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Pacific Northwest
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Compendium of Material Composition Data for Radiation Transport Modeling

R.G. Williams III
C.J. Gesh
R.T. Pagh

April 2006

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Richland, Washington 99352

Foreword

Computational modeling of radiation transport problems including homeland security, radiation shielding and protection, and criticality safety all depend upon material definitions. This document has been created to serve two purposes: 1) to provide a quick reference of material compositions for analysts and 2) a standardized reference to reduce the differences between results from two independent analysts. Analysts are always encountering a variety of materials for which elemental definitions are not readily available or densities are not defined. This document provides a location where unique or hard to define materials will be located to reduce duplication in research for modeling purposes. Additionally, having a common set of material definitions helps to standardize modeling across PNNL and provide two separate researchers the ability to compare different modeling results from a common materials basis.

Three information blocks are provided for each material definition: 1) the base material information block, 2) MCNP material card block, and 3) CEPXS material card block. The base material information block contains the elemental composition of the material listed using standard elemental symbols. The elements are listed by weight fraction and atom fraction, both normalized to sum to one except where noted. The elements are also listed by atom density (atoms per barn-cm) based upon the provided density. It should be noted that density of materials can vary widely from typical or average values, especially for foams and insulating/shock absorbing materials. Project specific density values should always be used over the typical density values provided here. Finally, the base material information block contains any comments that analysts should be aware of with regards to the material and the reference from which the material was obtained.

The MCNP material card block provides the material definition according to the format required by the radiation transport code Monte Carlo N-Particle. Four distinct sub-blocks are provided to allow analysts flexibility in representing materials. For computational models involving the transport of neutrons or coupled neutrons and photons calculations the Neutron block provides the material definition. This Neutron block defines the material by either by weight fraction through the use of the minus signs or atom fraction by neglecting the minus signs. The elements are identified using the cross section identifiers found in Appendix G of Volume 1 of the MCNP Manual with the appropriate fraction identified to the right of the element identifier. The Photon block provides material definitions for models involving the transport of photons. This block is very similar to the Neutron block where the element identifier is followed by the weight fraction for negative values or atom fraction for positive values. Only one of the four sub-blocks will be used in any specific MCNP input deck. It is recommended to use the atom fraction definitions of the materials as the MCNP computer code will convert weight fraction to atom fraction based upon a set of data which may not match the values used to define weight fraction for this document. While the difference between the atom fraction listed in this document and that calculated by MCNP will be small, it provides a potential uncertainty in calculations. Density is not defined in the material block, rather it is provided in the cell definition of the model. See Volume 2 of the MCNP Manual for further information regarding material definition in the MCNP code.

The CEPXS material card block provides the material definition according to the format required by the cross section generation code CEPXS. The first section of the format block is the material composition. The word “material” is followed by a listing of elements defined by the standard elemental symbols followed by values defining the weight fraction of that element. CEPXS requires that the weight fraction of the elements sum to 1.0 within a small tolerance. For materials whose weight fractions do not sum to 1.0 in the base information block, the CEPXS block has been changed to meet the normalization

requirements. The second section of the format block is the material name. This is the name that will refer to this material in the cross section file generated by CEPXS. The third section of the formatblock contains the density information. Using the density provided in this document, CEPXS will generate macroscopic cross sections for use in radiation transport codes. To generate microscopic cross sections this density value will need to be modified to an appropriate value. The final element that may need to be present in the block is for gaseous material declaration. If a material is solid, then no information will be present. If a material is gaseous, then the word gas will appear.

Any materials used by analysts that are not in this document should be forwarded to the authors for inclusion into future revisions. Users of this document on the distribution list will be alerted when a new revision is released.

Contents

Acrylic glass

See Lucite.

Acrylite

See Lucite.

Air (Dry, near sea level)

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
C	0.000124	0.000151	0.000000007
N	0.755268	0.784437	0.000039128
O	0.231781	0.210750	0.000010512
Ar	0.012827	0.004671	0.000000233

Density (g/cm^3) = 0.001205
Comments:
Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c   Air, Dry (near sea level), rho = 0.001205
$  Neutron
     6000  -0.000124   $ C
     7014  -0.755268   $ N
     8016  -0.231781   $ O
     18000  -0.012827   $ Ar
-----------------------------------------------------------------------------------
     6000  0.000151   $ C
     7014  0.784437   $ N
     8016  0.210750   $ O
     18000  0.004671   $ Ar
_____________________________________________________________________________
$  Photon
     6000  -0.000124   $ C
     7000  -0.755268   $ N
     8000  -0.231781   $ O
     18000  -0.012827   $ Ar
-----------------------------------------------------------------------------------
     6000  0.000151   $ C
     7000  0.784437   $ N
     8000  0.210750   $ O
     18000  0.004671   $ Ar
```

CEPXS Form

material c 0.000124 n 0.755268 o 0.231781 ar 0.012827
matname air
density 0.001205
gas

Aluminum

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Al	1.000000	1.000000	0.060238

Density (g/cm^3)= 2.6989
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=013

MCNP Form

c Aluminum, rho = 2.6989 g/cc
$ **Neutron**
13027 -1.000000

13027 1.000000
_____
$ **Photon**
13000 -1.000000

13000 1.000000

CEPXS Form

material al 1.000000
matname aluminum
density 2.6989

Bakelite

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.057444	0.431814	0.042900
C	0.774589	0.488641	0.048546
O	0.167968	0.079545	0.007903

Density (g/cm^3)= 1.25

Comments:

Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c   Bakelite, rho = 1.250E+00
$  Neutron
     1001  -0.057444   $ H
     6000  -0.774589   $ C
     8016  -0.167968   $ O
-------------------------------------------------------------------------------------------
     1001  0.431814   $ H
     6000  0.488641   $ C
     8016  0.079545   $ O

_____________________________________________________________________________
$  Photon
     1000  -0.057444   $ H
     6000  -0.774589   $ C
     8000  -0.167968   $ O
-------------------------------------------------------------------------------------------
     1000  0.431814   $ H
     6000  0.488641   $ C
     8000  0.079545   $ O
```

CEPXS Form

```
material  h 0.057443 c 0.774589 o 0.167968
matname  bakelite
density  1.25
```

Beryllium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Be	1.000000	1.000000	0.123487

Density (g/cm^3)= 1.848
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=004

MCNP Form

```
c   Beryllium, rho = 1.848 g/cc
$  Neutron
     4009  -1.000000
-------------------------------------------------------------------------------
     4009  1.000000
_______________________________________________________________________________
$  Photon
     4000  -1.000000
-------------------------------------------------------------------------------
     4000  1.000000
```

CEPXS Form

```
material  be 1.000000
matname  beryllium
density  1.848
```

Bismuth

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Bi	1.000000	1.000000	0.028088

Density (g/cm^3)= 9.747
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=083

MCNP Form

```
c  Bismuth, rho = 9.747 g/cc
$  Neutron
     83209  -1.000000
-------------------------------------------------------------------------------------
     83209  1.000000

_____________________________________________________________________________________
$  Photon
     83000  -1.000000
-------------------------------------------------------------------------------------
     83000  1.000000
```

CEPXS Form

```
material  bi 1.000000
matname  bismuth
density  9.747
```

Borax

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.052859	0.465118	0.054636
B	0.113391	0.093023	0.010927
O	0.713187	0.395346	0.046440
Na	0.120563	0.046511	0.005464

Density (g/cm^3)= 1.73

Comments:

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

```
c   Borax,     rho = 1.73 g/cc
$  Neutron
     1001  -0.052859
     5011  -0.113391
     8016  -0.713187
     11023  -0.120563
-------------------------------------------------------------------------------------
     1001  0.465118
     5011  0.093023
     8016  0.395346
     11023  0.046511

_____________________________________________________________________________________
$  Photon
```

```
     1000  -0.052859
     5000  -0.113391
     8000  -0.713187
     11000  -0.120563
-------------------------------------------------------------------------------------
     1000  0.465118
     5000  0.093023
     8000  0.395346
     11000  0.046511
```

CEPXS Form

```
material  h 0.052859 b 0.113391 o 0.713187 na 0.120563
matname  borax
density  1.73
```

Boron Carbide

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
B	0.782610	0.799981	0.109858
C	0.217390	0.200018	0.027468

Density (g/cm^3)= 2.52

Comments:

Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:

http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=121

MCNP Form

```
c  Boron Carbide, rho = 2.52 g/cc
$  Neutron
     5011  -0.782610
     6012  -0.217390
-------------------------------------------------------------------------------------
     5011  0.799981
     6012  0.200018

_____________________________________________________________________________________
$  Photon
     5000  -0.782610
     6000  -0.217390
-------------------------------------------------------------------------------------
     5000  0.799981
     6000  0.200018
```

CEPXS Form

```
material  b 0.782610 c 0.217390
matname  boron_carbide
density  2.52
```

Bricks, Common Silica

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
O	0.524858	0.663062	0.035560
Al	0.005227	0.003916	0.000210
Si	0.449011	0.323140	0.017330
Ca	0.014419	0.007272	0.000390
Fe	0.007213	0.002610	0.000140

Density (g/cm^3)= 1.80

Comments: Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

```
c  Bricks, Common Silica, rho = 1.80
$  Neutron
     8016  -0.524858
     13027  -0.005227
     14000  -0.449011
     20000  -0.014419
     26000  -0.007213
-------------------------------------------------------------------------------------
     8016  0.663062
     13027  0.003916
     14000  0.323140
     20000  0.007272
     26000  0.002610
_____________________________________________________________________________________
$  Photon
     8000  -0.524858
     13000  -0.005227
     14000  -0.449011
     20000  -0.014419
     26000  -0.007213
-------------------------------------------------------------------------------------
     8000  0.663062
     13000  0.003916
```

```
     14000  0.323140
     20000  0.007272
     26000  0.002610
```

CEPXS Form

```
material  o 0.524476 al 0.005223 si 0.448684 ca 0.014409 fe 0.007208
matname  brick_silicon
density  1.80
```

Cadmium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Cd	1.000000	1.000000	0.046340

Density (g/cm^3)= 8.65

Comments:

Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:

http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=048

MCNP Form

```
c  Cadmium, rho = 8.65 g/cc
$  Neutron
     48000  -1.000000
-------------------------------------------------------------------------------
     48000  1.000000
_______________________________________________________________________________
$  Photon
     48000  -1.000000
-------------------------------------------------------------------------------
     48000  1.000000
```

CEPXS Form

```
material  cd 1.000000
matname  cadmium
density  8.65
```

Carbon

1: Amorphous Carbon

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
C	1.000000	1.000000	0.100280

Density (g/cm^3)= 2.0

Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=006

MCNP Form

c Carbon, Amorphous, rho = 2.0 g/cc
$ **Neutron**
6012 -1.000000

6012 1.000000

$ **Photon**
6000 -1.000000

6000 1.000000

CEPXS Form

material c 1.000000
matname carbon
density 2.0

2: Graphite

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
C	1.000000	1.000000	0.085238

Density (g/cm^3)= 1.70

Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=906

MCNP Form

```
c   Carbon, Graphite, rho = 1.70 g/cc
$  Neutron
     6012  -1.000000
-------------------------------------------------------------------------------
     6012  1.000000
_______________________________________________________________________________
$  Photon
     6000  -1.000000
-------------------------------------------------------------------------------
     6000  1.000000
```

CEPXS Form

```
material  c 1.000000
matname  carbon_graphite
density  1.70
```

Carbon Tetrachloride

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
C	0.078083	0.200003	0.006241
Cl	0.921917	0.799985	0.024962

Density (g/cm^3)= 1.594

Comments:

Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:

http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=135

MCNP Form

```
c  Carbon Tetrachloride, rho = 1.594 g/cc
$  Neutron
     6012  -0.078083
     17000  -0.921917
-------------------------------------------------------------------------------
     6012  0.200003
     17000  0.799985
_______________________________________________________________________________
$  Photon
     6000  -0.078083
     17000  -0.921917
-------------------------------------------------------------------------------
     6000  0.200003
     17000  0.799985
```

CEPXS Form

```
material  c 0.078083 cl 0.921917
matname  carbon_tetrachloride
density  1.594
```

Cesium Iodide

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
I	0.488451	0.499999	0.010454
Cs	0.511549	0.500012	0.010454

Density (g/cm^3)= 4.51

Comments:

Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c   Cesium Iodide, rho = 4.510
$  Neutron
     53127  -0.488451   $ I
     55133  -0.511549   $ Cs
-------------------------------------------------------------------------------------------
     53127  0.499999   $ I
     55133  0.500012   $ Cs
_____________________________________________________________________________
$  Photon
     53000  -0.488451   $ I
     55000  -0.511549   $ Cs
-------------------------------------------------------------------------------------------
     53000  0.499999   $ I
     55000  0.500012   $ Cs
```

CEPXS Form

```
material  i 0.488451 cs 0.511549
matname  cesium_iodide
density  4.51
```

Chromium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Cr	1.000000	1.000000	0.083158

Density (g/cm^3)= 7.18
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=024

MCNP Form

```
c  Chromium, rho = 7.18 g/cc
$  Neutron
     24000  -1.000000
-------------------------------------------------------------------------------
     24000  1.000000
_______________________________________________________________________________
$  Photon
     24000  -1.000000
-------------------------------------------------------------------------------
     24000  1.000000
```

CEPXS Form

```
material  cr 1.000000
matname  chromium
density  7.18
```

Concrete

1: Ordinary Concrete

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.022100	0.304245	0.030369
C	0.002484	0.002870	0.000286
O	0.574930	0.498628	0.049773
Na	0.015208	0.009179	0.000916
Mg	0.001266	0.000717	0.000072
Al	0.019953	0.010261	0.001024
Si	0.304627	0.150505	0.015023
K	0.010045	0.007114	0.000356
Ca	0.042951	0.014882	0.001485

Fe	0.006435	0.001599	0.000160

Density (g/cm^3)= 2.30
Comments:
Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c  Concrete, Ordinary, rho = 2.300
$  Neutron
     1001  -0.022100
     6012  -0.002484
     8016  -0.574930
     11023  -0.015208
     12000  -0.001266
     13027  -0.019953
     14000  -0.304627
     19000  -0.010045
     20000  -0.042951
     26000  -0.006435
-------------------------------------------------------------------------------------
     1001  0.304245
     6012  0.002870
     8016  0.498628
     11023  0.009179
     12000  0.000717
     13027  0.010261
     14000  0.150505
     19000  0.007114
     20000  0.014882
     26000  0.001599
_____________________________________________________________________________________
$  Photon
     1000  -0.022100
     6000  -0.002484
     8000  -0.574930
     11000  -0.015208
     12000  -0.001266
     13000  -0.019953
     14000  -0.304627
     19000  -0.010045
     20000  -0.042951
     26000  -0.006435
-------------------------------------------------------------------------------------
     1000  0.304245
     6000  0.002870
     8000  0.498628
```

```
     11000  0.009179
     12000  0.000717
     13000  0.010261
     14000  0.150505
     19000  0.007114
     20000  0.014882
     26000  0.001599
```

CEPXS Form

```
material  h 0.022101 c 0.002484 o 0.574930 na 0.015208 mg 0.001266 -
          al 0.019953 si 0.304627 k 0.010045 ca 0.042951 fe 0.006435
matname  concrete_ordinary
density  2.30
```

2: Barite Concrete (Type BA)

