RSICC DATA LIBRARY DLC-185

1. NAME AND TITLE OF DATA LIBRARY

BUGLE-96: Coupled 47 Neutron, 20 Gamma-Ray Group Cross Section Library Derived from ENDF/B-VI for LWR Shielding and Pressure Vessel Dosimetry Applications.

2. NAME AND TITLE OF DATA RETRIEVAL PROGRAMS

BCBN: Convert ANISN card-image data to binary format.

3. CONTRIBUTOR

Oak Ridge National Laboratory, Oak Ridge, Tennessee.

4. HISTORICAL BACKGROUND AND INFORMATION

A new multigroup cross-section library based on ENDF/B-VI data has been produced and tested for light water reactor shielding and reactor pressure vessel dosimetry applications. The broad-group library, designated DLC-185/BUGLE-96, is intended to replace the DLC-75/BUGLE-80 and DLC-76/SAILOR libraries, which are both based on ENDF/B-IV data. It also replaces the DLC-175/BUGLE-93 library by correcting some deficiencies and adding several additional data sets. The processing methodology for BUGLE-96 is consistent with ANSI/ANS 6.1.2, since the ENDF data were first processed into a fine-group, pseudo-problem-independent format and then collapsed into the final broadgroup format. An extensive integral data testing effort was performed to qualify the data and to assess its impact on LWR shielding applications. In general, results using the new data show significant improvements relative to earlier ENDF data.

5. APPLICATION OF THE DATA

The BUGLE-96 cross sections are intended for use in LWR shielding and pressure vessel dosimetry applications. The multigroup data have been collapsed, and in some cases self-shielded, using flux spectra typical of PWR and BWR reactor models. Flux spectra from five specific locations within these models were used, corresponding to: (1) off-center in a BWR core region, (2) off-center in a PWR core region, (3) the downcomer region in a PWR model, (4) within the pressure vessel at a depth of one-fourth the total thickness, and (5) within the concrete shield surrounding a PWR reactor vessel. The concrete-spectrum-weighted cross sections have been shown to be generally applicable to a wide range of shielding problems.

6. SOURCE AND SCOPE OF DATA

BUGLE-96 contains 120 nuclides which have been processed as infinitely dilute and collapsed using an LWR concrete shield spectrum. Additionally, it contains 105 nuclides which have been energy

self-shielded and collapsed using LWR-specific material compositions and flux spectra. A separate set of data are included which combines the isotopic BUGLE nuclides into natural elements and provides them with material identifiers which are identical to the original DLC-76/SAILOR library. In addition to the BUGLE-96 and SAILOR-96 data sets, which have been processed without upscatter in the thermal groups, two new data sets are provided which retain the upscatter reactions for groups below 5eV. These data sets are designated as BUGLE-96T and SAILOR-96T. Nuclides with $Z < 30$ (hydrogen through copper) are given in a P_7 Legendre expansion while P_5 expansion is available for all other nuclides. Several dosimetry and standard response functions are included with the library along with kerma factors for all nuclides. The library was collapsed from the VITAMIN-B6 fine-group library using the AMPX-77 processing code system. VITAMIN-B6 is derived from ENDF/B-VI Release 3 nuclear data, except for two nuclides (Sn obtained from LENDL and Zirc2 obtained from ENDF/B-IV). The responses and kerma factors were also derived primarily from ENDF/B-VI.

Attached tables provide information on file contents.

7. DISCUSSION OF THE DATA RETRIEVAL PROGRAM

The BCBN Fortran program is included to read formatted ANISN records and write them as unformatted records.

8. DATA FORMAT AND COMPUTER

Card images in ANISN format; all computers (D00185/ALLCP/00).

9. TYPICAL RUNNING TIME

Not applicable.

10. REFERENCES

a) Included in document:

RSIC, "READ.ME" (March 28, 1996).

