REPORT OF THE UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION

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NOTE

Throughout the present report and the annexes thereto, references to the annexes are indicated by a letter followed by a number: the letter denotes the relevant annex and the number the paragraph therein. Within each annex, references to its scientific bibliography are indicated by numbers.

Symbols of United Nations documents are composed of capital letters combined with figures. Mention of such a symbol indicates a reference to a United Nations document.

ANNEX A

DEFINITIONS OF QUANTITIES, UNITS AND SYMBOLS

1. The Committee has used in the present report the radiological quantities and units defined in the 1959 report of the International Commission on Radiological Units and Measurements (ICRU),[1] the relevant part of which is reproduced below.* It should however be noted that ICRU has appointed an *ad hoc* committee to examine the quantities and definitions of units and some modifications of existing definitions may shortly be recommended.

"1.1. *Absorbed dose* of any ionizing radiation is the energy imparted to matter by ionizing particles per unit mass of irradiated material at the place of interest.

"1.2 The unit of absorbed dose is the *rad*. One rad is 100 ergs/g.

"1.3. *Integral absorbed dose* in a certain region is the energy imparted to matter by ionizing particles in that region.

"1.4. The unit of integral absorbed dose is the *gram rad*. One gram rad is 100 ergs.

"1.5. *Absorbed dose rate* is the absorbed dose per unit time.

"1.6. The unit of absorbed dose rate is the *rad per unit time*.

"1.7. *Exposure dose of X- or gamma radiation* at a certain place is a measure of the radiation that is based upon its ability to produce ionization.

"1.8. The unit of exposure dose of X- or gamma radiation is the *roentgen* (r). One roentgen is an exposure dose of X- or gamma radiation such that the associated corpuscular emission per 0.001293 g of air produces, in air, ions carrying 1 electrostatic unit of quantity of electricity of either sign.

"1.9. *Exposure dose rate* is the exposure dose per unit time.

"1.10. The unit of exposure dose rate is the *roentgen per unit time*.

"1.11. *Intensity of radiation* (radiant energy flux density) at a given place is the energy per unit time entering a small sphere centered at that place per unit cross-sectional area of the sphere.

"1.12. The unit of intensity of radiation may be *erg per square centimeter second*, or *watt per square centimeter*.

"1.13. The unit of quantity of radio-active material, evaluated according to its radio-activity, is the *curie* (c). One curie is a quantity of radio-active nuclide in which the number of disintegrations per second is 3.700×10^{10}.

"1.14. *Specific gamma-ray emission* (specific gamma-ray output) of a radio-active nuclide is the exposure dose rate produced by the unfiltered gamma rays from a point source of a defined quantity of that nuclide at a defined distance.

"1.15 The unit of specific gamma-ray emission is the *roentgen per millicurie hour* (r/mch) *at 1 cm*.

"1.16. *Linear energy transfer* (LET) is the linear-rate of loss of energy (locally absorbed) by an ionizing particle traversing a material medium.

"1.17. Linear energy transfer may be conveniently expressed in *kilo electron volts per micron* (kev/μ).

"1.18. *Mass stopping power* is the loss of energy per unit mass per unit area by an ionizing particle traversing a material medium.

"1.19. Mass stopping power may be conveniently expressed in *kilo electron volts per milligram per square centimeter* (kev cm^2/mg)."

2. According to ICRU:[1]

"The absorbed dose, D (in rads), of any radiation must be multiplied by an agreed factor, RBE (relative biological effectiveness), whose values for different radiations are laid down by the International Commission on Radiological Protection (ICRP). This product, called the RBE dose, is expressed in rems where

RBE dose (in rems) = (RBE) (D)

"In the case of mixed radiations the total RBE dose is assumed to be equal to the sum of the products of the absorbed dose of each radiation and its RBE.

"RBE dose (in rems) = Σ [(absorbed dose in rads) (RBE)]."

For the sake of simplicity in the present report 1 roentgen of X-, beta or gamma radiation is assumed to correspond to a tissue dose of 1 rad and, since the RBE of these radiations is conventionally unity, the tissue dose may also be expressed as 1 rem.

3. The RBE values that have been used in the present report are those established by ICRP in establishing protection standards. The table below gives the values of RBE for different types of radiation.[2] The ICRP Committee on RBE is currently examining the concept and use of RBE in radiation protection calculations and new recommendations may shortly be made.

* The following is quoted from the above-mentioned ICRU report:

"*Symbols and nomenclature*. There are numerous national and international bodies that have reached varying degrees of acceptance of the use of symbols and units for physical quantities. However, there is no universal acceptance of any one set of recommendations. It is suggested that each country modify the symbols used herein, in accordance with its own practices. Thus one may write: kev, keV, or Kev; ^{14}C or C^{14}; rad per unit time, rad per time, or rad divided by time; rad/sec, rad/s, or rad.s^{-1}; etc. The most generally accepted system of symbols and units may be that contained in document UIP 6 (1956) prepared by the International Union of Pure and Applied Physics. These are in fairly close agreement with the recommendations of the International Standardization Organization project ISO/TC 12, the Conférence Générale de Poids et Mesures, Union Internationale de Chimie Pure et Appliquée, and the International Electrotechnical Committee."

TABLE I. RBE VALUES

1. *X-rays, electrons and positrons of any specific ionization*

RBE = 1

2. *Heavy ionizing particles*

Average specific ionization (ion pairs per micron of water)	*RBE*	*Average linear energy transfer to water (kev per micron)*
100 or less	1	3.5 or less
100 to 200	1 to 2	3.5 to 7.0
200 to 650	2 to 5	7.0 to 23
650 to 1,500	5 to 10	23 to 53
1,500 to 5,000	10 to 20	53 to 175

For practical purposes, an RBE of 10 is applicable to fast neutrons and protons up to 10 MeV and an RBE of 20 to heavy recoil nuclei for whole-body irradiation and the most sensitive critical organs.

REFERENCES

1. Report of the International Commission on Radiological Units and Measurements (ICRU) (1959). National Bureau of Standards, Handbook 78.

2. Recommendations of the International Commission on Radiological Protection. Brit. J. Radiol. Suppl. No. 6 (1955).

back to first page