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.003585	0.109602	0.007175
O	0.311622	0.600193	0.039293
Mg	0.001195	0.001515	0.000099
Al	0.004183	0.004777	0.000313
Si	0.010457	0.011473	0.000751
S	0.107858	0.103654	0.006786
Ca	0.050194	0.038593	0.002527
Fe	0.047505	0.026213	0.001716
Ba	0.463400	0.103984	0.006808

Density (g/cm^3)= 3.35
Comments:
Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c  Concrete, Barite (Type BA), rho = 3.350
$  Neutron
     1000  -0.003585
     8000  -0.311622
     12000  -0.001195
     13000  -0.004183
     14000  -0.010457
     16000  -0.107858
     20000  -0.050194
     26000  -0.047505
     56000  -0.463400
c ---------------------------------------------------------------------------------------
     1000  0.109602
```

```
    8000  0.600193
    12000  0.001515
    13000  0.004777
    14000  0.011473
    16000  0.103654
    20000  0.038593
    26000  0.026213
    56000  0.103984
_____________________________________________________________________________
$ Photon
    1001  -0.003585
    8016  -0.311622
    12000  -0.001195
    13027  -0.004183
    14000  -0.010457
    16000  -0.107858
    20000  -0.050194
    26000  -0.047505
    56138  -0.463400
-----------------------------------------------------------------------------------------
    1001  0.109602
    8016  0.600193
    12000  0.001515
    13027  0.004777
    14000  0.011473
    16000  0.103654
    20000  0.038593
    26000  0.026213
    56138  0.103984
```

CEPXS Form

```
material  h 0.003585 o 0.311622 mg 0.001195 al 0.004183 si 0.010457 -
          s 0.107858 ca 0.050194 fe 0.047505 ba 0.463400
matname  concrete_barite
density  3.35
```

3: Portland

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.010000	0.168759	0.013742
C	0.001000	0.001416	0.000115
O	0.529107	0.562522	0.045806
Na	0.016000	0.011838	0.000964
Mg	0.002000	0.001400	0.000114
Al	0.033872	0.021354	0.001739

Si	0.337021	0.204115	0.016621
K	0.013000	0.005656	0.000461
Ca	0.044000	0.018674	0.001521
Fe	0.014000	0.004264	0.000347

Density (g/cm^3)= 2.30
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=144

MCNP Form

c Concrete, Portland, rho = 2.30
$ **Neutron**
1001 -0.010000
6012 -0.001000
8016 -0.529107
11023 -0.016000
12000 -0.002000
13027 -0.033872
14000 -0.337021
19000 -0.013000
20000 -0.044000
26000 -0.014000

1001 0.168759
6012 0.001416
8016 0.562522
11023 0.011838
12000 0.001400
13027 0.021354
14000 0.204115
19000 0.005656
20000 0.018674
26000 0.004264

$ **Photon**
1000 -0.010000
6000 -0.001000
8000 -0.529107
11000 -0.016000
12000 -0.002000
13000 -0.033872
14000 -0.337021
19000 -0.013000
20000 -0.044000

```
    26000  -0.014000
-------------------------------------------------------------------------------
    1000  0.168759
    6000  0.001416
    8000  0.562522
    11000  0.011838
    12000  0.001400
    13000  0.021354
    14000  0.204115
    19000  0.005656
    20000  0.018674
    26000  0.004264
```

CEPXS Form

```
material  h 0.010000 c 0.001000 o 0.529107 na 0.016000 mg 0.002000 -
          al 0.033872 si 0.337021 k 0.013000 ca 0.044000 fe 0.014000
matname  concrete_portland
density  2.30
```

4: Type 04

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.005567	0.103697	0.007770
O	0.498825	0.585346	0.043860
Na	0.017159	0.014013	0.001050
Mg	0.002592	0.002002	0.000150
Al	0.045840	0.031896	0.002390
Si	0.315439	0.210863	0.015800
K	0.019177	0.009209	0.000690
Ca	0.082904	0.038836	0.002910
Fe	0.012306	0.004137	0.000310

Density (g/cm^3)= 2.336

Comments: Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

c Concrete, Type 04, rho = 2.336
$ **Neutron**
1001 -0.005567
8016 -0.498825
11023 -0.017159
12000 -0.002592
13027 -0.045840
14000 -0.315439
19000 -0.019177
20000 -0.082904
26000 -0.012306

1001 0.103697
8016 0.585346
11023 0.014013
12000 0.002002
13027 0.031896
14000 0.210863
19000 0.009209
20000 0.038836
26000 0.004137

$ **Photon**
1000 -0.005567
8000 -0.498825
11000 -0.017159
12000 -0.002592
13000 -0.045840
14000 -0.315439
19000 -0.019177
20000 -0.082904
26000 -0.012306

1000 0.103697
8000 0.585346
11000 0.014013
12000 0.002002
13000 0.031896
14000 0.210863
19000 0.009209
20000 0.038836
26000 0.004137

CEPXS Form

```
material  h 0.005568 o 0.498920 na 0.017162 mg 0.002592 al 0.045849 -
          si 0.315499 k 0.019181 ca 0.082920 fe 0.012308
matname  concrete_type04
density  2.336
```

5: LS

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.006262	0.108068	0.008523
C	0.177318	0.256799	0.020253
O	0.403413	0.438586	0.034590
Na	0.000335	0.000254	0.000020
Mg	0.032954	0.023584	0.001860
Al	0.011112	0.007164	0.000565
Si	0.034804	0.021555	0.001700
K	0.001140	0.000507	0.000040
Ca	0.325043	0.141073	0.011126
Fe	0.007735	0.002409	0.000190

Density (g/cm^3)= 2.278

Comments: Composite aggregate of limestone and silicates. Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

```
c  Concrete, LS, rho = 2.278
$  Neutron
     1001  -0.006262
     6012  -0.177318
     8016  -0.403413
     11023  -0.000335
     12000  -0.032954
     13027  -0.011112
     14000  -0.034804
     19000  -0.001140
     20000  -0.325043
     26000  -0.007735
-------------------------------------------------------------------------------------------
     1001  0.108068
     6012  0.256799
     8016  0.438586
```

```
     11023  0.000254
     12000  0.023584
     13027  0.007164
     14000  0.021555
     19000  0.000507
     20000  0.141073
     26000  0.002409
```

```
$ Photon
     1000  -0.006262
     6000  -0.177318
     8000  -0.403413
     11000  -0.000335
     12000  -0.032954
     13000  -0.011112
     14000  -0.034804
     19000  -0.001140
     20000  -0.325043
     26000  -0.007735
```

```
     1000  0.108068
     6000  0.256799
     8000  0.438586
     11000  0.000254
     12000  0.023584
     13000  0.007164
     14000  0.021555
     19000  0.000507
     20000  0.141073
     26000  0.002409
```

CEPXS Form

```
material  h 0.006262 c 0.177297 o 0.403366 na 0.000335 mg 0.032950 -
          al 0.011111 si 0.034800 k 0.001140 ca 0.325005 fe 0.007734
matname  concrete_ls
density  2.278
```

6: L

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.005135	0.094080	0.007170
C	0.100250	0.154136	0.011747
O	0.485288	0.560122	0.042688
Mg	0.001710	0.001299	0.000099
Al	0.005138	0.003517	0.000268

Si	0.011974	0.007873	0.000600
Ca	0.382590	0.176285	0.013435
Fe	0.008134	0.002690	0.000205

Density (g/cm^3)= 2.337

Comments: Principally limestone aggregate. Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

```
c   Concrete, L, rho = 2.337
$  Neutron
     1001  -0.005135
     6012  -0.100250
     8016  -0.485288
     12000  -0.001710
     13027  -0.005138
     14000  -0.011974
     20000  -0.382590
     26000  -0.008134
-------------------------------------------------------------------------------------
     1001  0.094080
     6012  0.154136
     8016  0.560122
     12000  0.001299
     13027  0.003517
     14000  0.007873
     20000  0.176285
     26000  0.002690
_____________________________________________________________________________________
$  Photon
     1000  -0.005135
     6000  -0.100250
     8000  -0.485288
     12000  -0.001710
     13000  -0.005138
     14000  -0.011974
     20000  -0.382590
     26000  -0.008134
-------------------------------------------------------------------------------------
     1000  0.094080
     6000  0.154136
     8000  0.560122
```

```
    12000  0.001299
    13000  0.003517
    14000  0.007873
    20000  0.176285
    26000  0.002690
```

CEPXS Form

```
material  h 0.005134 c 0.100228 o 0.485182 mg 0.001710 al 0.005137 -
          si 0.011971 ca 0.382506 fe 0.008132
matname  concrete_l
density  2.337
```

7: ORNL

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.006488	0.116933	0.008605
O	0.518069	0.588267	0.04329
Na	0.016577	0.013100	0.000964
Al	0.035137	0.023658	0.001741
Si	0.349085	0.225808	0.016617
K	0.015324	0.007121	0.000524
Ca	0.045057	0.020424	0.001503
Fe	0.014411	0.004688	0.000345

Density (g/cm^3)= 2.220

Comments: Principally silicate aggregate also referred to as concrete S. Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

```
c   Concrete, ORNL, rho = 2.220
$  Neutron
     1001  -0.006488
     8016  -0.518069
     11023  -0.016577
     13027  -0.035137
     14000  -0.349085
     19000  -0.015324
     20000  -0.045057
     26000  -0.014411
-------------------------------------------------------------------------------------------
     1001  0.116933
```

8016 0.588267
11023 0.013100
13027 0.023658
14000 0.225808
19000 0.007121
20000 0.020424
26000 0.004688

$ **Photon**

1000 -0.006488
8000 -0.518069
11000 -0.016577
13000 -0.035137
14000 -0.349085
19000 -0.015324
20000 -0.045057
26000 -0.014411

1000 0.116933
8000 0.588267
11000 0.013100
13000 0.023658
14000 0.225808
19000 0.007121
20000 0.020424
26000 0.004688

CEPXS Form

```
material  h 0.006487 o 0.517992 na 0.016575 al 0.035132 si 0.349033 -
          k 0.015322 ca 0.045050 fe 0.014409
matname  concrete_ornl
density  2.220
```

8: Rocky Flats

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.007500	0.136471	0.010401
C	0.055502	0.084748	0.006459
O	0.492926	0.565027	0.043063
S	0.179258	0.102527	0.007814
K	0.007497	0.003516	0.000268
Ca	0.229502	0.105020	0.008004
Fe	0.008191	0.002690	0.000205

Density (g/cm^3)= 2.321

Comments: Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.
Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

c Concrete, Rocky Flats, rho = 2.321
$ **Neutron**
1001 -0.007500
6012 -0.055502
8016 -0.492926
16000 -0.179258
19000 -0.007497
20000 -0.229502
26000 -0.008191

1001 0.136471
6012 0.084748
8016 0.565027
16000 0.102527
19000 0.003516
20000 0.105020
26000 0.002690

$ **Photon**
1000 -0.007500
6000 -0.055502
8000 -0.492926
16000 -0.179258
19000 -0.007497
20000 -0.229502
26000 -0.008191

1000 0.136471
6000 0.084748
8000 0.565027
16000 0.102527
19000 0.003516
20000 0.105020
26000 0.002690

CEPXS Form

```
material  h 0.007650 c 0.056613 o 0.502793 s 0.182846 k 0.007647 -
          ca 0.234096 fe 0.008355
matname  concrete_rockyflats
density  2.321
```

9: Magnetite

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.003000	0.083258	0.006184
O	0.320000	0.559481	0.041554
Mg	0.006000	0.006905	0.000513
Al	0.029000	0.030066	0.002233
Si	0.035000	0.034860	0.002589
P	0.001700	0.001535	0.000114
S	0.010700	0.009335	0.000693
Ca	0.007000	0.004886	0.000363
Ti	0.028000	0.016363	0.001215
Mn	0.000700	0.000356	0.000026
Fe	0.505000	0.252957	0.018788

Density (g/cm^3)= 3.45

Comments: Magnetite concrete.

Reference: H. E Hungerford, *Reactor Handbook*, Vol. I, Materials, C. R. Tipton, Jr. (Ed.), p. 1086, Interscience Publishers, a division of John Wiley & Sons, Inc., New York, 1960.

MCNP Form

```
c   Concrete, Magnetite, rho = 3.45
$  Neutron
     1001  -0.003000
     8016  -0.320000
     12000  -0.006000
     13027  -0.029000
     14000  -0.035000
     15031  -0.001700
     16000  -0.010700
     20000  -0.007000
     22000  -0.028000
     25055  -0.000700
     26000  -0.505000
-------------------------------------------------------------------------------------------
     1001  0.083258
     8016  0.559481
     12000  0.006905
```

```
    13027  0.030066
    14000  0.034860
    15031  0.001535
    16000  0.009335
    20000  0.004886
    22000  0.016363
    25055  0.000356
    26000  0.252957
```

$ **Photon**

```
    1000  -0.003000
    8000  -0.320000
    12000  -0.006000
    13000  -0.029000
    14000  -0.035000
    15000  -0.001700
    16000  -0.010700
    20000  -0.007000
    22000  -0.028000
    25000  -0.000700
    26000  -0.505000
```

```
    1000  0.083258
    8000  0.559481
    12000  0.006905
    13000  0.030066
    14000  0.034860
    15000  0.001535
    16000  0.009335
    20000  0.004886
    22000  0.016363
    25000  0.000356
    26000  0.252957
```

CEPXS Form

```
material  h 0.003170 o 0.338231 mg 0.006342 al 0.030652 si 0.036994 -
          p 0.001797 s 0.011310 ca 0.007399 ti 0.029595 mn 0.000740 -
          fe 0.533770
matname  concrete_magnetite
density  3.45
```

10: Ferro-phosphorus

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.005000	0.158643	0.014339
O	0.104000	0.207881	0.018790
Mg	0.002000	0.002632	0.000238
Al	0.004000	0.004741	0.000429
Si	0.034000	0.038715	0.003499
P	0.197000	0.203403	0.018385
Ca	0.042000	0.033514	0.003029
Fe	0.612000	0.350472	0.031678

Density (g/cm^3)= 4.80

Comments: Ferro-phosphorus concrete.

Reference: H. E Hungerford, *Reactor Handbook*, Vol. I, Materials, C. R. Tipton, Jr. (Ed.), p. 1086, Interscience Publishers, a division of John Wiley & Sons, Inc., New York, 1960.

MCNP Form

```
c  Concrete, Ferro-phosphorus, rho = 4.80
$ Neutron
     1001  -0.005000
     8016  -0.104000
     12000  -0.002000
     13027  -0.004000
     14000  -0.034000
     15031  -0.197000
     20000  -0.042000
     26000  -0.612000
-------------------------------------------------------------------------------
     1001  0.158643
     8016  0.207881
     12000  0.002632
     13027  0.004741
     14000  0.038715
     15031  0.203403
     20000  0.033514
     26000  0.350472
_______________________________________________________________________________
$ Photon
     1000  -0.005000
     8000  -0.104000
     12000  -0.002000
     13000  -0.004000
```

```
     14000  -0.034000
     15000  -0.197000
     20000  -0.042000
     26000  -0.612000
-------------------------------------------------------------------------------------
     1000  0.158643
     8000  0.207881
     12000  0.002632
     13000  0.004741
     14000  0.038715
     15000  0.203403
     20000  0.033514
     26000  0.350472
```

CEPXS Form