J. E. White, D. T. Ingersoll, R. Q. Wright, H. T. Hunter, C. O. Slater, N. M. Greene, R. E. MacFarlane, R. W. Roussin, "Production and Testing of the Revised VITAMIN-B6 Fine-Group and the BUGLE-96 Broad-Group Neutron/Photon Cross-Section Libraries Derived from ENDF/B-VI.3 Nuclear Data," ORNL-6795, R1, NUREG/CR-6214, Revision 1 (January 1995) (DRAFT).

b) Background information:

D. T. Ingersoll, J. E. White, R. Q. Wright, H. T. Hunter, C. O. Slater, N. M. Greene, R. E. MacFarlane, R. W. Roussin, "Production and Testing of the VITAMIN-B6 Fine-Group and the BUGLE-93 Broad-Group Neutron/Photon Cross-Section Libraries Derived from ENDF/B-VI Nuclear Data," ORNL-6795, NUREG/CR-6214 (January 1995).

11. CONTENTS OF LIBRARY

Included are the referenced document and a compressed file which contains the data files and BCBN retrieval program. The package is available on either CD-ROM or Unix cartridge tape. If package is transmitted on CD-ROM, both Unix and DOS files are included. If package is transmitted on tape, only the Unix file is included.

12. DATE OF ABSTRACT

February 1994, revised April 1994, May 1994, March 1996, July 1999.

KEYWORDS: ANISN FORMAT; BENCHMARK PROBLEM CROSS SECTIONS; CONCRETE CROSS SECTIONS; COUPLED NEUTRON-GAMMA-RAY CROSS SECTIONS; MULTIGROUP CROSS SECTIONS; MULTIGROUP CROSS SECTIONS BASED ON ENDF/B; NEUTRON CROSS SECTIONS; KERMA FACTORS; DETECTOR RESPONSE

Nuclide Tables Follow:

Table 1. Nuclides in BUGLE-96 which are infinitely dilute and weighted with a concrete flux spectrum. This is table 3.10 in NUREG/CR-6214 pp. 49-50. It is unchanged from the BUGLE-93 release.

Entry Nuclide ANISN-ID

1 Ag-107 1-6

2 Ag-109 7-12

3 Al-27 13-20

4 Am-241 21-26

5 Am-242 27-32

6 Am-242m 33-38

7 Am-243 39-44

8 Au-197 45-50

35 Eu-151 237-242

36 Eu-152 243-248

37 Eu-153 249-254

38 Eu-154 255-260

39 Eu-155 261-266

40 F-19 267-274

41 Fe-54 275-282

42 Fe-56 283-290

43 Fe-57 291-298

44 Fe-58 299-306

45 Ga 307-312

46 H-1 (H2O) 313-320

47 H-1 (CH2) 321-328

48 H-2 (D2O) 329-336

49 H-3 337-344

50 He-3 345-352

51 He-4 353-360

52 Hf-174 361-366

53 Hf-176 367-372

54 Hf-177 373-378

55 Hf-178 379-384

56 Hf-179 385-390

57 Hf-180 391-396

58 In-Nat 397-402

59 K 403-410

60 Li-6 411-418

61 Li-7 419-426

62 Mg 427-434

63 Mn-55 435-442

64 Mo 443-448

65 N-14 449-456

66 N-15 457-464

67 Na-23 465-472

68 Nb-93 473-478

69 Ni-58 479-486

70 Ni-60 487-494

71 Ni-61 495-502

72 Ni-62 503-510

73 Ni-64 511-518

74 Np-237 519-524

75 Np-238 525-530

76 Np-239 531-536

77 O-16 537-544

78 O-17 545-552

79 P-31 553-560

80 Pa-231 561-566

81 Pa-233 567-572

82 Pb-206 573-578

83 Pb-207 579-584

84 Pb-208 585-590

85 Pu-236 591-596

86 Pu-237 597-602

87 Pu-238 603-608

88 Pu-239 609-614

89 Pu-240 615-620

90 Pu-241 621-626

91 Pu-242 627-632

92 Pu-243 633-638

93 Pu-244 639-644

94 Re-185 645-650

95 Re-187 651-656

96 S 657-664

97 S-32 665-672

98 Si 673-680

99 Sn-Nat 681-686

100 Ta-181 687-692

101 Ta-182 693-698

102 Th-230 699-704

103 Th-232 705-710

104 Ti 711-718

105 U-232 719-724

106 U-233 725-730

107 U-234 731-736

108 U-235 737-742

109 U-236 743-748

110 U-237 749-754

111 U-238 755-760

112 V 761-768

113 W-Nat 769-774

114 W-182 775-780

115 W-183 781-786

116 W-184 787-792

117 W-186 793-798

118 Y-89 799-804

119 Zr 805-810

120 Zr (Zirc-2) 811-816

Table 2. Materials in the BUGLE-96 broad-group library with special PWR and BWR weightings. This table is a modification of Table 3.11 to reflect changes in BUGLE-96.

