d. The breeding and conversion ratios are automatically defined by specifying certain nuclides as fissile in the depletion chain.

e. Power-density searches are available which adjust material compositions to achieve the desired system eigenvalue and specified ratios of maximum (or average) power densities in given search zones.

f. Nuclide depletion includes destruction by (n,α) and (n,p) reactions and production by $(n,2n)$.

g. The length of a depletion sequence may be determined by the maximum allowable burnup of certain material units, a minimum allowable concentration of certain nuclides or a minimum eigenvalue.

h. A wide variety of edits are available including extensive perturbation edits and the calculation of beta-effective, prompt-neutron lifetime, and prompt- and delayed-neutron worths.

i. The use of free format input directives allows the user great flexibility in specifying data and constructing sequences of calculations and edits.

8. Related and Auxiliary Programs: RETAP—A code for preparing a microgroup library for use by the FARED Code. The library tape generated by this program contains seven data files as follows:

   (1) Microgroup energies

   (2) Depletion chain descriptions

   (3) Resolved resonance data

   (4) Unresolved resonance data

   (5) Smooth cross sections and matrices

   (6) Fission spectra

   (7) Depletion, fission-product and delayed-neutron data.

   An update may be performed on an existing library to add or change nuclide data for any file.

9. Status: The program is currently in production use at Babcock & Wilcox. The following material is available from the Argonne Code Center:

   Magnetic Tape Transmittal:

FARED Source Deck	(15387 cards)
RETAP Source Deck	(3916 cards)
RETAP Sample Input	(16471 cards)
RETAP Sample Output	
FARED Sample Input	(79 cards)
FARED Sample Output	

   Reference Reports:

   Volume 1 - User's Manual

   Volume 2 - Listing of RETAP and FARED Codes

   Volume 3 - Listing of RETAP and FARED Sample Problem Output

   Volume 4 - Production Tests and Sensitivity Studies Using the FARED Code

10. Machine Requirements: CDC-6600 or equivalent machine with 142300_8 core storage. Sixteen tape drives or distinct disk files are needed in addition to the usual input and output devices and system requirements.

11. Programming Language: Standard CDC FORTRAN IV language is used with the exception of two short COMPASS machine language routines. The program is in overlay structure with three primary overlays and thirteen secondary overlays.

12. Operating System: CDC SCOPE 3.

13. Any Other Programming or Operating Information: The two COMPASS machine language routines are described in the Reference and are easily convertible to another machine language. Provision is made for varying the number of characters per word in the program.

14. *Acknowledgment*: This research was sponsored by the U.S. Atomic Energy Commission under contract number AT(30-1)-3867.

15. *References*:

[1]D. H. ROY, J. M. TILFORD, A. Z. LIVOLSI, P. N. COLPO, C. D. CARMICHAEL, and J. A. JACOBSEN, "Fast Breeder Static Physics Methods Development and Analysis Project," Vol. 1—FARED: One-Dimensional Fast Reactor Physics Design and Analysis Code; Vol. 2—Listing of FARED and RETAP Programs; Vol. 3—Listing of Sample Problem Output from RETAP and FARED Programs, BAW-3867-9 (October 1969).

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Received January 6, 1970

REPCDC

1. Name or Designation of Program: REPCDC.

2. Computer for Which Program is Designed and Others Upon Which it is Operable: CDC-6600.
   Programming Languages: FORTRAN IV, except for random number generators of CDC-6600 at BNL.

3. Nature of Physical Problem Solved: Monte Carlo calculation of Resonance Reaction Rates and Resonance Integrals in Reactor Lattices using ENDF/B data. Square or hexagonal lattices of cylindrical rods can be treated. The rods can be subdivided into annular regions at different temperatures. The library contains ^{238}U and ^{235}U as well as four isotopes of plutonium. The effect of temperature changes on the Monte Carlo estimates can be studied.

4. Method of Solution: Neutron trajectories are traced in the lattice over an energy interval specified in the input. Reaction rates are obtained from the neutron weight which is appropriately modified at each collision. The Breit-Wigner single level formula with interference scattering and Doppler broadening is used to calculate resonance cross sections, as specified in the ENDF/B manual.

5. Restrictions on the Complexity of the Problem: 5 Annular Regions. Neutron injection in proportion to slowing down power and assuming $1/E$ spectrum above maximum energy considered in the problem. Resonance integrals are calculated from reaction rates using constant slowing down power in each energy group. Resonances of structural and coolant materials are ignored.