```
material  h 0.005000 o 0.104000 mg 0.002000 al 0.004000 si 0.034000 -
          p 0.197000 ca 0.042000 fe 0.612000
matname  concrete_ferro-phosphorus
density  4.80
```

11: Iron-limonite

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.000500	0.018192	0.001276
O	0.180000	0.412589	0.028930
Mg	0.002000	0.003018	0.000212
Al	0.005000	0.006796	0.000477
Si	0.014000	0.018281	0.001282
S	0.001000	0.001144	0.000080
Ca	0.061000	0.055818	0.003914
Mn	0.016000	0.010681	0.000749
Fe	0.721000	0.473478	0.033199

Density (g/cm^3)= 4.27

Comments: Iron-limonite concrete.

Reference: H. E Hungerford, *Reactor Handbook*, Vol. I, Materials, C. R. Tipton, Jr. (Ed.), p. 1086, Interscience Publishers, a division of John Wiley & Sons, Inc., New York, 1960.

MCNP Form

```
c   Concrete, Iron-limonite, rho = 4.27
$  Neutron
     1001  -0.000500
     8016  -0.180000
     12000  -0.002000
```

```
    13027  -0.005000
    14000  -0.014000
    16000  -0.001000
    20000  -0.061000
    25055  -0.016000
    26000  -0.721000
-------------------------------------------------------------------------------------
    1001  0.018192
    8016  0.412589
    12000  0.003018
    13027  0.006796
    14000  0.018281
    16000  0.001144
    20000  0.055818
    25055  0.010681
    26000  0.473478
_____________________________________________________________________________________
$ Photon
    1000  -0.000500
    8000  -0.180000
    12000  -0.002000
    13000  -0.005000
    14000  -0.014000
    16000  -0.001000
    20000  -0.061000
    25000  -0.016000
    26000  -0.721000
-------------------------------------------------------------------------------------
    1000  0.018192
    8000  0.412589
    12000  0.003018
    13000  0.006796
    14000  0.018281
    16000  0.001144
    20000  0.055818
    25000  0.010681
    26000  0.473478
```

CEPXS Form

```
material  h 0.000500 o 0.179910 mg 0.001998 al 0.004997 si 0.013993 -
          s 0.001000 ca 0.060970 mn 0.015992 fe 0.720640
matname  concrete_iron-limonite
density  4.27
```

12: Iron-portland

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.003300	0.135585	0.011436
O	0.058200	0.150645	0.012706
Mg	0.001300	0.002215	0.000187
Al	0.003300	0.005065	0.000427
Si	0.009100	0.013418	0.001132
S	0.000500	0.000646	0.000054
Ca	0.039600	0.040919	0.003451
Mn	0.003500	0.002638	0.000223
Fe	0.875000	0.648872	0.054727

Density (g/cm^3)= 5.80

Comments: Iron-portland concrete.

Reference: H. E Hungerford, *Reactor Handbook*, Vol. I, Materials, C. R. Tipton, Jr. (Ed.), p. 1086, Interscience Publishers, a division of John Wiley & Sons, Inc., New York, 1960.

MCNP Form

```
c  Concrete, Iron-portland, rho = 5.80
$  Neutron
    1001  -0.003300
    8016  -0.058200
    12000  -0.001300
    13027  -0.003300
    14000  -0.009100
    16000  -0.000500
    20000  -0.039600
    25055  -0.003500
    26000  -0.875000
-------------------------------------------------------------------------------
    1001  0.135585
    8016  0.150645
    12000  0.002215
    13027  0.005065
    14000  0.013418
    16000  0.000646
    20000  0.040919
    25055  0.002638
    26000  0.648872
_______________________________________________________________________________
$  Photon
    1000  -0.003300
    8000  -0.058200
```

12000 -0.001300
13000 -0.003300
14000 -0.009100
16000 -0.000500
20000 -0.039600
25000 -0.003500
26000 -0.875000

1000 0.135585
8000 0.150645
12000 0.002215
13000 0.005065
14000 0.013418
16000 0.000646
20000 0.040919
25000 0.002638
26000 0.648872

CEPXS Form

```
material  h 0.003320 o 0.058563 mg 0.001308 al 0.003321 si 0.009157 -
          s 0.000503 ca 0.039847 mn 0.003522 fe 0.880459
matname  concrete_iron-portland
density  5.80
```

13: Colemanite-baryte

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.008500	0.208729	0.016251
B	0.009800	0.022437	0.001747
O	0.348900	0.539753	0.042024
Na	0.001100	0.001184	0.000092
Mg	0.002200	0.002240	0.000174
Al	0.006100	0.005596	0.000436
Si	0.017600	0.015511	0.001208
S	0.096300	0.074335	0.005788
Ca	0.084600	0.052247	0.004068
Mn	0.000100	0.000045	0.000004
Fe	0.010300	0.004565	0.000355
Ba	0.407000	0.073356	0.005711

Density (g/cm^3)= 3.20

Comments: Colemanite-baryte concrete.

Reference: H. E Hungerford, *Reactor Handbook*, Vol. I, Materials, C. R. Tipton, Jr. (Ed.), p. 1086, Interscience Publishers, a division of John Wiley & Sons, Inc., New York, 1960.

MCNP Form

c Concrete, Colemanite-baryte, rho = 3.20
$ **Neutron**
1001 -0.008500
5011 -0.009800
8016 -0.348900
11023 -0.001100
12000 -0.002200
13027 -0.006100
14000 -0.017600
16000 -0.096300
20000 -0.084600
25055 -0.000100
26000 -0.010300
56138 -0.407000

1001 0.208729
5011 0.022437
8016 0.539753
11023 0.001184
12000 0.002240
13027 0.005596
14000 0.015511
16000 0.074335
20000 0.052247
25055 0.000045
26000 0.004565
56138 0.073356

$ **Photon**
1000 -0.008500
5000 -0.009800
8000 -0.348900
11000 -0.001100
12000 -0.002200
13000 -0.006100
14000 -0.017600
16000 -0.096300
20000 -0.084600
25000 -0.000100
26000 -0.010300
56000 -0.407000

1000 0.208729
5000 0.022437
8000 0.539753

```
    11000  0.001184
    12000  0.002240
    13000  0.005596
    14000  0.015511
    16000  0.074335
    20000  0.052247
    25000  0.000045
    26000  0.004565
    56000  0.073356
```

CEPXS Form

```
material  h 0.008563 b 0.009874 o 0.351537 na 0.001108 mg 0.002217 -
          al 0.006146 si 0.017733 s 0.097028 ca 0.085239 mn 0.000101 -
          fe 0.010378 ba 0.410076
matname  concrete_colmanite-baryte
density  3.20
```

14: Boron Frits-baryte

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.005600	0.147522	0.010372
B	0.010400	0.025543	0.001796
O	0.338000	0.560938	0.039439
F	0.002300	0.003214	0.000226
Na	0.012100	0.013975	0.000983
Mg	0.002300	0.002513	0.000177
Al	0.006400	0.006298	0.000443
Si	0.033100	0.031293	0.002200
S	0.091500	0.075769	0.005327
K	0.001000	0.000679	0.000048
Ca	0.062600	0.041473	0.002916
Mn	0.000200	0.000097	0.000007
Fe	0.021900	0.010413	0.000732
Zn	0.006600	0.002679	0.000188
Ba	0.401300	0.077592	0.005455

Density (g/cm^3)= 3.10

Comments: Boron frits-baryte concrete.

Reference: H. E Hungerford, *Reactor Handbook*, Vol. I, Materials, C. R. Tipton, Jr. (Ed.), p. 1086, Interscience Publishers, a division of John Wiley & Sons, Inc., New York, 1960.

MCNP Form

c Concrete, Boron Frits-baryte, rho = 3.10
$ **Neutron**
1001 -0.005600
5011 -0.010400
8016 -0.338000
9019 -0.002300
11023 -0.012100
12000 -0.002300
13027 -0.006400
14000 -0.033100
16000 -0.091500
19000 -0.001000
20000 -0.062600
25055 -0.000200
26000 -0.021900
30000 -0.006600
56138 -0.401300

1001 0.147522
5011 0.025543
8016 0.560938
9019 0.003214
11023 0.013975
12000 0.002513
13027 0.006298
14000 0.031293
16000 0.075769
19000 0.000679
20000 0.041473
25055 0.000097
26000 0.010413
30000 0.002679
56138 0.077592

$ **Photon**
1000 -0.005600
5000 -0.010400
8000 -0.338000
9000 -0.002300
11000 -0.012100
12000 -0.002300
13000 -0.006400
14000 -0.033100
16000 -0.091500
19000 -0.001000
20000 -0.062600

```
    25000  -0.000200
    26000  -0.021900
    30000  -0.006600
    56000  -0.401300
-------------------------------------------------------------------------------------
    1000  0.147522
    5000  0.025543
    8000  0.560938
    9000  0.003214
    11000  0.013975
    12000  0.002513
    13000  0.006298
    14000  0.031293
    16000  0.075769
    19000  0.000679
    20000  0.041473
    25000  0.000097
    26000  0.010413
    30000  0.002679
    56000  0.077592
```

CEPXS Form

```
material  h 0.005627 b 0.010449 o 0.339596 f 0.002311 na 0.012157 -
          mg 0.002311 al 0.006430 si 0.033256 s 0.091932 k 0.001005 -
          ca 0.062896 mn 0.000201 fe 0.022003 zn 0.006631 ba 0.403195
matname  concrete_boron-frits-baryte
density  3.10
```

15: Lumnite-colemanite-baryte

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.010900	0.247678	0.020189
B	0.008800	0.018643	0.001520
O	0.369500	0.528941	0.043114
Na	0.001100	0.001096	0.000089
Mg	0.001400	0.001319	0.000108
Al	0.017600	0.014940	0.001218
Si	0.009600	0.007829	0.000638
S	0.090600	0.064713	0.005275
Ca	0.054800	0.031316	0.002553
Ti	0.012700	0.006077	0.000495
Mn	0.001200	0.000500	0.000041
Fe	0.030700	0.012591	0.001026
Ba	0.385900	0.064360	0.005246

Density (g/cm^3)= 3.10

Comments: Lumnite-colemanite-baryte concrete.

Reference: H. E Hungerford, *Reactor Handbook*, Vol. I, Materials, C. R. Tipton, Jr. (Ed.), p. 1086, Interscience Publishers, a division of John Wiley & Sons, Inc., New York, 1960.

MCNP Form

```
c  Concrete, Lumnite-colemanite-baryte, rho = 3.10
$ Neutron
     1001  -0.010900
     5011  -0.008800
     8016  -0.369500
     11023  -0.001100
     12000  -0.001400
     13027  -0.017600
     14000  -0.009600
     16000  -0.090600
     20000  -0.054800
     22000  -0.012700
     25055  -0.001200
     26000  -0.030700
     56138  -0.385900
-------------------------------------------------------------------------------------
     1001  0.247678
     5011  0.018643
     8016  0.528941
     11023  0.001096
     12000  0.001319
     13027  0.014940
     14000  0.007829
     16000  0.064713
     20000  0.031316
     22000  0.006077
     25055  0.000500
     26000  0.012591
     56138  -0.064360
_____________________________________________________________________________
$ Photon
     1000  -0.010900
     5000  -0.008800
     8000  -0.369500
     11000  -0.001100
     12000  -0.001400
     13000  -0.017600
     14000  -0.009600
     16000  -0.090600
```

```
    20000  -0.054800
    22000  -0.012700
    25000  -0.001200
    26000  -0.030700
    56000  -0.385900
-------------------------------------------------------------------------------------------
    1000  0.247678
    5000  0.018643
    8000  0.528941
    11000  0.001096
    12000  0.001319
    13000  0.014940
    14000  0.007829
    16000  0.064713
    20000  0.031316
    22000  0.006077
    25000  0.000500
    26000  0.012591
    56000  -0.064360
```

CEPXS Form

```
material  h 0.010959 b 0.008846 o 0.371431 na 0.001106 mg 0.001407 -
          al 0.017692 si 0.009650 s 0.091074 ca 0.055086 ti 0.012766 -
          mn 0.001206 fe 0.030860 ba 0.387917
matname  concrete_lum-colem-baryte
density  3.10
```

16: Lumnite-portland-colemanite-baryte

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.001100	0.248270	0.020374
B	0.010200	0.021463	0.001761
O	0.369800	0.525809	0.043149
Na	0.001100	0.001088	0.000089
Mg	0.002000	0.001872	0.000154
Al	0.013200	0.011129	0.000913
Si	0.014900	0.012069	0.000990
S	0.089700	0.063639	0.005222
Ca	0.076700	0.043537	0.003573
Ti	0.000710	0.000337	0.000028
Mn	0.000400	0.000166	0.000014
Fe	0.018700	0.007618	0.000625
Ba	0.380300	0.062999	0.005170

Density (g/cm^3)= 3.10

Comments: Lumnite-portland-colemanite-baryte concrete.
Reference: H. E Hungerford, *Reactor Handbook*, Vol. I, Materials, C. R. Tipton, Jr. (Ed.), p. 1086, Interscience Publishers, a division of John Wiley & Sons, Inc., New York, 1960.

MCNP Form

```
c  Concrete, Lumnite-portland-colemanite-baryte, rho = 3.10
$  Neutron
     1001  -0.011000
     5011  -0.010200
     8016  -0.369800
     11023  -0.001100
     12000  -0.002000
     13027  -0.013200
     14000  -0.014900
     16000  -0.089700
     20000  -0.076700
     22000  -0.000710
     25055  -0.000400
     26000  -0.018700
     56138  -0.380300
-------------------------------------------------------------------------------------
     1001  0.248270
     5011  0.021463
     8016  0.525809
     11023  0.001088
     12000  0.001872
     13027  0.011129
     14000  0.012069
     16000  0.063639
     20000  0.043537
     22000  0.000337
     25055  0.000166
     26000  0.007618
     56138  -0.062999
_____________________________________________________________________________
$  Photon
     1000  -0.011000
     5000  -0.010200
     8000  -0.369800
     11000  -0.001100
     12000  -0.002000
     13000  -0.013200
     14000  -0.014900
     16000  -0.089700
     20000  -0.076700
     22000  -0.000710
```

```
     25000  -0.000400
     26000  -0.018700
     56000  -0.380300
-------------------------------------------------------------------------------------------
     1000  0.248270
     5000  0.021463
     8000  0.525809
     11000  0.001088
     12000  0.001872
     13000  0.011129
     14000  0.012069
     16000  0.063639
     20000  0.043537
     22000  0.000337
     25000  0.000166
     26000  0.007618
     56000  -0.062999
```

CEPXS Form

