

UNITED NATIONS

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



GENERAL ASSEMBLY
OFFICIAL RECORDS : THIRTEENTH SESSION
SUPPLEMENT No. 17 (A/3838)



NOTE

Throughout this report and its annexes cross-references are denoted by a letter followed by a number: the letter refers to the relevant technical annex (see Table of Contents) and the number is that of the relevant paragraph. Within each technical annex, references are made to its individual scientific bibliography by a number without any preceding letter.

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ANNEXES

Annex A

DEFINITIONS OF QUANTITIES, UNITS AND SYMBOLS

1. The 1956 report of the International Commission on Radiological Units and Measurements¹ gives the following definitions of quantities and units used in radiological physics.*

"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 of unit cross-sectional area centred at that place.

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

* 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; ¹⁴C or C¹⁴; 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 (1955) 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.

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"1.13 The unit of quantity of radioactive material, evaluated according to its radioactivity, is the *curie* (c). One curie is a quantity of a radioactive 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 radioactive 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 cm²/mg)."

2. The RBE symbol is described in the I.C.R.U. report, in the following way:

"2.1 *RBE* (relative biological effectiveness) is used to compare the effectiveness of absorbed dose of radiation delivered in different ways. It has been commonly represented by the symbol η . It signifies that m rads delivered by a particular irradiation procedure produces a biological response identical with that produced by $m\eta$ rads delivered by a different procedure.

The statement that 'the RBE of α radiation relative to γ radiation is 10' signifies that m rads of α radiation produces a particular biological response in the same degree as 10m rads of γ radiation. This statement may be further summarized as $\eta_{\alpha}^{\gamma} = 10$.

The concept of RBE has a limited usefulness because the biological effectiveness of any radiation depends on many factors. Thus the RBE of two radiations cannot in general be expressed by a single factor but varies with many subsidiary factors, such as the type and degree of biological damage (and hence with the absorbed dose), the absorbed dose rate, the fractionation, the oxygen tension, the pH, and the temperature.

"2.2 *RBE dose* is equal numerically to the product of the dose in rads and an agreed conventional value of the RBE with respect to a particular form of radiation effect. The standard of comparison is X- or gamma radiation having a LET in water of 3 kev/ μ delivered at a rate of about 10 rad/min.

"2.3 The unit of RBE is the *rem*. It has the same inherent looseness as the RBE and in addition assumes conventional and not necessarily measured

values of RBE. It is therefore recommended that its use be restricted to statements relating to radiation protection. For example the statement might be made:

The permissible weekly whole body RBE dose is 0.3 rem regardless of the type of radiation to which a person is exposed.

Should occasion arise when results have been evaluated with other than agreed conventional values of RBE, the values used should be clearly stated.

In the case of mixed radiations the 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) \times RBE]."

REFERENCE

1. International Commission on Radiological Units and Measurements (ICRU): Report of the ICRU, 1956. U.S. National Bureau of Standards, Handbook 62, Washington 1957.

Appendix

LIST OF SCIENTIFIC EXPERTS

The scientific experts who have taken part in the preparation of the report while attending Committee sessions as members of national delegations are listed below. The Committee must also express its appreciation to the many individual scientists not directly connected with national delegations whose voluntary co-operation and good will contributed in no small measure to the preparation of the report.

ARGENTINA :

Dr. C. Nuñez (*Representative*)
Dr. D. J. Beninson
Professor E. Favret
Dr. N. Nussis
Dr. J. A. Olarte

AUSTRALIA :

Dr. C. F. Eddy (*Representative—first session*)
Mr. D. J. Stevens (*Representative*)
Dr. A. R. W. Wilson

BELGIUM :

Professor Z. Bacq (*Representative*)
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Dr. M. Errera
Professor F. Twisselman

BRAZIL :

Professor C. Chagas (*Representative*)
Dr. B. Gross
Professor N. Libanio
Professor C. Pavan
Father F. X. Roser, S.J.

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Dr. Colin Hunter
Dr. G. H. Josie
Dr. C. A. Mawson
Dr. H. B. Newcombe
Dr. F. D. Sowby

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Professor F. Běhounek
Dr. M. Hašek
Dr. L. Novák
Professor V. Sobek
Dr. I. Ulehla
Dr. V. Zelený

EGYPT*

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Dr. H. T. Daw

FRANCE :

Professor L. Bugnard (*Representative*)
Dr. A. Allisy
Dr. J. Coursaget
Dr. H. Jammet
Dr. J. Labeyrie
Dr. J. Lejeune

INDIA :

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Dr. A. S. Rao

JAPAN :

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Dr. M. Nakaidzumi
Mr. S. Ohta
Dr. N. Saito
Dr. E. Tajima

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Dr. F. A. Andrade
Dr. H. Zalce

SWEDEN :

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Dr. B. A. A. Aler
Dr. R. G. Björnerstedt
Professor G. Bonnier
Professor T. O. Caspersson
Professor C. A. T. Gustafsson
Dr. A. G. A. Nelson

* Now in the United Arab Republic.

UNION OF SOVIET SOCIALIST REPUBLICS:

Professor A. V. Lebedinsky (*Representative*)
Professor K. K. Aglintsev
Professor B. M. Isaev
Professor P. M. Kireev
Professor A. N. Kraevsky
Professor A. M. Kuzin

UNITED KINGDOM OF GREAT BRITAIN AND
NORTHERN IRELAND

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first session*)
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Dr. T. C. Carter
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Professor Th. Dobzhansky
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Dr. J. H. Harley
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