ERHS PHYSICS

DOSIMETRY: measuring radiation

There are FOUR different domains of describing relative radiation contact by man: SOURCE ACTIVITY, EXPOSURE, ABSORPTION, and TISSUE DAMAGE. The various units for each area are given below:

SOURCE ACTIVITY:

This is the emission rate of radiation from a radioactive source. It does not apply to man if no man is present. Source activity can be regarded as the rate of disintegration of a radioactive source (rate of decrease in the number of radioactive nuclei present).

The current unit of disintegration is the Curie (Ci), and is roughly equivalent to the rate of disintegration of one gram radium:

$1\ Ci = 3.7 \times 10^{10}$ disintegrations/second

One Ci is a large amount of radiation, and sources emitting radiation in this degree must be shielded. Often the microcurie (mCi) is used.
The S.I. system uses a different unit, the Becquerel (Bq) which is one disintegration per second . kBq and MBq are often used to express the radioactivity of a source. This unit does not make any distinctions between the effects of different types of radiation.

$1\ \text{curie (Ci)} = 3.7 \times 10^{10}$ Bq

EXPOSURE :

Exposure indicates the amount of ionizing radiation which reaches a target area, such as a man, and does not reflect how much actually penetrates. Exposure is defined only for X-rays and gamma rays up to 3 MeV and not for other forms of radiation. Exposure really measures the ionization produced by radioactivity. The unit is the Roentgen such that:

$1\ \text{Roentgen (R)} = 2.58 \times 10^{-4}$ Coulomb/kilogram

Thus, 1 R of X-rays will produce 2.58×10^{-4} C of positive ions in a kilogram of dry

air at STP, and an equal amount of negative ions.

ABSORBED DOSE:

Being in an environment where radiation is present, and having that radiation be absorbed into your body are two different things. When your body does absorb radiation, it is the energy which is measured (since it is the absorbed energy which will do tissue damage such as burning). It refers to a physical effect: the transfer of energy to a material. The older unit here is the rad , where

1 rad = 0.01 Joule per kilogram

A 1 Roentgen exposure to X-rays will result in an absorbed dose of about 1 rad. Living tissue exposed to 100 rads is completely destroyed. The newer unit, the Gray (Gy) is the official S.I. unit and is equivalent to 100 rads (1 Joule/kg). Bq and Gy are slowly replacing curies and rads in the scientific language.

TISSUE DAMAGE:

The biological damage produced on a given organism is called the dose equivalent , measured in Sieverts (Sv) in the SI system. Once radiation energy is absorbed, the actual damage to body tissues depends upon the type of radiation. Fast neutrons are 10 times more damaging than 200 keV X-rays (the standard). Fast neutrons are said to have a quality factor (QF) of 10. Beta particles have a QF of 1, and alpha particles have a QF of between 10 and 20. In order to equate all these different values of damage, the older Rem unit is often still used. One Rem of radiation from any source produces the same degree of damage, and is calculated by multiplying the rad value by the QF. Rem stands for Rad-equivalent-man and is also called the biologically equivalent dose. The unit in the S.I. system is the Seivert which is produced by multiplying the dose in Grays times the QF.

1 Sv = 100 rem = 10^5 mrem
(rem -- rad equivalent man)
dose equivalent(Sv) = absorbed dose(Gy) x a quality factor(Q)

Coulomb = 6.24 x 10^{19} elementary charges
eV = 1.6 x 10^{-19} Joule

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