```
material  h 0.001123 b 0.010421 o 0.377806 na 0.001124 mg 0.002043 -
          al 0.013486 si 0.015223 s 0.091642 ca 0.078360 ti 0.000725 -
          mn 0.000409 fe 0.019105 ba 0.388533
matname  concrete_lum-portland-colem-baryte
density  3.10
```

Explosive Compounds

1: TNT

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.022189	0.238099	0.021928
C	0.370160	0.333331	0.030698
N	0.185004	0.142857	0.013156
O	0.422648	0.285713	0.026312

Density (g/cm^3)= 1.654

Comments: TNT (2,4,6-Tinitrotoluene)

Reference: *Modern Methods and Applications in Analysis of Explosives*, Jehuda Yinon and Shmuel Zitrin, p. 3, John Wiley & Sons, Inc., New York, 1993.

MCNP Form

c TNT, rho = 1.654
$ **Neutron**
1001 -0.022189
6012 -0.370160
7014 -0.185004
8016 -0.422648

1001 0.238099
6012 0.333331
7014 0.142857
8016 0.285713

$ **Photon**
1000 -0.022189
6000 -0.370160
7000 -0.185004
8000 -0.422648

1000 0.238099
6000 0.333331
7000 0.142857
8000 0.285713

CEPXS Form

material h 0.022188 c 0.370160 n 0.185004 o 0.422648
matname explosive_tnt
density 1.654

2: RDX

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.027227	0.285712	0.029379
C	0.162222	0.142857	0.014690
N	0.378361	0.285714	0.029379
O	0.432190	0.285715	0.029379

Density (g/cm^3)= 1.806
Comments: RDX (1,3,5-Tinitro-1,3,5-triazacyclohexane)
Reference: *Modern Methods and Applications in Analysis of Explosives*, Jehuda Yinon and Shmuel Zitrin, p. 5, John Wiley & Sons, Inc., New York, 1993.

MCNP Form

```
c  RDX,   rho = 1.806
$  Neutron
     1001  -0.027227
     6012  -0.162222
     7014  -0.378361
     8016  -0.432190
-------------------------------------------------------------------------------------
     1001  0.285712
     6012  0.142857
     7014  0.285714
     8016  0.285715

_____________________________________________________________________________________
$  Photon
     1000  -0.027227
     6000  -0.162222
     7000  -0.378361
     8000  -0.432190
-------------------------------------------------------------------------------------
     1000  0.285712
     6000  0.142857
     7000  0.285714
     8000  0.285715
```

CEPXS Form

```
material  h 0.027227 c 0.162222 n 0.378361 o 0.432190
matname  explosive_rdx
density  1.806
```

3: HMX

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.027227	0.285712	0.030940
C	0.162222	0.142857	0.015470
N	0.378361	0.285714	0.030941
O	0.432190	0.285714	0.030941

Density (g/cm^3)= 1.902

Comments: HMX (1,3,5,7-Tetranitro-1,3,5,7-tetrazacyclooctane)

Reference: *Modern Methods and Applications in Analysis of Explosives*, Jehuda Yinon and Shmuel Zitrin, p. 6, John Wiley & Sons, Inc., New York, 1993.

MCNP Form

```
c  HMX,   rho = 1.902
$  Neutron
     1001  -0.027227
     6012  -0.162222
     7014  -0.378361
     8016  -0.432190
-------------------------------------------------------------------------------------
     1001  0.285712
     6012  0.142857
     7014  0.285714
     8016  0.285714
_____________________________________________________________________________________
$  Photon
     1000  -0.027227
     6000  -0.162222
     7000  -0.378361
     8000  -0.432190
-------------------------------------------------------------------------------------
     1000  0.285712
     6000  0.142857
     7000  0.285714
     8000  0.285714
```

CEPXS Form

```
material  h 0.027227 c 0.162222 n 0.378361 o 0.432190
matname  explosive_hmx
density  1.902
```

4: NG (Nitroglycerin)

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.022193	0.250001	0.014983
C	0.158671	0.150000	0.008990
N	0.185040	0.150001	0.008990
O	0.634096	0.450002	0.026970

Density (g/cm^3)= 1.13

Comments: NG (Nitroglycerin) , Glycerol Trinitrate

Reference: *Modern Methods and Applications in Analysis of Explosives*, Jehuda Yinon and Shmuel Zitrin, p. 8, John Wiley & Sons, Inc., New York, 1993.

MCNP Form

c NG, rho = 1.13
$ **Neutron**
1001 -0.022193
6012 -0.158671
7014 -0.185040
8016 -0.634096

1001 0.250001
6012 0.150000
7014 0.150001
8016 0.450002

$ **Photon**
1000 -0.022193
6000 -0.158671
7000 -0.185040
8000 -0.634096

1000 0.250001
6000 0.150000
7000 0.150001
8000 0.450002

CEPXS Form

material h 0.022193 c 0.158671 n 0.185040 o 0.634096
matname explosive_nitroglycerin
density 1.13

5: PETN

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.025506	0.275859	0.027019
C	0.189961	0.172414	0.016887
N	0.177223	0.137931	0.013510
O	0.607310	0.413794	0.040529

Density (g/cm^3)= 1.773

Comments: PETN (Pentaerythritol Tetranitrate)

Reference: *Modern Methods and Applications in Analysis of Explosives*, Jehuda Yinon and Shmuel Zitrin, p. 9, John Wiley & Sons, Inc., New York, 1993.

MCNP Form

c PETN, rho = 1.773
$ **Neutron**
1001 -0.025506
6012 -0.189961
7014 -0.177223
8016 -0.607310

1001 0.275859
6012 0.172414
7014 0.137931
8016 0.413794

$ **Photon**
1000 -0.025506
6000 -0.189961
7000 -0.177223
8000 -0.607310

1000 0.275859
6000 0.172414
7000 0.137931
8000 0.413794

CEPXS Form

material h 0.025506 c 0.189961 n 0.177223 o 0.607310
matname explosive_petn
density 1.773

6: EGDN (Ethylene Glycol Dinitrate)

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.026514	0.285716	0.023604
C	0.157970	0.142857	0.011802
N	0.184222	0.142856	0.011802
O	0.631294	0.428570	0.035405

Density (g/cm^3)= 1.490
Comments: EGDN (Ethylene Glycol Dinitrate)
Reference: *Modern Methods and Applications in Analysis of Explosives*, Jehuda Yinon and Shmuel Zitrin, p. 11, John Wiley & Sons, Inc., New York, 1993.

MCNP Form

c EGDN, rho = 1.490
$ **Neutron**
1001 -0.026514
6012 -0.157970
7014 -0.184222
8016 -0.631294

1001 0.285716
6012 0.142857
7014 0.142856
8016 0.428570

$ **Photon**
1000 -0.026514
6000 -0.157970
7000 -0.184222
8000 -0.631294

1000 0.285716
6000 0.142857
7000 0.142856
8000 0.428570

CEPXS Form

material h 0.026514 c 0.157970 n 0.184222 o 0.631294
matname explosive_egdn
density 1.490

7: AN (Ammonium Nitrate)

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.050370	0.444446	0.052064
N	0.349978	0.222221	0.026032
O	0.599652	0.333331	0.039047

Density (g/cm^3)= 1.730

Comments: AN (Ammonium Nitrate)

Reference: *Modern Methods and Applications in Analysis of Explosives*, Jehuda Yinon and Shmuel Zitrin, p. 12, John Wiley & Sons, Inc., New York, 1993.

MCNP Form

c AN, rho = 1.730
$ **Neutron**
1001 -0.050370
7014 -0.349978
8016 -0.599652

1001 0.444446
7014 0.222221
8016 0.333331

$ **Photon**
1000 -0.050370
7000 -0.349978
8000 -0.599652

1000 0.444446
7000 0.222221
8000 0.333331

CEPXS Form

material h 0.050370 n 0.349978 o 0.599652
matname explosive_ammonium-nitrate
density 1.730

8: NC (Nitrocellulose)

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.028320	0.291664	0.028088
C	0.289258	0.250000	0.024076
N	0.168664	0.125000	0.012038
O	0.513758	0.333333	0.032101

Density (g/cm^3)= 1.660
Comments: NC (Nitrocellulose)
Reference: *Modern Methods and Applications in Analysis of Explosives*, Jehuda Yinon and Shmuel Zitrin, p. 13, John Wiley & Sons, Inc., New York, 1993.

MCNP Form

c NC, rho = 1.660
$ **Neutron**
1001 -0.028320
6012 -0.289258
7014 -0.168664
8016 -0.513758

1001 0.291664
6012 0.250000
7014 0.125000
8016 0.333333

$ **Photon**
1000 -0.028320
6000 -0.289258
7000 -0.168664
8000 -0.513758

1000 0.291664
6000 0.250000
7000 0.125000
8000 0.333333

CEPXS Form

material h 0.028320 c 0.289258 n 0.168664 o 0.513758
matname explosive_nitrocellulose
density 1.660

Ferrous Sulfate

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.108376	0.660238	0.066305
O	0.878959	0.337338	0.033878
Na	0.000022	0.000006	0.000001
S	0.012553	0.002404	0.000241
Cl	0.000035	0.000006	0.000001
Fe	0.000055	0.000006	0.000001

Density (g/cm^3)= 1.024
Comments: Standard Fricke
Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c Ferrous Sulfate (Standard Fricke), rho = 1.024
$  Neutron
     1001  -0.108376
     8016  -0.878959
     11023  -0.000022
     16000  -0.012553
     17000  -0.000035
     26000  -0.000055
-------------------------------------------------------------------------------------
     1001  0.660238
     8016  0.337338
     11023  0.000006
     16000  0.002404
     17000  0.000006
     26000  0.000006

_____________________________________________________________________________
$  Photon
     1000  -0.108376
     8000  -0.878959
     11000  -0.000022
     16000  -0.012553
     17000  -0.000035
     26000  -0.000055
-------------------------------------------------------------------------------------
     1000  0.660238
     8000  0.337338
     11000  0.000006
     16000  0.002404
     17000  0.000006
     26000  0.000006
```

CEPXS Form

```
material  h 0.108376 o 0.878959 na 0.000022 s 0.012553 cl 0.000035 -
          fe 0.000055
matname  ferrous_sulfate
density  1.024
```

Fertilizer

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.0000504	0.001848	0.000030
O	0.0007176	0.001657	0.000027
Na	0.0087350	0.014039	0.000227
Mg	0.0002058	0.000313	0.000005

S	0.0001590	0.000183	0.000003
Cl	0.4778000	0.497978	0.008035
K	0.5117000	0.483587	0.007803
Ca	0.0002758	0.000254	0.000004
Br	0.0003303	0.000153	0.000002

Density (g/cm^3)= 0.990

Comments: Combination of "Evergro" and "Agrium". Muriate of Potash.

Reference: Pallet Load of Potash as NORM by E.R. Siciliano (Feb. 2006), http://www.agrium.com/uploads/muriate_potash_blender_coarse_grade_e.pdf, http://www.growercentral.com/UPLOADS/PDFS/0-0-62%20muriate%20of%20potash%20fine%20label.pdf

MCNP Form

```
c   Fertilizer (Muriate of Potash), rho = 0.990
$  Neutron
     1001  -0.0000504
     8016  -0.0007176
     11023  -0.0087350
     12000  -0.0002058
     16000  -0.0001590
     17000  -0.4778000
     19000  -0.5117000
     20000  -0.0002758
     35079  -0.0003303
-------------------------------------------------------------------------------------------
     1001  0.001848
     8016  0.001657
     11023  0.014039
     12000  0.000313
     16000  0.000183
     17000  0.497978
     19000  0.483587
     20000  0.000254
     35079  0.000153
_____________________________________________________________________________
$  Photon
     1000  -0.0000504
     8000  -0.0007176
     11000  -0.0087350
     12000  -0.0002058
     16000  -0.0001590
     17000  -0.4778000
     19000  -0.5117000
     20000  -0.0002758
     35000  -0.0003303
```

1000 0.001848
8000 0.001657
11000 0.014039
12000 0.000313
16000 0.000183
17000 0.497978
19000 0.483587
20000 0.000254
35000 0.000153

CEPXS Form

material h 0.0000504 o 0.0007176 na 0.008735 mg 0.0002058 s 0.000159 -
cl 0.4778 k 0.5117 ca 0.0002758 br 0.0003303
matname fertilizer
density 0.990

Gadolinium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Gd	1.000000	1.000000	0.030256

Density (g/cm^3)= 7.9004
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=064

MCNP Form

c Gadolinium, rho = 7.9004 g/cc
$ **Neutron**
64000 -1.000000

64000 1.000000

$ **Photon**
64000 -1.000000

64000 1.000000

CEPXS Form

```
material  gd 1.000000
matname  gadolinium
density  7.9004
```

Gallium Arsenide

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Ga	0.482030	.500000	0.022108
As	0.517970	.500004	0.022108

Density (g/cm^3)= 5.310

Comments:

Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c  Gallium Arsenide, rho = 5.310
$  Neutron
     31000  -0.482030
     33075  -0.517970
-------------------------------------------------------------------------------------
     31000  0.500000
     33075  0.500004
_____________________________________________________________________________________
$  Photon
     31000  -0.482030
     33000  -0.517970
-------------------------------------------------------------------------------------
     31000  0.500000
     33000  0.500004
```

CEPXS Form

```
material  ga 0.482030 as 0.517970
matname  gallium_arsenide
density  5.310
```

Gasoline

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.160000	0.694164	0.065358
C	0.840000	0.305836	0.028796

Density (g/cm^3)= 0.6837

Comments: Perry's Chemical Engineers Handbook, 4th edition, has gasoline constituents ranging from 83.5-85 wt% carbon, 15-15.8 wt% hydrogen with 0-1 wt% oxygen and nitrogen. Gasoline is a blend of many hydrocarbons and heptane is the primary constituent. This analysis will use heptane from the 74th CRC of Chem and Physics with a density of 0.6837. Heptane is C7 H16.
Reference: Perry's Chemical Engineers Handbook, 4th edition

MCNP Form

```
c  Gasoline, rho = 0.6837
$  Neutron
     1001  -0.160000
     6012  -0.840000
-------------------------------------------------------------------------------------------
    1001  0.694164
     6012  0.305836
_____________________________________________________________________________________$
Photon
     1000  -0.160000
     6000  -0.840000
-------------------------------------------------------------------------------------------
     1000  0.694164
     6000  0.305836
```

CEPXS Form

```
material  h 0.160000 c 0.840000
matname  gasoline
density  0.6837
```

Glass

1: Borosilicate

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
B	0.040066	0.070452	0.004977
O	0.539559	0.641094	0.045289
Na	0.028191	0.023311	0.001647
Al	0.011644	0.008204	0.000580
Si	0.377220	0.255328	0.018037
K	0.003321	0.001615	0.000114

Density (g/cm^3)= 2.230
Comments:
Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c  Glass, Borosilicate (Pyrex), rho = 2.230
$  Neutron
     5011  -0.040066
     8016  -0.539559
     11023  -0.028191
     13027  -0.011644
     14000  -0.377220
     19000  -0.003321
-------------------------------------------------------------------------------------
     5011  0.070452
     8016  0.641094
     11023  0.023311
     13027  0.008204
     14000  0.255328
     19000  0.001615

_____________________________________________________________________________
$  Photon
     5000  -0.040066
     8000  -0.539559
     11000  -0.028191
     13000  -0.011644
     14000  -0.377220
     19000  -0.003321
-------------------------------------------------------------------------------------
     5000  0.070452
     8000  0.641094
     11000  0.023311
     13000  0.008204
     14000  0.255328
     19000  0.001615
```

CEPXS Form

```
material  b 0.040066 o 0.539558 na 0.028191 al 0.011644 si 0.377220 -
          k 0.003321
matname  glass_pyrex
density  2.230
```

2: Lead Glass

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
O	0.156453	0.592955	0.036629
Si	0.080866	0.174593	0.010785
Ti	0.008092	0.010251	0.000633
As	0.002651	0.002146	0.000133

