UCRL 6795-T

University of California

Ernest O. Lawrence Radiation Laboratory

Livermore, California

DISCLAIMER

UCRL-6795T

UNIVERSITY OF CALIFORNIA
Lawrence Radiation Laboratory
Livermore, California

Contract No. W-7405-eng-48

A CALCULATIONAL METHOD TO DETERMINE GAMMA HEATING IN INFINITE SOURCE MEDIA

Alex Lorenz

February 16, 1962

A CALCULATIONAL METHOD TO DETERMINE GAMMA HEATING IN INFINITE SOURCE MEDIA

Alex Lorenz

Lawrence Radiation Laboratory, University of California
Livermore, California

A time-independent technique to calculate gamma energy deposition in materials composing an infinite homogeneous medium containing a uniform source has been developed to study trends and effects in nuclear heating. The code utilizes cross section input in calculating probabilities of events or branching ratios, and energy down-scatter; these quantities determine the allocation of the photon energies of a given source spectrum to the constituent elements of the medium. With a capacity to handle 30 energy groups and 9 materials, a single problem runs a few seconds on the IBM 7090 computer.

The photons are considered to undergo three independent processes: compton scattering, photoelectric absorption, and pair production. An energy transfer matrix is employed to distribute the scattered energy in a manner required by the Klein-Nishina formula; the energy of the .51 Mev photons created in the pair production interaction is allocated to the appropriate energy group. A distribution of "available energy" is determined by summing the source and transferred energy within each group. The absorption of photons, and the allocation of their energies to the constituent atoms, is calculated directly from the "available energy" distribution and the absorption probabilities. All three photon interactions result in the emission of energetic electrons; it is assumed that their energy is absorbed by the respective materials involved in the particular interaction. This assumption is valid where the electron ranges are short compared to the dimensions of the test samples.

Summations from all absorptive processes performed over all energy groups for each material, normalized to the total energy input, yields gamma heating densities for each constituent material. The gamma flux spectrum in the medium is obtained by dividing the total energy absorbed in each group, summed over all materials, by the group absorption cross section.

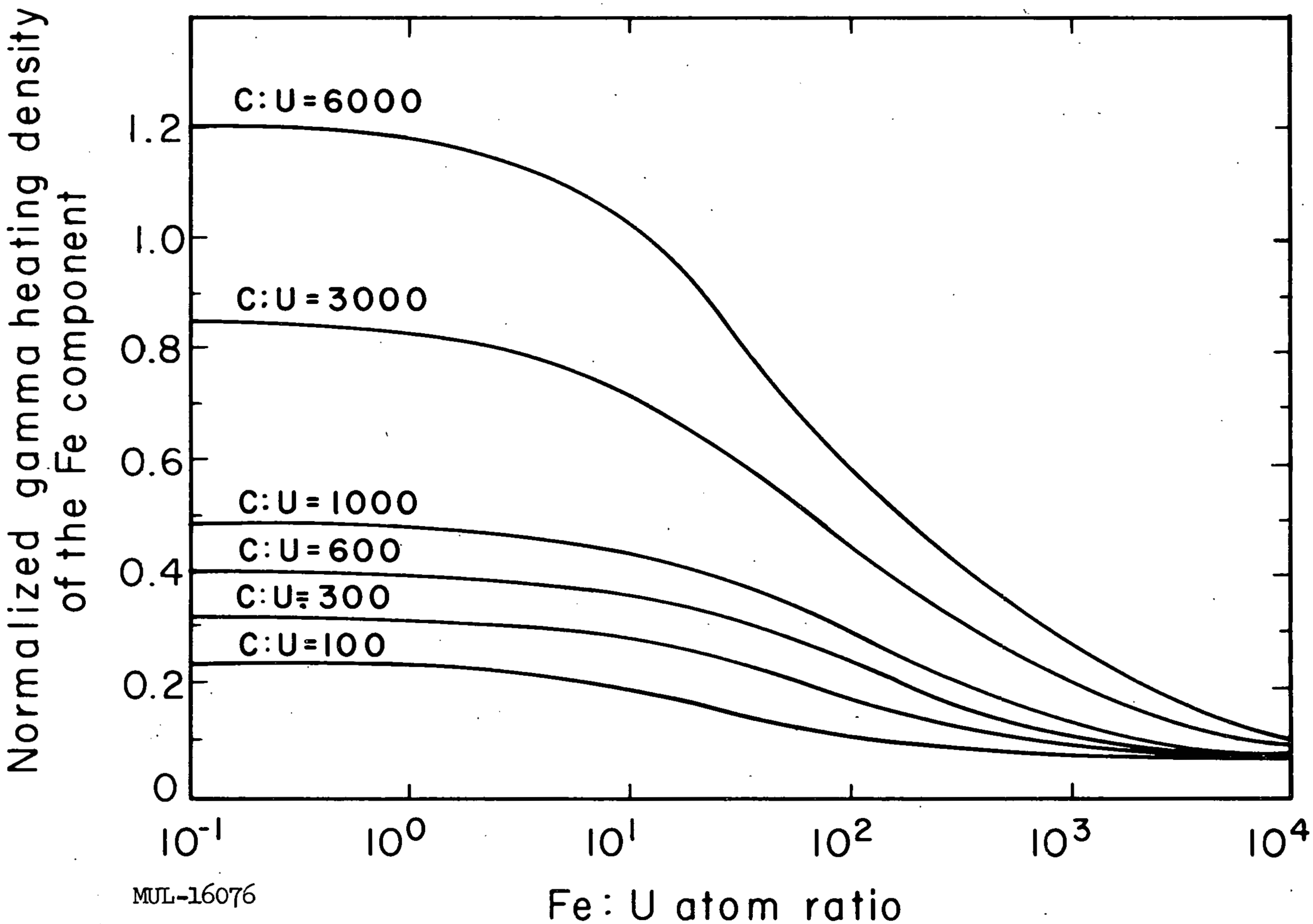
Two sample studies have been performed to illustrate the applicability of the method:

a) calculation of the effect of the variation of the C:U and Fe:U ratios in a C-U-Fe medium upon the heating of the iron component. The normalized gamma heating density as a function of the Fe:U atom ratio is given in the figure shown. Normalized gamma heating density is expressed in watts/cm^3 of solid material per watts/cm^3 in the source medium.

b) determination of the dependence of gamma heating on Z, the atomic number of a material, in a C-U medium. The results show that, for a sample element to uranium atom ratio of 10, the energy fraction absorbed by the test element has a $Z^{1.3}$ dependence.

A 30 group fission gamma spectrum of 15.14 Mev/fission, spanning the energy range between 0.01 and 10.0 Mev, was used in both cases.

The method has been extended to treat non-homogeneous media by application of self-shielding corrections to the cross sections.


C: U = 6000
C: U = 3000
C: U = 1000
C: U = 600
C: U = 300
C: U = 100
Normalized gamma heating density of the Fe component
1.2
1.0
0.8
0.6
0.4
0.2
0
10^-1
10^0
10^1
10^2
10^3
10^4
Fe: U atom ratio

MUL-16076