NASA TECH BRIEF

Lewis Research Center

An Empirical Relationship for the Penetration of 1 to 3 MeV Electrons

An empirical correlation for the penetration of high energy electrons into materials has been formulated from recently published experimental data. The correlation allows predictions of practical ranges (measure of electron penetration) for different elements and alloys.

A knowledge of the penetration of high energy electrons into a wide variety of materials is important in a number of otherwise unrelated technologies such as radiation shielding for extended earth orbit mission or radiation induced chemical processing. Often, the practical range, with only sufficient accuracy for an engineering estimate, is required for a material being considered for an application, and it is found that there are no available data. The well known Katz-Penfold range-energy equation accurately fits the published data on practical ranges in aluminum expressed in normalized units (i.e., gm/cm^2). However, the normalized units approach does not work well for predicting electron ranges in other materials.

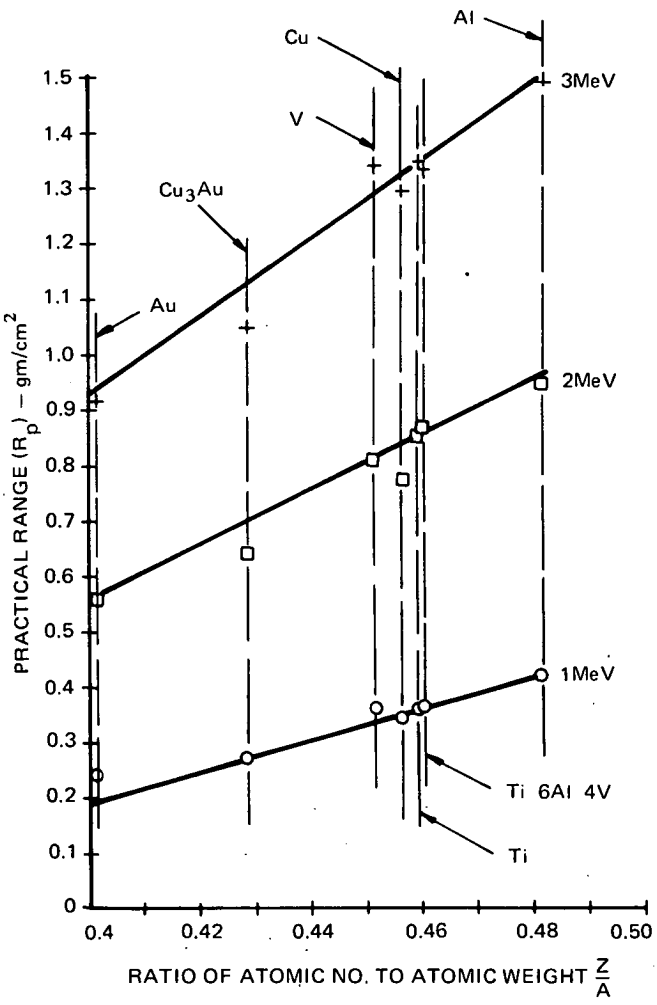
A solution to this problem was to make an empirical correlation of a set of recently published experimental values of practical range (R_p) in a number of elements (Al, Ti, V, Cu, Au) which were measured at half MeV intervals from 1 to 3 MeV. The results can be expressed in a simple algebraic equation as follows:

$$R_p\,(gm/cm^2) = E\left[2.096\,(Z/A) - 0.471\right] + 0.700\,(Z/A) - 0.453 \qquad (1)$$

where E is the electron energy in MeV, Z is the atomic number, and A is the atomic weight. The figure compares some of the experimental data with the values computed from equation (1). The mean deviation of the predicted values for all the elemental data is 4.4%. Since this empirical correlation is based on data for a wide variety of elements, it can be used with some confidence for determining R_p in all elements.

For alloys, an effective Z/A based on the weight percent of the constituent elements was found to be satisfactory as can be seen in the figure, specifically:

$$(Z/A)_{eff} = \sum_{i=1}^{N} f_i\,(Z/A)_i \qquad (2)$$



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where N is the number of constituent elements, f_i is the fraction by weight of the i th element, and $(Z/A)_i$ is the ratio of the atomic number to weight for the i th element.

Extrapolation of equation (1) above 3 MeV should be possible, with perhaps some loss in accuracy, since Katz and Penfold have found that a linear dependence of R_p with energy for aluminum analogous to equation (1) gives a good fit to the data from 2.5 MeV to 16.6 MeV.

Note:

No further documentation is available. Technical questions, however, may be directed to:

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Patent status:

No patent action is contemplated by NASA.

Source: F.R. Stevenson
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