6. Typical Running Time: The running time depends on the number of histories run, the atomic weight of the principal moderator nuclide, the number of resonance nuclides in the lattice and the number of resonances above and below the neutron energy used in the cross-section calculation. For a slightly enriched uranium-rod light-water-moderated lattice and using two resonance pairs spanning the neutron energy ~10 min CDC-6600 time are required for 10 000 histories.

7. Unusual Features of Program: Unresolved resonance routine uses a different resonance ladder in each history. s and p wave resonances can be included.

8. Related and Auxiliary Programs: Extends the REPETITIOUS code, brings it in line with ENDF/B procedures, uses Fortran IV.

9. Machine Requirements: 36K storage. One library tape.

10. Operating System or Monitor Under Which Program is Executed: CDC-6600 SCOPE 3.

11. Any Other Programming or Operating Information or Restrictions: Adaptation to IBM 360/65 available.

12. Material Available: Magnetic Tape (BCD Card Images) Source Deck, Library Deck, Reference Reports BNL-13851.

13. Category: Resonance Absorption of Neutrons.

14. Acknowledgment: This work was performed under the auspices of the U.S. Atomic Energy Commission.

15. *References:*

W. ROTHENSTEIN, Monte Carlo Code for the Calculation of Resonance Reaction Rates and Effective Resonance Integrals Based on ENDF/B Data (REPCDC) -BNL-13851, Brookhaven National Laboratory (July 1969).

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Received September 8, 1969

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LAPH

1. Name of Code: LAPH, Multigroup Photon Production Matrix and Source Vector Code for ENDF/B.
Auxiliary Routines: CHECKER, Format Syntax Checking Code for ENDF/B. PHOX, "Physics" Checking Code for Photon Production Data in ENDF/B. ETOL, A Code to Prepare an Input Tape for LAPH from One or More ENDF/B Data Tapes.

2. Coding Language and Computer: FORTRAN IV; CDC 6600.

3. Nature of Problem Solved: LAPH retrieves photon production cross sections or multiplicities and corresponding neutron interaction cross sections from the ENDF/B data file, applies suitable weighting functions over N specified neutron broad groups and G specified photon groups, and constructs a $G \times N$ photon production matrix. As an option, it operates on this matrix with flux vectors from a neutronics code, as well as with scalar multipliers such as atom number densities and effective photon group energies, to directly provide spatially dependent photon source vectors (number or energy) for transport calculations. Multiple zones can be accommodated, with separate cross-section weighting functions for each zone. Input is in the DTF-IV format and source vector output is also in this format, allowing direct coupling to DTF-IV. Complete freedom is allowed to pick those materials and reaction types for which photon production matrices are desired.

4. Method of Solution: LAPH first constructs photon production cross sections, pointwise in neutron and photon energy, from the ENDF/B data. These cross sections are then integrated over photon energy groups with either constant or direct energy weighting. After integrating over neutron energy in all neutron fine groups, weighting in neutron broad groups is by input fine-group weighting functions, usually the scalar fluxes from a fine-group neutronics calculation. At LASL, the MC^2 code has been modified to provide the weighting functions in the LAPH input format. Macroscopic photon production matrices and photon energy production matrices are then computed by scalar multiplication. Photon source vectors are computed by operating on these matrices with spatially dependent neutron flux vectors.

5. Restrictions or Limitations: The microscopic pointwise data must be in ENDF/B format. The code is presently restricted to 99 fine or broad groups, 49 photon groups, and 50 mixture specifications.

6. Typical Running Time: The central processor time for a sample problem with 3 regions, 6 materials, 10 mesh points, 26 neutron groups, and 11 photon groups, including calculation of both photon production matrices and source vectors, was 6 min.

7. Computer Hardware Requirements: (a) CDC 6600: 65 k_{10} words of memory; (b) One magnetic tape—the ENDF/B data tape is designated as tape 2. All other tapes are virtual tapes on disk.

8. Computer Software Requirements: The code runs under the SCOPE 3.2 System for the CDC 6600.

9. Contents of Code Package: The package contains the following items:

   a. the reference document

   b. a reel of magnetic tape with the following files:

      (1) a card-image copy of the BCD source deck

      (2) the sample problem input in BCD card image

      (3) the sample problem output in BCD card image

   c. a reel of magnetic tape with the ENDF/B data for the sample problem. This tape is the output tape from an ETOL run.