direction cosines and the initial energy of the neutron or gamma is required.
The ADONIS program considers the following neutron interactions:
1. Isotropic and anisotropic elastic scattering
2. Discrete and continuum inelastic scattering
3. Scattering by hydrogen
4. The (n, 2n) reaction in beryllium
5. Absorption.

The gamma portion of the ADONIS program considers the Compton scattering of photons. The photoelectric effect and pair production are regarded as absorption processes.
Particle histories in ADONIS are terminated when
1. an absorption occurs,
2. the particle degrades below an arbitrary cutoff energy,
3. a kill occurs due to splitting, or
4. the particle escapes.

Cross-section data for ADONIS are obtained from a Master Element Data Tape for either neutrons or gammas.
ADONIS is called in through the IBM-7090 Monitor System. It contains intermediate dump and edit procedures.

5. Restrictions on complexity of problem: Eighty regions (i.e., a region is defined as a rectangular parallelepiped of either finite or infinite dimensions. The totality of all such regions covers $x$, $y$, $z$ space). A maximum of 80 complex surfaces is permitted. (A complex surface is defined as a side of a parallelepiped adjacent to more than one region.) A maximum of 10 energy bins in which fluxes are stored.
6. Typical running times: The computation time required for a given thickness depends upon the choice of the importance weights assigned to the various regions, and hence it is impossible to give a good estimate of the time required to obtain a given accuracy. However, in a series of problems having a two-foot shield of steel and paraffin, an average of 15 min/problem was required for statistics good to 25%, in a 40-region problem having 10,000 source neutrons.
7. Status: Code is in use and available through United Nuclear. Contact S. Preiser for additional information.

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## SANE-SAGE (UNC Codes-90-7, 8)

1. Code name: SANE (UNC Code-90-7), SAGE (UNC Code-90-8).
2. Computer for which code is designed: IBM 7090
Programming system: FAP and FORTRAN
A 32K core and 6 tapes are required.
3. Nature of problem solved: Solves the neutron or gamma transport problem in spherically symmetric multilayer geometry. The programs compute neutron (SANE) or gamma (SAGE) fluxes at the interior of the assembly. Fast dose at the exterior is also calculated. By the use of response functions, and the SANE flux output, the strength of secondary gamma sources produced by any neutron induced reaction can be computed throughout the configuration. The SANE program handles volume distributed fission or monoenergetic sources. The SAGE program handles volume distributed monoenergetic gamma sources.
4. Method of solution: SANE and SAGE are Monte Carlo programs that track neutrons or gammas through spherical shields composed of different physical compositions.
All physical boundaries are flux boundaries and can also be splitting boundaries. Particle splitting is employed to improve the efficiency of the calculation. Flux boundaries may be placed anywhere and can be used to get detailed results. The present programs allow for 75 radial regions and 40 output energy bins. The energy bins may be arbitrarily spaced.
For the SANE program the source energies are picked from a complete or truncated fission spectrum. The neutron starting region and radius are picked by a rejection technique using starting probabilities supplied as input.
The SAGE program handles a monoenergetic source. The source is specified as piece-wise exponential in the radial source regions. A rejection technique is used to pick from the exponential distribution.
The SANE program considers the following neutron interactions:
1. Isotropic and anisotropic elastic scattering
2. Discrete and continuum inelastic scattering
3. Scattering by hydrogen
4. The (n, 2n) reaction in beryllium
5. Absorption.

The SAGE program considers the Compton scattering of photons. The photoelectric effect and pair production are regarded as absorption processes.
Particle histories in both programs are terminated when:
1. an absorption occurs,
2. the particle degrades below an arbitrary cutoff energy,
3. a kill occurs due to splitting, or
4. the particle escapes.

Cross-section data for the programs are obtained from a Master Element Data Tape. The SANE and SAGE programs each require a separate Element Data Tape. Cross-section data are stored on the tape by element. For each element the following data appear on the tape.
1. Probability of exciting a given level, as a function of the primary neutron energy, by inelastic scattering (SANE only).
2. List of possible excitation levels (SANE only).
3. Tables of energies scattered with equal probability from the incident energy. For inelastic continuum scattering (SANE only).
4. Tables of angular distributions for anisotropic scattering (SANE only).
5. Probability of inelastic scattering (SANE only).
6. Probability of elastic scattering.
7. Probability of absorption.
8. Microscopic total cross section.
9. Energy table.

Items 5–9 are tabulated as a function of energy in equal lethargy steps. The present programs allow for a maximum of 120 energies. Items 1, 3, 4 are tabulated for those energy steps in which they are applicable.
The SANE and SAGE programs are at present on magnetic tape and are called in through the IBM-7090 Monitor System. The programs contain intermediate dump and intermediate edit options. It is possible to obtain

an edit through the use of sense-switches although the input number of histories has not been processed. On line print-outs are available as sense-switch options.

In addition to the outputs previously discussed the programs will also deliver the following:

Standard deviations for each flux
Total absorptions for each radial region
Total degradations for each radial region
Total latents produced in each radial region
Total kills for each radial region
Total number of escapes.

5. Restrictions on complexity of problem: The present versions allow for 75 flux or physical regions and 40 output energy bins.
6. Typical running time: Time is a function of the statistical accuracy desired. Shields having attentuations of the order of $10^7$ have been fully studied (primary neutrons and gammas and secondary gammas) in approximately 80 min of 7090 time. An average collision time averaged over many different problems gives about 5 milliseconds per collision.
7. Status: Both programs are available through United Nuclear. Contact S. Preiser for information.

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