Pb	0.751938	0.220057	0.013594

Density (g/cm^3)= 6.220
Comments:
Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c  Glass, Lead, rho = 6.220
$  Neutron
     8016  -0.156453
     14000  -0.080866
     22000  -0.008092
     33075  -0.002651
     82000  -0.751938
-------------------------------------------------------------------------------------
     8016  0.592955
     14000  0.174593
     22000  0.010251
     33075  0.002146
     82000  0.220057
_____________________________________________________________________________________
$  Photon
     8000  -0.156453
     14000  -0.080866
     22000  -0.008092
     33000  -0.002651
     82000  -0.751938
-------------------------------------------------------------------------------------
     8000  0.592955
     14000  0.174593
     22000  0.010251
     33000  0.002146
```

CEPXS Form

```
material  o 0.156453 si 0.080866 ti 0.008092 as 0.002651 pb 0.751938
matname  glass_lead
density  6.220
```

3: Plate Glass

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
O	0.459800	0.603858	0.041536
Na	0.096441	0.088145	0.006063
Si	0.336553	0.251791	0.017319
Ca	0.107205	0.056205	0.003866

Density (g/cm^3)= 2.40
Comments:
Reference: Taken from NIST Listings, “Compositions of Materials used in STAR Databases” webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=171

MCNP Form

c Plate Glass, rho = 2.40 g/cc
$ **Neutron**
8016 -0.459800
11023 -0.096441
14000 -0.336553
20000 -0.107205

8016 0.603858
11023 0.088145
14000 0.251791
20000 0.056205

$ **Photon**
8000 -0.459800
11000 -0.096441
14000 -0.336553
20000 -0.107205

8000 0.603858
11000 0.088145
14000 0.251791
20000 0.056205

CEPXS Form

material o 0.459800 na 0.096442 si 0.336553 ca 0.107205
matname glass_plate
density 2.40

4: Pyrex

See Borosilicate Glass.

Granite

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.001325	0.027122	0.002160

C	0.000292	0.000502	0.000040
O	0.471188	0.607735	0.048400
Na	0.028817	0.025866	0.002060
Mg	0.021296	0.018081	0.001440
Al	0.082089	0.062783	0.005000
Si	0.280267	0.205927	0.016400
K	0.026407	0.013938	0.001110
Ca	0.036824	0.018960	0.001510
Fe	0.051650	0.019086	0.001520

Density (g/cm^3)= 2.729

Comments: Several densities for granite were found, with 2.729 being calculated based on the atom densities from the reference. Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

```
c  Granite, rho = 2.729
$ Neutron
    1001  -0.001325
    6012  -0.000292
    8016  -0.471188
    11023  -0.028817
    12000  -0.021296
    13027  -0.082089
    14000  -0.280267
    19000  -0.026407
    20000  -0.036824
    26000  -0.051650
-------------------------------------------------------------------------------------
    1001  0.027122
    6012  0.000502
    8016  0.607735
    11023  0.025866
    12000  0.018081
    13027  0.062783
    14000  0.205927
    19000  0.013938
    20000  0.018960
    26000  0.019086

_____________________________________________________________________________
$ Photon
    1000  -0.001325
    6000  -0.000292
```

8000 -0.471188
11000 -0.028817
12000 -0.021296
13000 -0.082089
14000 -0.280267
19000 -0.026407
20000 -0.036824
26000 -0.051650

1000 0.027122
6000 0.000502
8000 0.607735
11000 0.025866
12000 0.018081
13000 0.062783
14000 0.205927
19000 0.013938
20000 0.018960
26000 0.019086

CEPXS Form

```
material  h 0.001324 c 0.000292 o 0.471188 na 0.028817 mg 0.021296 -
          al 0.082089 si 0.280267 k 0.026407 ca 0.036824 fe 0.051650
matname  granite
density  2.729
```

Muriate of Potash

See Fertilizer.

Inconel-600

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Cr	0.180027	0.197637	0.017577
Fe	0.100015	0.102231	0.009092
Ni	0.719894	0.700133	0.062267

Density (g/cm^3)= 8.43

Comments: Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

```
c  Inconel-600, rho = 8.43
$  Neutron
     24000  -0.180027
     26000  -0.100015
     28000  -0.719894
-------------------------------------------------------------------------------------
     24000  0.197637
     26000  0.102231
     28000  0.700133
_____________________________________________________________________________________
$  Photon
     24000  -0.180027
     26000  -0.100015
     28000  -0.719894
-------------------------------------------------------------------------------------
     24000  0.197637
     26000  0.102231
     28000  0.700133
```

CEPXS Form

```
material  cr 0.180039 fe 0.100021 ni 0.719940
matname  inconel600
density  8.43
```

Incoloy-800

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Cr	0.210033	0.225565	0.019485
Fe	0.470055	0.470023	0.040602
Ni	0.319960	0.304412	0.026296

Density (g/cm^3)= 8.01

Comments: Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

```
c  Incoloy-800, rho = 8.01
$  Neutron
     24000  -0.210033
     26000  -0.470055
```

28000 -0.319960

24000 0.225565
26000 0.470023
28000 0.304412

$ **Photon**

24000 -0.210033
26000 -0.470055
28000 -0.319960

24000 0.225565
26000 0.470023
28000 0.304412

CEPXS Form

material cr 0.210023 fe 0.470032 ni 0.319945
matname incoloy800
density 8.01

Iron

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Fe	1.000000	1.000000	0.084911

Density (g/cm^3)= 7.874
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=026

MCNP Form

c Iron, rho = 7.874 g/cc
$ **Neutron**

26000 -1.000000

26000 1.000000

$ **Photon**

26000 -1.000000

26000 1.000000

CEPXS Form

```
material  fe 1.000000
matname  iron
density  7.874
```

Kynar

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.031496	0.333333	0.033120
C	0.375314	0.333333	0.033120
F	0.593668	0.333333	0.033120

Density (g/cm^3)= 1.76

Comments: Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

```
c  Kynar,     rho = 1.76 g/cc
$  Neutron
     1001  -0.031496
     6012  -0.375314
     9019  -0.593668
-------------------------------------------------------------------------------------
     1001  0.333333
     6012  0.333333
     9019  0.333333

_____________________________________________________________________________
$  Photon
     1000  -0.031496
     6000  -0.375314
     9000  -0.593668
-------------------------------------------------------------------------------------
     1000  0.333333
     6000  0.333333
     9000  0.333333
```

CEPXS Form

```
material  h 0.031481 c 0.375135 f 0.593384
matname  kynar
density  1.76
```

Lead

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Pb	1.000000	1.000000	0.032988

Density (g/cm^3)= 11.35
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=082

MCNP Form

c Lead, rho = 11.35 g/cc
$ **Neutron**
82000 -1.000000

82000 1.000000
_____
$ **Photon**
82000 -1.000000

82000 1.000000

CEPXS Form

material pb 1.000000
matname lead
density 11.35

Lithium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Li	1.000000	1.000000	0.046331

Density (g/cm^3)= 0.534
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=003

MCNP Form

```
c  Lithium, rho = 0.534 g/cc
$  Neutron
     3007  -1.000000
-------------------------------------------------------------------------------
     3007  1.000000
_______________________________________________________________________________
$  Photon
     3000  -1.000000
-------------------------------------------------------------------------------
     3000  1.000000
```

CEPXS Form

```
material  li 1.000000
matname  lithium
density  0.534
```

Lucite

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.080538	0.533320	0.057262
C	0.599848	0.333345	0.035791
O	0.319614	0.133335	0.014316

Density (g/cm^3)= 1.19

Comments: Acrylic glass, Acrylite, Perspex, Plexiglass, PMMA, Polymethyl methacrylate

Reference: Taken from NIST Listings, “Compositions of Materials used in STAR Databases” webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=223

MCNP Form

```
c  Lucite, rho = 1.19 g/cc
$  Neutron
     1001  -0.080538
     6012  -0.599848
     8016  -0.319614
-------------------------------------------------------------------------------
     1001  0.533320
     6012  0.333345
     8016  0.133335
_______________________________________________________________________________
$  Photon
     1000  -0.080538
     6000  -0.599848
```

```
     8000  -0.319614
-------------------------------------------------------------------------------
     1000  0.533320
     6000  0.333345
     8000  0.133335
```

CEPXS Form

```
material  h 0.080538 c 0.599848 o 0.319614
matname  lucite
density  1.19
```

Magnesium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Mg	1.000000	1.000000	0.043113

Density (g/cm^3)= 1.74

Comments:

Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:

http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=012

MCNP Form

```
c  Magnesium, rho = 1.74 g/cc
$  Neutron
     12000  -1.000000
-------------------------------------------------------------------------------
     12000  1.000000
_______________________________________________________________________________
$  Photon
     12000  -1.000000
-------------------------------------------------------------------------------
     12000  1.000000
```

CEPXS Form

```
material  mg 1.000000
matname  magnesium
density  1.74
```

Masonite

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.062198	0.476242	0.048310
C	0.444603	0.285686	0.028980
O	0.493545	0.238072	0.024150

Density (g/cm^3)= 1.30

Comments: Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

```
c  Masonite, rho = 1.30
$  Neutron
     1001  -0.062198
     6012  -0.444603
     8016  -0.493545
-----------------------------------------------------------------------------------------
     1001  0.476242
     6012  0.285686
     8016  0.238072
_____________________________________________________________________________
$  Photon
     1000  -0.062198
     6000  -0.444603
     8000  -0.493545
-----------------------------------------------------------------------------------------
     1000  0.476242
     6000  0.285686
     8000  0.238072
```

CEPXS Form

```
material  h 0.062177 c 0.444449 o 0.493374
matname  masonite
density  1.30
```

Molybdenum

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Mo	1.000000	1.000000	0.064151

Density (g/cm^3)= 10.22
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=042

MCNP Form

```
c  Molybdenum, rho = 10.22 g/cc
$  Neutron
     42000  -1.000000
-------------------------------------------------------------------------------
     42000  1.000000
_______________________________________________________________________________
$  Photon
     42000  -1.000000
-------------------------------------------------------------------------------
     42000  1.000000
```

CEPXS Form

```
material  mo 1.000000
matname  molybdenum
density  10.22
```

Mylar

See Polyethylene Terephthalate.

Nickel

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Ni	1.000000	1.000000	0.091338

Density (g/cm^3)= 8.902
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=028

MCNP Form

```
c  Nickel, rho = 8.902 g/cc
$  Neutron
     28000  -1.000000
-------------------------------------------------------------------------------------
     28000  1.000000
_____________________________________________________________________________________
$  Photon
     28000  -1.000000
-------------------------------------------------------------------------------------
     28000  1.000000
```

CEPXS Form

```
material  ni 1.000000
matname  nickel
density  8.902
```

Nylon

1: Nylon, Type 6 and Type 6/6

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.097976	0.578932	0.066733
C	0.636856	0.315803	0.036402
N	0.123779	0.052632	0.006067
O	0.141389	0.052633	0.006067

Density (g/cm^3)= 1.14

Comments:

Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=209

MCNP Form

```
c   Nylon Type 6 and Type 6/6, rho = 1.14 g/cc
$  Neutron
     1001  -0.097976
     6012  -0.636856
     7014  -0.123779
      8016  -0.141389
-----------------------------------------------------------------------------------------
     1001  0.578932
     6012  0.315803
     7014  0.052632
     8016  0.052633
_____________________________________________________________________________________
$  Photon
     1000  -0.097976
     6000  -0.636856
     7000  -0.123779
     8000  -0.141389
-----------------------------------------------------------------------------------------
     1000  0.578932
     6000  0.315803
     7000  0.052632
     8000  0.052633
```

CEPXS Form

```
material  h 0.097976 c 0.636856 n 0.123779 o 0.141389
matname  nylon_type6
density  1.14
```

2: Nylon, Dupont Elvamide 8062

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.103509	0.593363	0.066791
C	0.648415	0.311933	0.035112
N	0.099536	0.041060	0.004622
O	0.148539	0.053643	0.006038

Density (g/cm^3)= 1.08
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=208

MCNP Form

```
c   Nylon, Dupont Elvamide 8062, rho = 1.08 g/cc
$  Neutron
     1001  -0.103509
     6012  -0.648415
     7014  -0.099536
     8016  -0.148539
-----------------------------------------------------------------------------------------
     1001  0.593363
     6012  0.311933
     7014  0.041060
     8016  0.053643
_____________________________________________________________________________________
$  Photon
     1000  -0.103509
     6000  -0.648415
     7000  -0.099536
     8000  -0.148539
-----------------------------------------------------------------------------------------
     1000  0.593363
     6000  0.311933
     7000  0.041060
     8000  0.053643
```

CEPXS Form

```
material  h 0.103509 c 0.648416 n 0.099536 o 0.148539
matname  nylon_type8062
density  1.08
```

3: Nylon, Type 6/10

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.107062	0.599986	0.072922
C	0.680449	0.320013	0.038894
N	0.099189	0.040001	0.004862
O	0.113300	0.040001	0.004862

Density (g/cm^3)= 1.14

Comments:

Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=210

MCNP Form

```
c  Nylon, Type 6/10, rho = 1.14 g/cc
$  Neutron
     1001  -0.107062
     6012  -0.680449
     7014  -0.099189
     8016  -0.113300
-------------------------------------------------------------------------------------
     1001  0.599986
     6012  0.320013
     7014  0.040001
     8016  0.040001

$  Photon
     1000  -0.107062
     6000  -0.680449
     7000  -0.099189
     8000  -0.113300
-------------------------------------------------------------------------------------
     1000  0.599986
     6000  0.320013
     7000  0.040001
     8000  0.040001
```

CEPXS Form

```
material  h 0.107062 c 0.680449 n 0.099189 o 0.113300
matname  nylon_type6/10
density  1.14
```

4: Nylon, Type 11 (Rilsan)

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.115476	0.617633	0.098316
C	0.720819	0.323542	0.051502
N	0.076417	0.029412	0.004682
O	0.087289	0.029412	0.004682

Density (g/cm^3)= 1.425

Comments:

Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=211

MCNP Form

```
c  Nylon, Type 11 (Rilsan), rho = 1.425 g/cc
$  Neutron
     1001  -0.115476
     6012  -0.720819
     7014  -0.076417
     8016  -0.087289
-----------------------------------------------------------------------------------------
     1001  0.617633
     6012  0.323542
     7014  0.029412
     8016  0.029412

_____________________________________________________________________________________
$  Photon
     1000  -0.115476
     6000  -0.720819
     7000  -0.076417
     8000  -0.087289
-----------------------------------------------------------------------------------------
     1000  0.617633
     6000  0.323542
     7000  0.029412
     8000  0.029412
```

CEPXS Form

```
material  h 0.115476 c 0.720818 n 0.076417 o 0.087289
matname  nylon_type11
density  1.425
```

Oil

1: Crude Oil

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.120000	0.620069	0.069761
C	0.850000	0.368589	0.041468
N	0.010500	0.003904	0.000439
O	0.007750	0.002523	0.000284
S	0.030250	0.004913	0.000553

Density (g/cm^3)= 0.973

Comments: Average density of Mexican crude oil is 0.973 g/cc according to http://www.simetric.co.uk/si_liquids.htm . It varies depending upon the region.

Reference: *Handbook of Petroleum Analysis*, Nov 5, 2004, published by John Wiley & Sons. Electronic ISBN: 1-59124-737-3 on Knovel Database

MCNP Form

