,' EV'/1X,38('-')//);
 2288   $DUMP IEV,VPLASM,CBAR,X0,X1,SK,AFACT,SPC1,SPC2;
 2289
************
************
File SYS$SYSDEVICE:  NEW_PEGS4.MOR;9
 2783   %L
 2784   %I4      "INDENT MORTRAN"
 2785   !INDENT F2;
 2786   "**************************************************************************"
******
File SYS$SYSDEVICE:  OLD_PEGS4.MOR;8
 2586   "**************************************************************************"
************
************
File SYS$SYSDEVICE:  NEW_PEGS4.MOR;9
 4326   COMIN/DERCON,LSPION,EPSTAR/; "MOD NOV 24,1988"
 4327   "     COMMON POINT FOR E- AND E+ ENTRIES.                                "
******
File SYS$SYSDEVICE:  OLD_PEGS4.MOR;8
 4079   COMIN/DERCON,LSPION/;
 4080   "     COMMON POINT FOR E- AND E+ ENTRIES.                                "
************
************
File SYS$SYSDEVICE:  NEW_PEGS4.MOR;9
 4355
 4356   "     NOW COMPUTE THE DENSITY CORRECTION TERM.                           "
 4357
 4358   IF(EPSTFL = 0) ["USE STANDARD PEGS4 METHOD"
 4359   IF (X.LE.X0) [DELTA=0.0;]
 4360   ELSEIF (X.LT.X1) [DELTA=TOLN10*X - CBAR + AFACT*(X1 - X)**SK;]
 4361   ELSE [DELTA=TOLN10*X - CBAR;]]
 4362
 4363   ELSE ["USE LINEAR INTERPOLATION OF USER SUPPLIED INPUT TABLE"
 4364
 4365   "IEPST IS A POINTER SUCH THAT                                           "
 4366   "       EPSTEN(IEPST) <= E0 < EPSTEN(IEPST+1)                           "
 4367   "                                                                       "
 4368   "IEPST IS INITIALIZED IN BLOCK DATA TO 1. WE START FROM                 "
 4369   "THE PREVIOUS VALUE OF THE POINTER SINCE WE ASSUME THAT                 "
 4370   "THE CODE IS WORKING UP OR DOWN A GRID.                                 "
 4371   "  THIS CODING IS FAR FROM OPTIMAL                                      "
 4372
 4373   IF(E0 >= EPSTEN(IEPST))["AT OR ABOVE PREVIOUS ENTRY"
 4374   IF(E0 = EPSTEN(IEPST))["FOUND ENTRY, INCLUDING THE POSSIBILITY"
 4375   "THAT WE ARE AT THE TOP OF THE TABLE"     GO TO :END-SEARCH:;]
 4376
 4377   DO I= IEPST,NEPST-1 [
 4378        IF(E0<EPSTEN(I+1))["WE FOUND IT" IEPST = I; GO TO :END-SEARCH:]
 4379        ]
 4380   "IF WE FALL THRU TO HERE, WE MUST BE AT UPPER ENERGY"
 4381   IEPST = NEPST; GO TO :END-SEARCH:;
 4382   ]"END OF BLOCK E0>EPSTEN(IEPST)"
 4383
 4384   ELSE [ "E0<EPSTEN(IEPST)"
 4385
 4386   DO I = IEPST,2,-1 [
 4387       IF(E0 >= EPSTEN(I-1)) [IEPST = I-1; GO TO :END-SEARCH:;]
 4388       ]
 4389   "   IF WE GET HERE WE MUST BE IN THE FIRST REGION"
```

```
 4390       IEPST = 1;]
 4391
 4392    :END-SEARCH:
 4393
 4394    "NOW JUST INTERPOLATE LINEARLY IN THE ENERGY"
 4395    IF(IEPST < NEPST) [
 4396       DELTA = EPSTD(IEPST) + (EO - EPSTEN(IEPST))/
 4397       (EPSTEN(IEPST+1) - EPSTEN(IEPST)) * (EPSTD(IEPST+1) - EPSTD(IEPST));]
 4398    ELSE [DELTA = EPSTD(NEPST);]
 4399
 4400    ]"END OF EPSTFL NON-ZERO BLOCK"
 4401
 4402    "      NOW PUT IT ALL TOGETHER                                          "
******
File SYS$SYSDEVICE:  OLD_PEGS4.MOR;8
 4108    "      NOW COMPUTE THE DENSITY CORRECTION TERM.                         "
 4109    IF (X.LE.XO) [DELTA=0.0;]
 4110    ELSEIF (X.LT.X1) [DELTA=TOLN10*X - CBAR + AFACT*(X1 - X)**SK;]
 4111    ELSE [DELTA=TOLN10*X - CBAR;]
 4112    "      NOW PUT IT ALL TOGETHER                                          "
************
```

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