Nuclide ANISN-ID Description

B-10 1001-1008 PWR core coolant

Cr-50 1009-1016 PWR core clad

Cr-52 1017-1024 PWR core clad

Cr-53 1025-1032 PWR core clad

Cr-54 1033-1040 PWR core clad

Fe-54 1041-1048 PWR core clad

Fe-56 1049-1056 PWR core clad

Fe-57 1057-1064 PWR core clad

Fe-58 1065-1072 PWR core clad

H-1(H2O) 1073-1080 PWR core coolant

Ni-58 1081-1088 PWR core clad

Ni-60 1089-1096 PWR core clad

Ni-61 1097-1104 PWR core clad

Ni-62 1105-1112 PWR core clad

Ni-64 1113-1120 PWR core clad

O-16 1121-1128 PWR core coolant

O-16 1129-1136 PWR core fuel

U-235 1137-1142 PWR core fuel

U-238 1143-1148 PWR core fuel

Zr 1149-1154 PWR core clad

H-1(H2O) 2001-2008 PWR downcomer

O-16 2009-2016 PWR downcomer

C 2017-2024 PWR downcomer

Cr-50 2025-2032 PWR downcomer

Cr-52 2033-2040 PWR downcomer

Cr-53 2041-2048 PWR downcomer

Cr-54 2049-2056 PWR downcomer

Fe-54 2057-2064 PWR downcomer

Fe-56 2065-2072 PWR downcomer

Fe-57 2073-2080 PWR downcomer

Fe-58 2081-2088 PWR downcomer

Mn-55 2089-2096 PWR downcomer

Ni-58 2097-2104 PWR downcomer

Ni-60 2105-2112 PWR downcomer

Ni-61 2113-2120 PWR downcomer

Ni-62 2121-2128 PWR downcomer

Ni-64 2129-2136 PWR downcomer

C 3001-3008 PWR 1/4 T in Pressure Vessel

Cr-50 3009-3016 PWR 1/4 T in Pressure Vessel

Cr-52 3017-3024 PWR 1/4 T in Pressure Vessel

Cr-53 3025-3032 PWR 1/4 T in Pressure Vessel

Cr-54 3033-3040 PWR 1/4 T in Pressure Vessel

Fe-54 3041-3048 PWR 1/4 T in Pressure Vessel

Fe-56 3049-3056 PWR 1/4 T in Pressure Vessel

Fe-57 3057-3064 PWR 1/4 T in Pressure Vessel

Fe-58 3065-3072 PWR 1/4 T in Pressure Vessel

Mn-55 3073-3080 PWR 1/4 T in Pressure Vessel

Ni-58 3081-3088 PWR 1/4 T in Pressure Vessel

Ni-60 3089-3096 PWR 1/4 T in Pressure Vessel

Ni-61 3097-3104 PWR 1/4 T in Pressure Vessel

Ni-62 3105-3112 PWR 1/4 T in Pressure Vessel

Ni-64 3113-3120 PWR 1/4 T in Pressure Vessel

Al-27 4001-4008 Concrete type 04

C 4009-4016 Concrete type 04

Ca 4017-4024 Concrete type 04

Fe-54 4025-4032 Concrete type 04

Fe-56 4033-4040 Concrete type 04

Fe-57 4041-4048 Concrete type 04

Fe-58 4049-4056 Concrete type 04

H-1(H2O) 4057-4064 Concrete type 04

K 4065-4072 Concrete type 04

Mg 4073-4080 Concrete type 04

Na-23 4081-4088 Concrete type 04

O-16 4089-4096 Concrete type 04

Si 4097-4104 Concrete type 04

C 5001-5008 Carbon steel

C 5009-5016 Stainless steel

Cr-50 5017-5024 Carbon steel

Cr-50 5025-5032 Stainless steel

Cr-52 5033-5040 Carbon steel

Cr-52 5041-5048 Stainless steel

Cr-53 5049-5056 Carbon steel

Cr-53 5057-5064 Stainless steel

Cr-54 5065-5072 Carbon steel