```
c   Oil, Crude,     rho = 0.973 g/cc
$  Neutron
     1001  -0.120000
     6012  -0.850000
     7014  -0.010500
     8016  -0.007750
     16000  -0.030250
-----------------------------------------------------------------------------------------
     1001  0.620069
     6012  0.368589
     7014  0.003904
     8016  0.002523
     16000  0.004913

_____________________________________________________________________________________
$  Photon
     1000  -0.120000
     6000  -0.850000
     7000  -0.010500
     8000  -0.007750
     16000  -0.030250
-----------------------------------------------------------------------------------------
     1000  0.620069
     6000  0.368589
     7000  0.003904
     8000  0.002523
     16000  0.004913
```

CEPXS Form

```
material  h 0.117820 c 0.834561 n 0.010309 o 0.007609 s 0.029701
matname  oil_crude
density  0.973
```

2: Hydraulic Oil

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.040509	0.392848	0.030980
C	0.585083	0.476160	0.037550
O	0.078042	0.047679	0.003760
P	0.037771	0.011920	0.000940
Cl	0.258941	0.071392	0.005630

Density (g/cm^3)= 1.28

Comments: Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

```
c  Oil, Hydraulic,     rho = 1.28 g/cc
$  Neutron
     1001  -0.040509
     6012  -0.585083
     8016  -0.078042
     15031  -0.037771
     17000  -0.258941
-------------------------------------------------------------------------------------
     1001  0.392848
     6012  0.476160
     8016  0.047679
     15031  0.011920
     17000  0.071392
_____________________________________________________________________________________
$  Photon
     1000  -0.040509
     6000  -0.585083
     8000  -0.078042
     15000  -0.037771
     17000  -0.258941
-------------------------------------------------------------------------------------
     1000  0.392848
```

6000 0.476160
8000 0.047679
15000 0.011920
17000 0.071392

CEPXS Form

material h 0.040495 c 0.584881 o 0.078015 p 0.037758 cl 0.258851
matname oil_hydraulic
density 1.28

3: Lard Oil

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.117673	0.620706	0.064330
C	0.779024	0.344848	0.035740
O	0.103657	0.034446	0.003570

Density (g/cm^3)= 0.915

Comments: Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

c Oil, Lard, rho = 0.915 g/cc
$ **Neutron**
1001 -0.117673
6012 -0.779024
8016 -0.103657

1001 0.620706
6012 0.344848
8016 0.034446

$ **Photon**
1000 -0.117673
6000 -0.779024
8000 -0.103657

1000 0.620706
6000 0.344848
8000 0.034446

CEPXS Form

```
material  h 0.117632 c 0.778748 o 0.103620
matname  oil_lard
density  0.915
```

Paraffin Wax

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.148605	0.675311	0.082572
C	0.851395	0.324689	0.039701

Density (g/cm^3)= 0.930

Comments:

Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:

http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=213

MCNP Form

```
c  Paraffin Wax, rho = 0.930 g/cc
$  Neutron
     1001  -0.148605
     6012  -0.851395
-------------------------------------------------------------------------------------
     1001  0.675311
     6012  0.324689
_____________________________________________________________________________________
$  Photon
     1000  -0.148605
     6000  -0.851395
-------------------------------------------------------------------------------------
     1000  0.675311
     6000  0.324689
```

CEPXS Form

```
material  h 0.148605 c 0.851395
matname  paraffin
density  0.930
```

Perspex

See Lucite.

Photographic Emulsion

1: Kodak Type AA

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.030500	0.440293	0.040090
C	0.210700	0.255254	0.023242
N	0.072100	0.074899	0.006820
O	0.163200	0.148420	0.013514
Br	0.222800	0.040572	0.003694
Ag	0.300700	0.040562	0.003693

Density (g/cm^3)= 2.20
Comments:
Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c   Photographic Emulsion (Kodak Type AA), rho = 2.200
$  Neutron
     1001  -0.030500
     6012  -0.210700
     7014  -0.072100
     8016  -0.163200
     35079  -0.222800
     47000  -0.300700
-------------------------------------------------------------------------------------
     1001  0.440293
     6012  0.255254
     7014  0.074899
     8016  0.148420
     35079  0.040572
     47000  0.040562

_____________________________________________________________________________
$  Photon
     1000  -0.030500
     6000  -0.210700
     7000  -0.072100
     8000  -0.163200
     35000  -0.222800
     47000  -0.300700
```

```
-------------------------------------------------------------------------------------------
     1000  0.440293
     6000  0.255254
     7000  0.074899
     8000  0.148420
     35000  0.040572
     47000  0.040562
```

CEPXS Form

```
material  h 0.030500 c 0.210700 n 0.072100 o 0.163200 br 0.222800 -
          ag 0.300700
matname  photoemulsion_kodak-aa
density  2.200
```

2: Standard Nuclear

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.014100	0.407082	0.032139
C	0.072261	0.175079	0.013822
N	0.019320	0.040139	0.003169
O	0.066101	0.120227	0.009492
S	0.001890	0.001715	0.000135
Br	0.349104	0.127140	0.010038
Ag	0.474105	0.127902	0.010098
I	0.003120	0.000715	0.000056

Density (g/cm^3)= 3.815

Comments:

Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c  Photographic Emulsion (Standard Nuclear), rho = 3.815
$  Neutron
     1001  -0.014100
     6012  -0.072261
     7014  -0.019320
     8016  -0.066101
     16000  -0.001890
     35079  -0.349104
     47000  -0.474105
     53127  -0.003120
-------------------------------------------------------------------------------------------
     1001  0.407082
     6012  0.175079
     7014  0.040139
```

8016 0.120227
16000 0.001715
35079 0.127140
47000 0.127902
53127 0.000715

$ **Photon**
1000 -0.014100
6000 -0.072261
7000 -0.019320
8000 -0.066101
16000 -0.001890
35000 -0.349104
47000 -0.474105
53000 -0.003120

1000 0.407082
6000 0.175079
7000 0.040139
8000 0.120227
16000 0.001715
35000 0.127140
47000 0.127902
53000 0.000715

CEPXS Form

```
material  h 0.014100 c 0.072260 n 0.019320 o 0.066101 s 0.001890 -
          br 0.349104 ag 0.474105 i 0.003120
matname  photoemulsion_stdnuclear
density  3.815
```

Plastic Scintillator (PVT)

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.085000	0.525382	0.052410
C	0.915000	0.474618	0.047346

Density (g/cm^3)= 1.032
Comments: Polyvinyl toluene
Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

c Plastic Scintillator, Vinyltoluene, rho = 1.032
$ **Neutron**
1001 -0.085000

6012 -0.915000

1001 0.525382
6012 0.474618

$ **Photon**
1000 -0.085000
6000 -0.915000

1000 0.525382
6000 0.474618

CEPXS Form

material h 0.085000 c 0.915000
matname plastic_scintillator
density 1.032

Plexiglass

See Lucite.

Plutonium

1: DOE 3013 WGPu

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Pu-238	0.000500	0.000502	0.000025
Pu-239	0.935000	0.935270	0.046732
Pu-240	0.060000	0.059767	0.002986
Pu-241	0.004000	0.003968	0.000198
Pu-242	0.000500	0.000494	0.000025

Density (g/cm^3)= 19.84
Comments: DOE 3013 WGPu.
Reference: *DOE Standard Stabilization, Packaging, and Storage of Plutonium-Bearing Materials*, DOE-STD-3013-2000, Table B-6, U.S. Department of Energy, September 2000.

MCNP Form

c WGPu, DOE 3013, rho = 19.84
$ **Neutron**
94238 -0.000500
94239 -0.935000
94240 -0.060000

```
     94241  -0.004000
     94242  -0.000500
-------------------------------------------------------------------------------------
     94238  0.000502
     94239  0.935270
     94240  0.059767
     94241  0.003968
     94242  0.000494
_____________________________________________________________________________________
$  Photon
     94000  -1.000000
-------------------------------------------------------------------------------------
     94000  1.000000
```

CEPXS Form

```
material  pu 1.000000
matname  plutonium_3013_wg
density  19.84
```

2: Shefelbine WGPu

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Pu-238	0.000300	0.000301	0.000015
Pu-239	0.939000	0.939439	0.046932
Pu-240	0.057000	0.056789	0.002837
Pu-241	0.003000	0.002976	0.000149
Pu-242	0.000300	0.000296	0.000015
Am-241	0.000200	0.000198	0.000010

Density (g/cm^3)= 19.84

Comments: Shefelbine WGPu. Weight Fractions are not normalized. The atom fraction and atom density are calculated from the weight fraction in the reference.

Reference: *Preliminary Evaluation of the Characteristics of Defense Transuranic Wastes*, SAND78-1850, Table 4, Sandia National Laboratory, November 1978.

MCNP Form (Note: Am-241 cross-sections may not exist)

```
c   WGPu, Shefelbine, rho = 19.84
$  Neutron
     94238  -0.000300
     94239  -0.939000
     94240  -0.057000
     94241  -0.003000
     94242  -0.000300
```

95241 -0.000200

94238 0.000301
94239 0.939439
94240 0.056789
94241 0.002976
94242 0.000296
95241 0.000198

$ Photon
94000 -0.9996
95000 -0.0002

94000 0.999801
95000 0.000198

CEPXS Form

material pu 0.9998 am 0.0002
matname plutonium_shefel_wg
density 19.84

3: Aged WGPu (4-7% Pu-240)

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Pu-238	0.000100	0.000100	0.000005
Pu-239	0.937700	0.936559	0.046867
Pu-240	0.060000	0.059677	0.002986
Pu-241	0.002000	0.001981	0.000099
Pu-242	0.000300	0.000296	0.000015
Am-241	0.001400	0.001387	0.000069

Density (g/cm^3)= 19.84

Comments: Aged WGPu (4-7% Pu-240). Weight Fractions are not normalized. The atom fraction and atom density are calculated from the weight fraction in the reference.

Reference: *DOE Standard Stabilization, Packaging, and Storage of Plutonium-Bearing Materials*, DOE-STD-3013-2000, Table B-6, U.S. Department of Energy, September 2000.

MCNP Form (Note: Am-241 cross-sections may not exist)

c WGPu, Aged (4-7% Pu-240), rho = 19.84
$ **Neutron**
94238 -0.000100
94239 -0.937700
94240 -0.060000

```
     94241  -0.002000
     94242  -0.000300
     95241  -0.001400
-------------------------------------------------------------------------------------------
     94238  0.000100
     94239  0.936559
     94240  0.059677
     94241  0.001981
     94242  0.000296
     95241  0.001387
_____________________________________________________________________________
$  Photon
     94000  -1.000100
     95000  -0.001400
-------------------------------------------------------------------------------------------
     94000  0.998613
     95000  0.001387
```

CEPXS Form

```
material  pu 0.998602 am 0.001398
matname  plutonium_aged4wg
density  19.84
```

4: Aged WGPu (10-13% Pu-240)

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Pu-238	0.000900	0.000897	0.000045
Pu-239	0.869400	0.862470	0.043453
Pu-240	0.118100	0.116670	0.005878
Pu-241	0.010000	0.009838	0.000496
Pu-242	0.001700	0.001666	0.000084
Am-241	0.008600	0.008460	0.000426

Density (g/cm^3)= 19.84

Comments: Aged WGPu (10-13% Pu-240). Weight Fractions are not normalized. The atom fraction and atom density are calculated from the weight fraction in the reference.

Reference: *DOE Standard Stabilization, Packaging, and Storage of Plutonium-Bearing Materials*, DOE-STD-3013-2000, Table B-6, U.S. Department of Energy, September 2000.

MCNP Form (Note: Am-241 cross-sections may not exist)

```
c  WGPu, Aged (10-13% Pu-240), rho = 19.84
$  Neutron
     94238  -0.000900
```

94239 -0.869400
94240 -0.118100
94241 -0.010000
94242 -0.001700
95241 -0.008600

94238 0.000897
94239 0.862470
94240 0.116670
94241 0.009838
94242 0.001666
95241 0.008460

$ Photon
94000 -1.000100
95000 -0.008600

94000 0.991541
95000 0.008460

CEPXS Form

material pu 0.991474 am 0.008526
matname plutonium_aged10wg
density 19.84

5: Aged WGPu (16-19% Pu-240)

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Pu238	0.002400	0.002347	0.000120
Pu239	0.806600	0.785422	0.040314
Pu240	0.169800	0.164652	0.008451
Pu241	0.014400	0.013905	0.000714
Pu242	0.006900	0.006635	0.000341
Am241	0.028000	0.027038	0.001388

Density (g/cm^3)= 19.84

Comments: Aged WGPu (16-19% Pu-240). Weight Fractions are not normalized. The atom fraction and atom density are calculated from the weight fraction in the reference.

Reference: *DOE Standard Stabilization, Packaging, and Storage of Plutonium-Bearing Materials*, DOE-STD-3013-2000, Table B-6, U.S. Department of Energy, September 2000.

MCNP Form

```
c  WGPu, Aged (16-19% Pu-240), rho = 19.84
$  Neutron
     94238  -0.002400
     94239  -0.806600
     94240  -0.169800
     94241  -0.014400
     94242  -0.006900
     95241  -0.028000
-------------------------------------------------------------------------------
     94238  0.002347
     94239  0.785422
     94240  0.164652
     94241  0.013905
     94242  0.006635
     95241  0.027038

_____________________________________________________________________________
$  Photon
     94000  -1.000100
     95000  -0.028000
-------------------------------------------------------------------------------
     94000  0.972961
     95000  0.027038
```

CEPXS Form

```
material  pu 0.972765 am 0.027235
matname  plutonium_aged16wg
density  19.84
```

6: Fuel Grade Plutonium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Pu-238	0.001000	0.001005	0.000050
Pu-239	0.861000	0.861559	0.043033
Pu-240	0.120000	0.119577	0.005973
Pu-241	0.016000	0.015880	0.000793
Pu-242	0.002000	0.001976	0.000099

Density (g/cm^3)= 19.84

Comments: Fuel grade plutonium.

Reference: *DOE Standard Stabilization, Packaging, and Storage of Plutonium-Bearing Materials*, DOE-STD-3013-2000, Table B-6, U.S. Department of Energy, September 2000.

MCNP Form

```
c   Plutonium, Fuel Grade , rho = 19.84
$  Neutron
     94238  -0.001000
     94239  -0.861000
     94240  -0.120000
     94241  -0.016000
     94242  -0.002000
-----------------------------------------------------------------------------------------
     94238  0.001005
     94239  0.861559
     94240  0.119577
     94241  0.015880
     94242  0.001976
_________________________________________________________________________________________
$  Photon
     94000  -1.000000
-----------------------------------------------------------------------------------------
     94000  1.000000
```

CEPXS Form

