Computer Code Abstracts*

APWRC-CELCOR

1 Name of code: APWRC-CELCOR
2. Computer for which code is designed: IBM-709 or 7090
   Programming system: FORTRAN II including FAP
3. Nature of problem solved: Multiple lethargy level cell corrections using P1 or S2 to S16 DSN fluxes in cylindrical, spherical and one- or two-dimensional slab geometry.
4. Restrictions on the complexity of the problem:
   10 lethargy levels; cell temperature 68–2980°F.
   10 mixtures, five materials per mixture
   25 regions per direction
   199 intervals per direction
   P1, S2, S4, S6, S8, S16; no S16 for cylinder.
   Machine requirements: 32K memory, nine tape units; card reader not necessary.
5. Typical running time: 6 min for two-dimensional cell with 20 intervals in each direction, S6 theory with flux convergence of 0.001, and 10 lethargy levels.
6. Unusual features of code: Program uses GE-ANP nuclear data tape format and lethargy level scheme. Assumption of flat flux at an arbitrary epithermal reference lethargy level is used to obtain a boundary condition on the slowing-down density in each region. The slowing-down density is obtained at each higher lethargy (lower energy) level using regional material cross sections and the Modified Age Theory equation for the slowing-down density. Effect of leakage from adjacent regions on slowing-down density is accounted for by adding a leakage term to the absorption cross section used in slowing-down density equation. The leakage term is assumed zero at the reference level. A value for a particular level is calculated from the regional interface currents and region average flux at the preceding level. Thus the leakage per unit flux is assumed to vary slowly with lethargy. The regional slowing-down density at each level is used as the source term for the spatial flux calculation at that level. At all epithermal levels, in-group scattering is assumed to be zero and "xi-sigma" scattering is added to the pure absorption. Two-dimensional slab geometry cell corrections are obtained by assuming two-dimensional flux shape occurs only in fissionable part of cell, where the fluxes are assumed separable. Nonfissionable part of cell (side plates of box, etc.) assumed to have flux variation only in direction parallel to plane of fuel plates. Cell corrections may be defined to be unity in the moderator or total cell average flux normalization may be used. Input data FORMAT and logical error diagnostics. Output includes on-line topological material edit for checking input data, and complete off-line edit with optional Benson-Lehner plotting data. Written under U. S. Army Pressurized Water Reactor Code Development Program.
7. Present status: In production; source and object programs with nuclear data file available on receipt of one full length magnetic tape. Three-thermal-group spectral hardening may be added in future. Requests should be submitted to: Mr. Clement Eicheldinger, Mail No. W-719, The Martin Company, Baltimore 3, Maryland.
8. *Reference:* G. A. Cannon, APWRC-CELCOR, A FORTRAN II program for multiple lethargy level P1 or S2 to S16 DSN cell corrections in cylindrical, spherical and one or two-dimensional slab geometry. MND-C-2459 (December 27, 1960).

G. A. Cannon
T. M. Olsen
E. A. Schaefer
The Martin Company
Baltimore, Maryland

WHIRLAWAY

1. Name of code: WHIRLAWAY
2. Computer for which code is designed: IBM-7090
   Programming system: FORTRAN
3. Nature of problem solved: Two-group, three-dimensional, neutron diffusion equations in XYZ geometry
4. Restrictions on the complexity of the problem:
   Maximum number of groups—2
   Maximum number of mesh points—12,750
   Maximum number of compositions—100
   Maximum number of regions—100
5. Typical running times: approximately 0.006 sec/pt.-iteration—from 1½ to 4 hr for a 10,000 point problem
6. Unusual features of the code: This code uses the same simple iterative procedure that is used in the two-dimensional code EQUIPOISE. It will compute adjoint fluxes and flux-adjoint flux regional integrals automatically if desired.
7. Present status: In use, available
8. *Reference:* T. B. Fowler and Melvin Tobias, WHIRLAWAY—A three-dimensional neutron diffusion code for the IBM-7090 computer. ORNL-3150 (July, 1961).

T. B. Fowler
Melvin Tobias
Oak Ridge National Laboratory
Oak Ridge, Tennessee

GAM-I

1. Code designation: GAM-I; A Consistent P_1 Multigroup Code for the Calculation of the Fast Neutron Spectrum and Multigroup Constants.

* Computer codes for this section should be submitted directly to Everitt P. Blizard, Editor, *Nuclear Science and Engineering*, Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, Tennessee.

