# Computer Code Abstract

## MACK-IV

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1. Program Identification: MACK-IV (Ref. 1), an expanded version of MACK (Ref. 2): A program to calculate nuclear response functions from basic nuclear data in the ENDF/B format.[3]

2. Description of Physical Problem Solved: MACK-IV calculates nuclear response functions important to the neutronics analysis of nuclear and fusion systems. A central part of the code deals with the calculation of the nuclear response function for nuclear heating, more commonly known as the kerma factor.[4] Pointwise and multigroup neutron kerma factors, individual reactions, helium, hydrogen, and tritium production response functions are calculated from any basic nuclear data file in the ENDF/B format. The program processes all reactions in the energy range from 0 to 20 MeV for fissionable and nonfissionable materials. The program also calculates the gamma production cross sections and the gamma production energy matrix. A built-in computational capability permits the code to calculate the cross sections in the resolved and unresolved resonance regions from resonance parameters in ENDF/B with an option for Doppler broadening. All energy pointwise and multigroup data calculated by the code can be punched, printed, and/or written on tape files. Multigroup response functions (e.g., kerma factors, reaction cross sections, gas production, atomic displacements, etc.) can be outputted in the format of a "MACK Activity Table" suitable for direct use with current neutron (and photon) transport codes.

3. Method of Solution: The neutron kerma factor, whose calculation is a central part of MACK-IV, is obtained by summing over all possible neutron reactions the product of the reaction cross section and the energy deposited in the reaction within a negligible distance from the site of collision. The energy deposited in a reaction is the sum of the kinetic energies imparted to the recoil nucleus and charged particles emitted. This is calculated from an energy balance that accounts for mass-to-energy conversion and the energies carried away from the site of collision by neutrons and secondary gamma rays. The kinetic energy of the neutrons is calculated from the angular or the energy distributions given in ENDF/B data files. The part of the reaction energy carried away with the gamma rays is calculated by one of two methods that can be selected by the user. In the first method, the gamma energy is calculated directly from information in the gamma production files of ENDF/B. In the second method, the gamma energy is deduced from solving all the nuclear kinematics equations (momentum as well as energy balance), assuming that direct information on gamma production is not available. The calculation of cross sections in the resonance region follows that of the NPTXS module in the AMPX system.[5] Multigroup kerma factors and cross sections are calculated using an arbitrary weighting function. The gamma production cross sections are calculated from the gamma production files in ENDF/B. The code ensures the consistency in preserving the energy in all phases of the nuclear heating calculations.

4. Related Materials: The program is self-contained, and no auxiliary programs are needed. A basic nuclear data library in ENDF/B format is required.

5. Restrictions: The main restriction is the availability of the computer core storage. The program utilizes the dynamic storage technique to save on core storage requirements.

6. Computer: IBM 370 models 195 and 158, UNIVAC-1110 (also compatible with CDC 7600 with minor modifications).

7. Running Time: The problem run time depends mainly on (a) number of resolved resonances, (b) size of the pointwise energy mesh, (c) method selected for calculating kerma factor, and (d) number of neutron and gamma energy groups. Typical central processor unit time is 1 to 3 min for nonresonance nuclides and 5 to 10 min for resonance nuclides on IBM 370/195 with 1000 energy points, 171 neutron groups, and 36 gamma energy groups.

8. Programming Languages: The code is written in FORTRAN-IV.

9. Operating System: Normal operating systems for the FORTRAN programs.

10. Machine Requirements: The central memory storage requirements vary but are typically within 400 to 800 K bytes. The input/output and temporary files vary from 4 to 13, depending on the problem.

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11. Material Available: Source program, test problems, results of executed test problems, and a program report. This package can be obtained through the Radiation Shielding Information Center at Oak Ridge National Laboratory and the Argonne Code Center at Argonne National Laboratory.

12. Acknowledgment: This work was supported by the U.S. Department of Energy, Office of Fusion Energy.

13. *References*

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