```
material  pu 1.000000
matname  plutonium_fuel
density  19.84
```

7: Power Grade Plutonium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Pu-238	0.010000	0.009965	0.000502
Pu-239	0.630000	0.625153	0.031488
Pu-240	0.220000	0.217396	0.010950
Pu-241	0.120000	0.118086	0.005949
Pu-242	0.030000	0.029399	0.001481

Density (g/cm^3)= 19.84

Comments: Power grade plutonium. Weight Fractions are not normalized. The atom fraction and atom density are calculated from the weight fraction in the reference.

Reference: *DOE Standard Stabilization, Packaging, and Storage of Plutonium-Bearing Materials*, DOE-STD-3013-2000, Table B-6, U.S. Department of Energy, September 2000.

MCNP Form

c Plutonium, Power Grade , rho = 19.84
$ **Neutron**
94238 -0.010000
94239 -0.630000
94240 -0.220000
94241 -0.120000
94242 -0.030000

94238 0.009965
94239 0.625153
94240 0.217396
94241 0.118086
94242 0.029399

$ Photon
94000 -1.010000

94000 1.000000

CEPXS Form

material pu 1.010000
matname plutonium_power
density 19.84

PMMA

See Lucite.

Polyethylene

1: Normal Polyethylene

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.143716	0.666662	0.079855
C	0.856284	0.333338	0.039929

Density (g/cm^3)= 0.9300
Comments:
Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

c Polyethylene, rho = 0.9300
$ **Neutron**

```
     1001  -0.143716
     6012  -0.856284
-------------------------------------------------------------------------------------
     1001  0.666662
     6012  0.333338
_____________________________________________________________________________________
$  Photon
     1000  -0.143716
     6000  -0.856284
-------------------------------------------------------------------------------------
     1000  0.666662
     6000  0.333338
```

CEPXS Form

```
material  h 0.143716 c 0.856384
matname  polyethylene_normal
density  0.9300
```

2: Polyethylene Terephthalate

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.041960	0.363632	0.034596
C	0.625016	0.454552	0.043247
O	0.333024	0.181816	0.017298

Density (g/cm^3)= 1.380

Comments:

Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c  Polyethylene Terephthalate (Mylar), rho = 1.380
$  Neutron
     1001  -0.041960
     6012  -0.625016
     8016  -0.333024
-------------------------------------------------------------------------------------
     1001  0.363632
     6012  0.454552
     8016  0.181816
_____________________________________________________________________________________
$  Photon
     1000  -0.041960
     6000  -0.625016
     8000  -0.333024
```

1000 0.363632
6000 0.454552
8000 0.181816

CEPXS Form

material h 0.041960 c 0.625016 o 0.333024
matname polyethylene_mylar
density 1.380

Polyiso(cyanurate)

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.040305	0.345000	0.000773
C	0.719721	0.517000	0.001158
N	0.112019	0.069000	0.000155
O	0.127955	0.069000	0.000155

Density (g/cm^3)= 0.0321
Comments: MDI
Reference: http://en.wikipedia.org/wiki/Polyisocyanurate, M.A.L. Kelly, S.M. Otterside, D. Pemberton, Physical Properties of MDI and TDI: A Review, International Isocyanate Institute, Inc., III Report Reference Number 11272, June 1997.

MCNP Form

c Polyiso(cyanurate), rho = 0.0321
$ **Neutron**
1001 -0.040305
6012 -0.719721
7014 -0.112019
8016 -0.127955

1001 0.345000
6012 0.517000
7014 0.069000
8016 0.069000

$ **Photon**
1000 -0.040305
6000 -0.719721
7000 -0.112019
8000 -0.127955

1000 0.345000

```
     6000  0.517000
     7000  0.069000
     8000  0.069000
```

CEPXS Form

```
material  h 0.040305 c 0.719721 n 0.112019 o 0.127955
matname  polyisocyanurate
density  0.0321
```

Polymethyl Methacrylate

See Lucite.

Polystyrene

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.077421	0.499994	0.049032
C	0.922579	0.500006	0.049033

Density (g/cm^3)= 1.06

Comments: This is the solid form. The foamed form is Styrofoam with density of about 0.1 g/cm^3. Density may vary by application.
Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c   Polystyrene, rho = 1.060
$  Neutron
     1001  -0.077421
     6012  -0.922579
-------------------------------------------------------------------------------
     1001  0.499994
     6012  0.500006

_____________________________________________________________________________
$  Photon
     1000  -0.077421
     6000  -0.922579
-------------------------------------------------------------------------------
     1000  0.499994
     6000  0.500006
```

CEPXS Form

```
material  h 0.077421 c 0.922579
matname  polystyrene
density  1.06
```

Polytetrafluoroethylene

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
C	0.240183	0.333339	0.027096
F	0.759818	0.666661	0.054191

Density (g/cm^3)= 2.25
Comments: PTFE, Teflon
Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

```
c  Polytetrafluoroethylene (Teflon), rho = 2.25
$  Neutron
     6012  -0.240183
     9019  -0.759818
-------------------------------------------------------------------------------------------
     6012  0.333339
     9019  0.666661
_____________________________________________________________________________________
$  Photon
     6000  -0.240183
     9000  -0.759818
-------------------------------------------------------------------------------------------
     6000  0.333339
     9000  0.666661
```

CEPXS Form

```
material  c 0.240183 f 0.759817
matname  polytetra_teflon
density  2.25
```

Polyurethane (Foam)

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.041000	0.360023	0.000514
C	0.544000	0.400878	0.000573
N	0.121000	0.076459	0.000109
O	0.294000	0.162639	0.000232

Density (g/cm^3)= 0.021
Comments: Density may vary by application.
Reference: "Criticality Calculations with MCNP5: A Primer 2nd Edition, Appendix C," ed. Tim Goorley, Los Alamos Report LA-UR-04-0294,

MCNP Form

c Polyurethane (Foam), rho = 0.021
$ **Neutron**
1001 -0.041000
6012 -0.544000
7014 -0.121000
8016 -0.294000

1001 0.360023
6012 0.400878
7014 0.076459
8016 0.162639

$ **Photon**
1000 -0.041000
6000 -0.544000
7000 -0.121000
8000 -0.294000

1000 0.360023
6000 0.400878
7000 0.076459
8000 0.162639

CEPXS Form

material h 0.041000 c 0.544000 n 0.121000 o 0.294000
matname polyurethane
density 0.021

Polyvinyl Chloride

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.048382	0.499995	0.040643
C	0.384361	0.333340	0.027096
Cl	0.567257	0.166665	0.013548

Density (g/cm^3)= 1.406
Comments: PVC
Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

c Polyvinyl Chloride, rho = 1.406
$ **Neutron**
1001 -0.048382
6012 -0.384361
17000 -0.567257

1001 0.499995
6012 0.333340
17000 0.166665

$ **Photon**
1000 -0.048382
6000 -0.384361
17000 -0.567257

1000 0.499995
6000 0.333340
17000 0.166665

CEPXS Form

material h 0.048382 c 0.384361 cl 0.567257
matname polychloride
density 1.406

Polyvinyl Toluene

See Plastic Scintillator.

Propane

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.182855	0.727260	0.00020532
C	0.817145	0.272740	0.00007700

Density (g/cm^3)= 0.00187939
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=238

MCNP Form

```
c  Propane, rho = 0.00187939 g/cc
$  Neutron
     1001  -0.182855
     6012  -0.817145
-----------------------------------------------------------------------------------------
     1001  0.727260
     6012  0.272740
_________________________________________________________________________________________
$  Photon
     1000  -0.182855
     6000  -0.817145
-----------------------------------------------------------------------------------------
     1000  0.727260
     6000  0.272740
```

CEPXS Form

```
material  h 0.182855 c 0.817145
matname  propane
density  0.00187939
```

PTFE

See Polytetrafluoroethylene.

PVC

See Polyvinyl Chloride.

Radiochromic Dye Film

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.101996	0.589073	0.065815
C	0.654396	0.317171	0.035436
N	0.098915	0.041110	0.004593
O	0.144693	0.052646	0.005882

Density (g/cm^3)= 1.08
Comments: Nylon Base
Reference: http://physics.nist.gov/PhysRefData/XrayMassCoef/tab2.html

MCNP Form

c Radiochromic Dye Film, Nylon Base, rho = 1.08
$ **Neutron**
1001 -0.101996
6012 -0.654396
7014 -0.098915
8016 -0.144693

1001 0.589073
6012 0.317171
7014 0.041110
8016 0.052646

$ **Photon**
1000 -0.101996
6000 -0.654396
7000 -0.098915
8000 -0.144693

1000 0.589073
6000 0.317171
7000 0.041110
8000 0.052646

CEPXS Form

material h 0.101996 c 0.654396 n 0.098915 o 0.144693
matname radiochromic_dye_film
density 1.08

Rock Salt

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Na	0.432538	0.500000	0.024700
Cl	0.667026	0.500000	0.024700

Density (g/cm^3)= 2.18

Comments: Weight Fractions are not normalized. The atom and weight fractions are calculated from the atom density in the reference.

Reference: "Criticality Safety Analysis Resource Book, Part II: Atom Densities and Dimensional Parameters," August 1977, by E. B. Reppond.

MCNP Form

```
c   Rock Salt,     rho = 2.18 g/cc
$  Neutron
     11023  -0.432538
     17000  -0.667026
-------------------------------------------------------------------------------------
     11023  0.500000
     17000  0.500000

_____________________________________________________________________________________
$  Photon
     11000  -0.432538
     17000  -0.667026
-------------------------------------------------------------------------------------
     11000  0.500000
     17000  0.500000
```

CEPXS Form

```
material  na 0.393372 cl 0.606628
matname  rock_salt
density  2.18
```

Rubber

1: Neoprene

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.056920	0.499985	0.041830
C	0.542646	0.400014	0.033466
Cl	0.400434	0.100001	0.008366

Density (g/cm^3)= 1.23

Comments: Polychloroprene rubber

Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=244

MCNP Form

```
c   Neoprene (Rubber), rho = 1.23 g/cc
$  Neutron
     1001  -0.056920
     6012  -0.542646
     17000  -0.400434
-------------------------------------------------------------------------------------
     1001  0.499985
     6012  0.400014
```

17000 0.100001

$ **Photon**
1000 -0.056920
6000 -0.542646
17000 -0.400434

1000 0.499985
6000 0.400014
17000 0.100001

CEPXS Form

material h 0.056920 c 0.542646 cl 0.400434
matname rubber_neoprene
density 1.23

2: Butyl Rubber

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.143711	0.666653	0.078994
C	0.856289	0.333347	0.039499

Density (g/cm^3)= 0.920
Comments: Polyisobutylene
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=242

MCNP Form

c Butyl Rubber, rho = 0.920 g/cc
$ **Neutron**
1001 -0.143711
6012 -0.856289

1001 0.666653
6012 0.333347

$ **Photon**
1000 -0.143711
6000 -0.856289

1000 0.666653
6000 0.333347

CEPXS Form

material h 0.143711 c 0.856289
matname rubber_butyl
density 0.920

3: Natural Rubber

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.118371	0.615370	0.065065
C	0.881629	0.384630	0.040668

Density (g/cm^3)= 0.920
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=243

MCNP Form

c Natural Rubber, rho = 0.920 g/cc
$ **Neutron**
1001 -0.118371
6012 -0.881629

1001 0.615370
6012 0.384630

$ **Photon**
1000 -0.118371
6000 -0.881629

1000 0.615370
6000 0.384630

CEPXS Form

material h 0.118371 c 0.881629
matname rubber_natural
density 0.920

4: Silicone Rubber

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.080700	0.597039	0.049108

C	0.321100	0.199360	0.016398
O	0.223500	0.104169	0.008568
Si	0.374500	0.099434	0.008179

Density (g/cm^3)= 1.0185
Comments: G.E. RTB12A
Reference: "Criticality Calculations with MCNP: A Primer," LA-12827-M, August 1994, by C.D. Armon,II et al.

MCNP Form

```
c   Silicon Rubber (G.E. RTB12A), rho = 1.0185 g/cc
$  Neutron
     1001  -0.0807
     6012  -0.3211
     8016  -0.2235
     14000  -0.3745
-------------------------------------------------------------------------------------
     1001  0.597039
     6012  0.199360
     8016  0.104169
     14000  0.099434
_____________________________________________________________________________________
$  Photon
     1000  -0.0807
     6000  -0.3211
     8000  -0.2235
     14000  -0.3745
-------------------------------------------------------------------------------------
     1000  0.597039
     6000  0.199360
     8000  0.104169
     14000  0.099434
```

CEPXS Form

```
material  h 0.080716 c 0.321164 o 0.223545 si 0.374575
matname  rubber_silicon
density  1.0185
```

5: Polychloroprene

See Neoprene.

6: Polyisobutylene

See Butyl Rubber.

Standard Fricke

See Ferrous Sulfate.

Steel

1: Carbon

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
C	0.005000	0.022831	0.001960
Fe	0.995000	0.977170	0.083907

Density (g/cm^3)= 7.82
Comments:
Reference: "Criticality Calculations with MCNP: A Primer," LA-12827-M, August 1994, by C.D. Armon,II et al.

MCNP Form

```
c   Steel, Carbon,       rho = 7.82 g/cc
$  Neutron
     6012  -0.005
     26000  -0.995
-------------------------------------------------------------------------------------
     6012  0.022831
     26000  0.977170
_____________________________________________________________________________________
$  Photon
     6000  -0.005
     26000  -0.995
-------------------------------------------------------------------------------------
     6000  0.022831
     26000  0.977170
```

CEPXS Form

```
material  c 0.005000 fe 0.995000
matname  steel_carbon
density  7.82
```

2: Stainless 304

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Cr	0.190000	0.202087	0.017428
Mn	0.020000	0.020133	0.001736

Fe	0.695000	0.688268	0.059358
Ni	0.095000	0.089514	0.007720

Density (g/cm^3)= 7.92

Comments:

Reference: "Criticality Calculations with MCNP: A Primer," LA-12827-M, August 1994, by C.D. Armon,II et al.

MCNP Form

```
c   Steel, Stainless 304, rho = 7.92 g/cc
$  Neutron
     24000  -0.190   $ Cr
     25055  -0.020   $ Mn
     26000  -0.695   $ Fe
     28000  -0.095   $ Ni
-------------------------------------------------------------------------------------------
     24000  0.202087   $ Cr
     25055  0.020133   $ Mn
     26000  0.688268   $ Fe
     28000  0.089514   $ Ni

_____________________________________________________________________________
$  Photon
     24000  -0.190   $ Cr
     25000  -0.020   $ Mn
     26000  -0.695   $ Fe
     28000  -0.095   $ Ni
-------------------------------------------------------------------------------------------
     24000  0.202087   $ Cr
     25000  0.020133   $ Mn
     26000  0.688268   $ Fe
     28000  0.089514   $ Ni
```

CEPXS Form

```
material  cr 0.190000 mn 0.020000 fe 0.695000 ni 0.095000
matname  steel_ss304
density  7.92
```

3: Stainless 316

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Si	0.010000	0.019755	0.001698
Cr	0.170000	0.181400	0.015594
Mn	0.020000	0.020198	0.001736
Fe	0.655000	0.650753	0.055941
Ni	0.120000	0.113436	0.009751

Mo	0.025000	0.014458	0.001243

Density (g/cm^3)= 7.92
Comments:
Reference: "Criticality Calculations with MCNP: A Primer," LA-12827-M, August 1994, by C.D. Armon,II et al.

MCNP Form