2. GAM-I, a FORTRAN II program for the IBM-7090 is now available for distribution. This program computes the slowing down spectrum in either the P_1 or the B_1 approximation using 68 groups of neutrons with a constant group width $\Delta u = 0.25$. The code calculates multigroup constant for up to 32 fast groups. Special features of this code include:
   (a) A subroutine that calculates resonance integrals from the resonance parameters for each group using the quantitative methods developed by L. W. Nordheim.
   (b) The energy angle correlation is retained for slowing down in all isotopes. That is, the P_0 and P_1 components of the scattering kernel are treated rigorously. For the common moderating materials and for some of the more common isotopes, terms up to P_6 in the Legendre expansion of the scattering cross section in the center of mass system are retained. For other isotopes, the scattering matrices are correct for linearly anisotropic scattering in the center of mass system.
   (c) The code contains a large library. At present, the library tape consists of 127 nuclides. The library tape contains all of the data needed in the calculation for each of the 68 subgroups.
   (d) Inelastic scattering and $(n,2n)$ processes are explicitly included.
   (e) The code contains an option that will calculate the neutron age in an infinite medium by the moments method.
   (f) Both microscopic and macroscopic cross sections can be obtained for as many isotopes as are on the data tape for any specified group structure.
   (g) Self-shielding factors may be included for any nuclide, if desired.
   (h) Nine different source spectra are included as options.
3. The running time for a typical problem is about one minute.
4. *Reference:* G. D. Joanou, E. J. Leshan and J. S. Dudek, GAM-I, A consistent P_1 multigroup code for the calculation of the fast neutron spectrum and multigroup constants. GA-1850 (May, 1961).

G. D. Joanou
General Dynamics
General Atomic Division
San Diego, California

SLOP-I

1. Code name: SLOP-1
2. Computer, programming system: Program is written in SAP for the IBM-704
3. Problem solved: SLOP-1 solves multigroup equations appropriate to the thermal neutron energy band and computes a position dependent thermal neutron flux spectrum. It is intended, primarily, for the study of the time independent flux shape produced, in the thermal range, by a given slowing-down density. However, a modified version of the code (not described in the referenced code report) may be used to determine the main mode flux shape in a pulsed moderator. Code treats one-dimensional slab, cylindrical, and spherical geometries.
4. Basic approximations: For slowing-down or pulse calculations the P_1, P_3, or double P_1 approximations are available in slab geometry. P_1 in other geometries. In addition, simple die away calculations may be done in P_3 for spheres. General P_0 through P_3 scattering is treated through transfer matrices.
5. Method of solution: Within each group, P_3 or double-P_1 equations are solved by inner iteration (see reference). The different groups are treated sequentially by Gauss-Seidel outer iteration. Overrelaxation or extrapolation may be used to accelerate convergence of the outer cycle. Microscopic cross sections and transfer matrices are stored in program library so that only number densities need be supplied as input.
6. Restrictions on complexity of problem: No. of groups ≤ 50. No. of mesh points ≤ 250 in P_1, ≤ 150 in double-P_1. No. of regions ≤ 25. No. of isotopes in any region ≤ 15. Restrictions quoted hold for 32K IBM-704. Program will run on smaller machines with reductions in maximum number of groups, points, etc. In slowing-down problems the slowing-down density is assumed to be isotropic and regionwise flat and, in all versions of SLOP-1, the temperature is assumed to be position independent. Only one element may act as a moderator. The moderating properties of that element are fixed by the transfer matrices stored on the program tape.
7. Typical running times: Depends on number of groups, number of points, order of approximation and convergence rate of outer cycle. This convergence rate decreases as the absorption cross section per moderating atom decreases. In P_1, 45 min for 100 mesh points and 36 groups would be typical. In double-P_1, roughly 75 min would be typical.
8. Status: Code is in production and is available from IBM.
9. *Reference:* H. Bohl, E. Gelbard, P. Buerger, and G. Culpepper, SLOP-1—A thermal multigroup program for the IBM-704. WAPD-TM-188 (October, 1960).

E. Gelbard
H. Bohl
Bettis Atomic Power Laboratory
Pittsburgh, Pennsylvania

ECESS

1. Code name: ECESS
2. Computer and programming system: Code is written in SAP for the IBM-704.
3. Problem solved: The ECESS code is designed, primarily, to compute parameters required in a multigroup treatment of the thermal neutron flux. The computation of multigroup parameters is based on a monatomic gas model of the physical moderator. ECESS may also be used, however, to obtain spectra for the scalar flux and current in large geometry. Averages over these spectra are evaluated to provide, in addition, coefficients for a one-group description of thermal neutrons.

   Coefficients are computed for the ratio M/m of atomic mass to neutron mass and the temperature specified. Coefficients for a treatment up to P_3 or double P_1 are obtained.
4. Method of solution: After the multigroup parameters are computed, the infinite medium flux spectrum is determined by Gauss-Seidel iteration. The current spectrum in the low buckling limit is then deduced from the flux spectrum.