Cr-54 5073-5080 Stainless steel

Fe-54 5081-5088 Carbon steel

Fe-54 5089-5096 Stainless steel

Fe-56 5097-5104 Carbon steel

Fe-56 5105-5112 Stainless steel

Fe-57 5113-5120 Carbon steel

Fe-57 5121-5128 Stainless steel

Fe-58 5129-5136 Carbon steel

Fe-58 5137-5144 Stainless steel

Mn-55 5145-5152 Carbon steel

Mn-55 5153-5160 Stainless steel

Ni-58 5161-5168 Carbon steel

Ni-58 5169-5176 Stainless steel

Ni-60 5177-5185 Carbon steel

Ni-60 5186-5192 Stainless steel

Ni-61 5193-5200 Carbon steel

Ni-61 5201-5208 Stainless steel

Ni-62 5209-5216 Carbon steel

Ni-62 5217-5224 Stainless steel

Ni-64 5225-5232 Carbon steel

Ni-64 5233-5240 Stainless steel

Fe-54 6001-6008 BWR core clad

Fe-56 6009-6016 BWR core clad

Fe-57 6017-6024 BWR core clad

Fe-58 6025-6032 BWR core clad

H-1(H2O) 6033-6040 BWR core coolant

O-16 6041-6048 BWR core coolant

O-16 6049-6056 BWR core fuel

U-235 6057-6062 BWR core fuel

U-238 6063-6068 BWR core fuel

Zr 6069-6074 BWR core clad

Table 3. SAILOR-96 identifiers for data in ANISN format

ANISN-ID Material identification

1 BUGLE-96 RESPONSE FUNCTIONS 1-55(FLAT WTNG)

2 BUGLE-96 RESPONSE FUNCTIONS 1-55(1/4T PV WTNG)

3-6 h1(h2o) PWR core coolant

7-10 b10 PWR core coolant

11-14 o16 PWR core coolant

15-18 cr PWR core clad

19-22 fe PWR core clad

23-26 ni PWR core clad

27-30 zr PWR core clad

31-34 u235 PWR core fuel

35-38 u238 PWR core fuel

39-42 o16 PWR core fuel

43-46 u235 BWR core fuel

47-50 u238 BWR core fuel

51-54 o16 BWR core fuel

55-58 h1(h2o) PWR downcomer

59-62 o16 PWR downcomer

63-66 cr PWR downcomer

67-70 mn55 PWR downcomer

71-74 fe PWR downcomer

75-78 ni PWR downcomer

79-82 c PWR downcomer

83-86 h1(h2o) Concrete type 04

87-90 c Concrete type 04

91-94 o16 Concrete type 04

95-98 na23 Concrete type 04

99-102 mg Concrete type 04

103-106 al27 Concrete type 04

107-110 si Concrete type 04

111-114 k Concrete type 04

115-118 ca Concrete type 04

119-122 fe Concrete type 04

123-126 cr PWR 1/4 T in PV

127-130 mn55 PWR 1/4 T in PV

131-134 fe PWR 1/4 T in PV

135-138 ni PWR 1/4 T in PV

139-142 c PWR 1/4 T in PV

Table 4. List of the ANISN identifiers for the response functions.

BUGLE-96 extends the available number of response functions as requested by users. Table 4a corresponds to the row positions of the response functions (same as DLC-175) plus additional responses given in table 4b. The ANISN identifiers for the response functions are:

7001 - flat weighting

7002 - flat weighting

7003 - 1/4 T in PV

7004 - 1/4 T in PV

Table 4a.