```
c   Steel, Stainless 316, rho = 7.92 g/cc
$  Neutron
     14000  -0.010   $ Si
     24000  -0.170   $ Cr
     25055  -0.020   $ Mn
     26000  -0.655   $ Fe
     28000  -0.120   $ Ni
     42000  -0.025   $ Mo
-------------------------------------------------------------------------------------------
     14000  0.019755   $ Si
     24000  0.181400   $ Cr
     25055  0.020198   $ Mn
     26000  0.650753  $ Fe
     28000  0.113436   $ Ni
     42000  0.014458   $ Mo

_____________________________________________________________________________
$  Photon
     14000  -0.010   $ Si
     24000  -0.170   $ Cr
     25000  -0.020   $ Mn
     26000  -0.655   $ Fe
     28000  -0.120   $ Ni
     42000  -0.025   $ Mo
-------------------------------------------------------------------------------------------
     14000  0.019755   $ Si
     24000  0.181400   $ Cr
     25000  0.020198   $ Mn
     26000  0.650753  $ Fe
     28000  0.113436   $ Ni
     42000  0.014458   $ Mo
```

CEPXS Form

```
material  si 0.010000 cr 0.170000 mn 0.020000 fe 0.655000 ni 0.120000 -
            mo 0.025000
matname  steel_ss316
density  7.92
```

4: Stainless 347

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Si	0.010000	0.019524	0.001698
Cr	0.180000	0.189823	0.016511
Mn	0.020000	0.019962	0.001736
Fe	0.685000	0.672594	0.058504
Ni	0.105000	0.098095	0.008532

Density (g/cm^3)= 7.92

Comments:

Reference: "Criticality Calculations with MCNP: A Primer," LA-12827-M, August 1994, by C.D. Armon,II et al.

MCNP Form

```
c   Steel, Stainless 347, rho = 7.92 g/cc
$  Neutron
     14000  -0.010   $ Si
     24000  -0.180   $ Cr
     25055  -0.020   $ Mn
     26000  -0.685   $ Fe
     28000  -0.105   $ Ni
-------------------------------------------------------------------------------------------
     14000  0.019524  $ Si
     24000  0.189823   $ Cr
     25055  0.019962   $ Mn
     26000  0.672594   $ Fe
     28000  0.098095   $ Ni
_____________________________________________________________________________________
$  Photon
     14000  -0.010   $ Si
     24000  -0.180   $ Cr
     25000  -0.020   $ Mn
     26000  -0.685   $ Fe
     28000  -0.105   $ Ni
-------------------------------------------------------------------------------------------
     14000  0.019524  $ Si
     24000  0.189823   $ Cr
     25000  0.019962   $ Mn
     26000  0.672594   $ Fe
     28000  0.098095   $ Ni
```

CEPXS Form

```
material  si 0.010000 cr 0.180000 mn 0.020000 fe 0.685000 ni 0.105000
matname  steel_ss347
density  7.92
```

5: HT9 Stainless

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
C	0.002000	0.009183	0.000790
Si	0.004000	0.007854	0.000675
P	0.000300	0.000534	0.000046
S	0.000200	0.000344	0.000030
V	0.003000	0.003248	0.000279
Cr	0.115000	0.121971	0.010488
Mn	0.006000	0.006023	0.000518
Fe	0.849500	0.838895	0.072132
Ni	0.005000	0.004698	0.000404
Mo	0.010000	0.005748	0.000494
W	0.005000	0.001500	0.000129

Density (g/cm^3)= 7.874

Comments:

Reference: AFCI Materials Handbook, Rev. 4, Page 18-5. LA-CP-03-0868.

MCNP Form

```
c   Steel, HT9 Stainless, rho = 7.874 g/cc
$  Neutron
     6012  -0.002000
     14000  -0.004000
     15031  -0.000300
     16000  -0.000200
     23000  -0.003000
     24000  -0.115000
     25055  -0.006000
     26000  -0.849500
     28000  -0.005000
     42000  -0.010000
     74000  -0.005000
-------------------------------------------------------------------------------------------
     6012  0.009183
     14000  0.007854
     15031  0.000534
     16000  0.000344
     23000  0.003248
```

```
    24000  0.121971
    25055  0.006023
    26000  0.838895
    28000  0.004698
    42000  0.005748
    74000  0.001500

_____________________________________________________________________________
$  Photon
    6000  -0.002000
    14000  -0.004000
    15000  -0.000300
    16000  -0.000200
    23000  -0.003000
    24000  -0.115000
    25000  -0.006000
    26000  -0.849500
    28000  -0.005000
    42000  -0.010000
    74000  -0.005000
-----------------------------------------------------------------------------------------
    6000  0.009183
    14000  0.007854
    15000  0.000534
    16000  0.000344
    23000  0.003248
    24000  0.121971
    25000  0.006023
    26000  0.838895
    28000  0.004698
    42000  0.005748
    74000  0.001500
```

CEPXS Form

```
material  c 0.002000 si 0.004000 p 0.000300 s 0.000200 v 0.003000 -
          cr 0.115000 mn 0.006000 fe 0.849500 ni 0.005000 mo 0.010000 -
          w 0.005000
matname  steel_ht9ss
density  7.874
```

Styrofoam

See Polystyrene.

Tantalum

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Ta	1.000000	1.000000	0.055426

Density (g/cm^3)= 16.654

Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=073

MCNP Form

```
c  Tantalum, rho = 16.654 g/cc
$  Neutron
     73181  -1.000000
-------------------------------------------------------------------------------
     73181  1.000000
_______________________________________________________________________________
$  Photon
     73000  -1.000000
-------------------------------------------------------------------------------
     73000  1.000000
```

CEPXS Form

```
material  ta 1.000000
matname  tantalum
density  16.654
```

Teflon

See Polytetrafluoroethylene.

Thorium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Th	1.000000	1.000000	0.030417

Density (g/cm^3)= 11.72
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=090

MCNP Form

```
c  Thorium, rho = 11.72 g/cc
$  Neutron
     90232  -1.000000
-------------------------------------------------------------------------------
     90232  1.000000
_______________________________________________________________________________
$  Photon
     90000  -1.000000
-------------------------------------------------------------------------------
     90000  1.000000
```

CEPXS Form

```
material  th 1.000000
matname  thorium
density  11.72
```

Titanium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Ti	1.000000	1.000000	0.057118

Density (g/cm^3)= 4.54
Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=022

MCNP Form

```
c  Titanium, rho = 4.54 g/cc
$  Neutron
     22000  -1.000000
-------------------------------------------------------------------------------------
     22000  1.000000
_____________________________________________________________________________________
$  Photon
     22000  -1.000000
-------------------------------------------------------------------------------------
     22000  1.000000
```

CEPXS Form

```
material  ti 1.000000
matname  titanium
density  4.54
```

Uranium

1: US HEU Average

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
U-234	0.009800	0.009849	0.000478
U-235	0.931550	0.932166	0.045229
U-236	0.004500	0.004484	0.000218
U-238	0.054150	0.053501	0.002596

Density (g/cm^3)= 18.95

Comments: US HEU Average.

Reference: Personal communication with Andy Luksic based on Y-12 information.

MCNP Form

```
c   HEU, US Average, rho = 18.95
$  Neutron
     92234  -0.009800
     92235  -0.931550
     92236  -0.004500
     92238  -0.054150
-------------------------------------------------------------------------------------
     92234  0.009849
     92235  0.932166
     92236  0.004484
     92238  0.053501
```

$ Photon

92000 -1.000000

92000 1.000000

CEPXS Form

material u 1.000000
matname uranium_heu_us
density 18.95

2: Russian HEU Average

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
U-234	0.009670	0.009722	0.000472
U-235	0.898000	0.898982	0.043600
U-236	0.003810	0.003798	0.000184
U-238	0.088520	0.087498	0.004244

Density (g/cm^3)= 18.95

Comments: Russian HEU Average.

Reference: Personal communication with Andy Luksic based on Y-12 information.

MCNP Form

c HEU, Russian Average, rho = 18.95
$ **Neutron**
92234 -0.009670
92235 -0.898000
92236 -0.003810
92238 -0.088520

92234 0.009722
92235 0.898982
92236 0.003798
92238 0.087498

$ Photon

92000 -1.000000

92000 1.000000

CEPXS Form

```
material  u 1.000000
matname  uranium_heu_russia
density  18.95
```

3: HPS HEU

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
U-234	0.010530	0.010582	0.000513
U-235	0.931730	0.932361	0.045238
U-236	0.002060	0.002053	0.000100
U-238	0.055670	0.055004	0.002669

Density (g/cm^3)= 18.95

Comments: Health Physics Society HEU. Weight Fractions are not normalized. The atom fraction and atom density are calculated from the weight fraction in the reference.

Reference: *Bioassay Programs for Uranium*, HPS 13.22-1995, American National Standards Institute, Inc., October 1995.

MCNP Form

```
c   HEU, HPS, rho = 18.95
$  Neutron
     92234  -0.010530
     92235  -0.931730
     92236  -0.002060
     92238  -0.055670
-----------------------------------------------------------------------------------------
     92234  0.010582
     92235  0.932361
     92236  0.002053
     92238  0.055004

_____________________________________________________________________________
$  Photon
     92000  -1.000000
-----------------------------------------------------------------------------------------
     92000  1.000000
```

CEPXS Form

```
material  u 1.000000
matname  uranium_heu_hps
density  18.95
```

4: Natural Uranium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
U-234	0.000057	0.000058	0.000003
U-235	0.007204	0.007295	0.000349
U-238	0.992739	0.992647	0.047466

Density (g/cm^3)= 18.90

Comments: Natural Uranium.

Reference: *The Health Physics and Radiological Health Handbook*, p. 286, B. Shleien, editor, Scinta, Inc., 1992.

MCNP Form

```
c   Natural Uranium, rho = 18.90
$  Neutron
     92234  -0.000057
     92235  -0.007204
     92238  -0.992739
-------------------------------------------------------------------------------------------
     92234  0.000058
     92235  0.007295
     92238  0.992647
_____________________________________________________________________________________
$  Photon
     92000  -1.000000
-------------------------------------------------------------------------------------------
     92000  1.000000
```

CEPXS Form

```
material  u 1.000000
matname  uranium_natural
density  18.90
```

5: Typical Depleted Uranium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
U-234	0.000005	0.000005	2.43E-07
U-235	0.002500	0.002532	0.000121
U-238	0.997500	0.997463	0.047693

Density (g/cm^3)= 18.90

Comments: Typical depleted uranium. Weight Fractions are not normalized. The atom fraction and atom density are calculated from the weight fraction in the reference.
Reference: *The Health Physics and Radiological Health Handbook*, p. 286, B. Shleien, editor, Scinta, Inc., 1992.

MCNP Form

```
c  Depleted Uranium, rho = 18.90
$ Neutron
    92234  -0.000005
    92235  -0.002500
    92238  -0.997500
-----------------------------------------------------------------------------------------
    92234  0.000005
    92235  0.002532
    92238  0.997463
_________________________________________________________________________________
$ Photon
    92000  -1.000000
-----------------------------------------------------------------------------------------
    92000  1.000000
```

CEPXS Form

```
material  u 1.000000
matname  uranium_depleted
density  18.90
```

6: Typical Commercial Enriched Uranium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
U-234	0.000300	0.000305	0.000015
U-235	0.029600	0.029967	0.001433
U-238	0.970100	0.969728	0.046383

Density (g/cm^3)= 18.90

Comments: Commercial enriched, typical.
Reference: *The Health Physics and Radiological Health Handbook*, p. 286, B. Shleien, editor, Scinta, Inc., 1992.

MCNP Form

```
c   Commercial Enriched Uranium, rho = 18.90
$  Neutron
     92234  -0.000300
     92235  -0.029600
     92238  -0.970100
-----------------------------------------------------------------------------------------
     92234  0.000305
     92235  0.029967
     92238  0.969728
_________________________________________________________________________________
$  Photon
     92000  -1.000000
-----------------------------------------------------------------------------------------
     92000  1.000000
```

CEPXS Form

```
material  u 1.000000
matname  uranium_commercial
density  18.90
```

Water

1: Water, Liquid

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.111894	0.666657	0.066853
O	0.888106	0.333343	0.033428

Density (g/cm^3)= 1.00

Comments:

Reference: Taken from NIST Listings, “Compositions of Materials used in STAR Databases” webpage:

http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=276

MCNP Form

```
c  Liquid Water, rho = 1.00 g/cc
$  Neutron
     1001  -0.111894
     8016  -0.888106
-----------------------------------------------------------------------------------------
     1001  0.666657
     8016  0.333343
_________________________________________________________________________________
```

$ **Photon**
1000 -0.111894
8000 -0.888106

1000 0.666657
8000 0.333343

CEPXS Form

material h 0.111894 o 0.888106
matname water_liquid
density 1.00

2: Water, Vapor

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.111894	0.666657	0.000050553
O	0.888106	0.333345	0.000025278

Density (g/cm^3)= 0.000756182

Comments:
Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:
http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=277

MCNP Form

c Water Vapor, rho = 0.000756182 g/cc
$ **Neutron**
1001 -0.111894
8016 -0.888106

1001 0.666657
8016 0.333345

$ **Photon**
1000 -0.111894
8000 -0.888106

1000 0.666657
8000 0.333345

CEPXS Form

material h 0.111894 o 0.888106
matname water_vapor
density 0.000756182

Wood

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
H	0.057889	0.476190	--
C	0.482667	0.285714	--
O	0.459444	0.238095	--

Density (g/cm^3)(cherry wood) = 0.433

Density (g/cm^3)(walnut wood) = 0.593

Density (g/cm^3)(southern pine) = 0.650

Density (g/cm^3)(red oak) = 0.673

Density (g/cm^3)(sugar maple) = 0.689

Density (g/cm^3)(birch wood) = 0.705

Density (g/cm^3)(mahogany) = 0.705

Comments: Cherry wood density found at:
http://www.mcelwee.net/html/densities_of_various_materials.html

Reference: *The Chemistry of Solid Wood*, Advances in Chemistry Series 207, Roger Rowell (Ed.), p. 58, American Chemical Society, 1983. See also http://en.wikipedia.org/wiki/Cellulose.

MCNP Form

```
c  Wood
$  Neutron
     1001  -0.057889
     6012  -0.482667
     8016  -0.459444
-------------------------------------------------------------------------------
     1001  0.476190
     6012  0.285714
     8016  0.238095

$  Photon
     1000  -0.057889
     6000  -0.482667
     8000  -0.459444
-------------------------------------------------------------------------------
     1000  0.476190
     6000  0.285714
     8000  0.238095
```

CEPXS Form (For Cherry Wood)

```
material  h 0.057889 c 0.482667 o 0.459444
matname  wood_cherry
density  0.433
```

Zirconium

Element	Weight Fraction	Atom Fraction	Atom Density $\left(\frac{atoms}{b*cm}\right)$
Zr	1.000000	1.000000	0.042949

Density (g/cm^3)= 6.506

Comments:

Reference: Taken from NIST Listings, "Compositions of Materials used in STAR Databases" webpage:

http://physics.nist.gov/cgi-bin/Star/compos.pl?matno=040

MCNP Form

```
c  Zirconium, rho = 6.506 g/cc
$  Neutron
     40000  -1.000000
-------------------------------------------------------------------------------
     40000  1.000000
_______________________________________________________________________________
$  Photon
     40000  -1.000000
-------------------------------------------------------------------------------
     40000  1.000000
```

CEPXS Form

```
material  zr 1.000000
matname  zirconium
density  6.506
```

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