Response Function Table Positions in Part A of Response Arrays

Pos. Description

----

1. Upper Energy Boundaries (MeV)

2. nuclide 92235 process1018 -- u235 chi

3. li6 helium production 2/17/94

4. nuclide 525 process 107 B10(n,alpha)

5. nuclide 9040 process 18 Th232(n,f)

6. nuclide 92235 process 18 -- u235(n,f)

7. nuclide 92238 process 18 -- u238(n,f)

8. nuclide 9346 process 18 Np237(n,f)

9. nuclide 94239 process 18 -- pu239(n,f)

10. nuclide 13027 process 103 -- al27(n,p)

11. nuclide 13027 process 107 -- al27(n,alpha)

12. nuclide 1111 process 103 (vb6wgt.s32) s-32(n,p) 2/17/94

13. nuclide 2225 process 103 Ti46(n,p)

14. nuclide 2228 process 103 Ti47(n,p)

15. nuclide 2228 process 28 Ti47(n,n'p)

16. nuclide 2231 process 103 Ti48(n,p)

17. nuclide 2231 process 28 Ti48(n,n'p)

18. nuclide 2525 process 16 Mn55(n,2n)

19. nuclide 2625 process 103 Fe54(n,p)

20. nuclide 2631 process 103 Fe56(n,p)

21. nuclide 2725 process 16 Co59(n,2n)

22. nuclide 2725 process 107 Co59(n,p)

23. nuclide 2825 process 103 Ni58(n,p)

24. nuclide 2825 process 16 Ni58(n,2n)

25. nuclide 2831 process 103 Ni60(n,p)

26. nuclide 2925 process 107 Cu63(n,alpha)

27. nuclide 2931 process 16 Cu65(n,2n)

28. nuclide 4931 process 51 In115(n,n')

29. nuclide 5325 process 16 I127(n,2n)

30. nuclide 2125 process 102 Sc45(n,g)

31. nuclide 1125 process 102 Na23(n,g)

32. nuclide 2637 process 102 Fe58(n,g)

33. nuclide 2725 process 102 Co59(n,g)

34. nuclide 2925 process 102 Cu63(n,g)

35. nuclide 4931 process 102 In115(n,g)

36. nuclide 7925 process 102 Au197(n,g)

37. nuclide 9040 process 102 Th232(n,g)

38. nuclide 9237 process 102 U238(n,g)

39. Square Root (E) where E is in MeV

40. Constant

41. nuclide 92234 process 18 -- u234(n,f)

42. nuclide 92236 process 18 -- u236(n,f)

43. nuclide 94240 process 18 -- pu240(n,f)

44. nuclide 94241 process 18 -- pu241(n,f)

45. nuclide 94242 process 18 -- pu242(n,f)

46. nuclide 4525 process 51 Rh103(n,n')

47. nuclide 1111 process 444 si-28 displacement kerma (eV-b) 2/17/94

48. nuclide 92238 process1018 -- u238 chi

49. nuclide 94239 process1018 -- pu239 chi

50. E > 1.0 MeV Neutron Flux

51. E > 0.1 MeV Neutron Flux

52. E < 0.414 eV Neutron Flux

53. Average Energy (MeV)

54. Delta-E (MeV)

55. Delta-u

Table 4b

Response Function Table Positions in Part B of Response Arrays

Pos. Description

----

1. nuclide 94238 process 18 -- pu238(n,f)

2. nuclide 92234 process 452 -- u234 nubar

3. nuclide 92235 process 452 -- u235 nubar

4. nuclide 92236 process 452 -- u236 nubar

5. nuclide 92238 process 452 -- u238 nubar

6. nuclide 94238 process 452 -- pu238 nubar

7. nuclide 94239 process 452 -- pu239 nubar

8. nuclide 94240 process 452 -- pu240 nubar

9. nuclide 94241 process 452 -- pu241 nubar

10. nuclide 94242 process 452 -- pu242 nubar

11. nuclide 92234 process1018 -- u234 chi

12. nuclide 92236 process1018 -- u236 chi

13. nuclide 94238 process1018 -- pu238 chi

14. nuclide 94240 process1018 -- pu240 chi

15. nuclide 94241 process1018 -- pu241 chi

16. nuclide 94242 process1018 -- pu242 chi