

## Schedule II Mathematic Formulas used in the Standards

### 1. Activity

The quantity A for an amount of radionuclide in a given energy state at a given time, defined as:

$$A = \frac{dN}{dt}$$

where dN is the expectation value of the number of spontaneous nuclear transformations from the given energy state in the time interval dt. The SI unit of activity is the reciprocal second (s<sup>-1</sup>), termed the becquerel (Bq).

### 2. Absorbed dose

The fundamental dosimetric quantity D, defined as:

$$D = \frac{d\bar{\varepsilon}}{dm}$$

where  $d\bar{\varepsilon}$  is the mean energy imparted by ionizing radiation to matter in a volume element and dm is the mass of matter in the volume element. The SI unit of absorbed dose is the joule per kilogram (J · kg<sup>-1</sup>), termed the gray (Gy).

### 3. Fluence (Φ)

The quotient of dN by da, where dN is the number of particles incident on a sphere of cross-sectional area da. The unit of fluence is m<sup>-2</sup>.

$$\Phi = dN/da : \text{Fluence}$$

$$\dot{\Phi} = d\Phi/dt : \text{Fluence rate}$$

### 4. Equivalent dose

The quantity H<sub>T,R</sub>, defined as:

$$H_{T,R} = D_{T,R} \cdot W_R$$

where D<sub>T,R</sub> is the absorbed dose delivered by radiation type R averaged over a tissue or organ T and W<sub>R</sub> is the radiation weighting factor for the radiation type R. When the radiation field is composed of different radiation types with different values of W<sub>R</sub>, the equivalent dose is:

$$H_T = \sum_R W_R \cdot D_{T,R}$$

The unit of equivalent dose is J · kg<sup>-1</sup>, termed the sievert (Sv).

### 5. Effective dose

The quantity E, defined as a summation of the tissue equivalent doses, each multiplied by the

appropriate tissue weighting factor:

$$E = \sum_T W_T \cdot H_T$$

where  $H_T$  is the equivalent dose in tissue T and  $W_T$  is the tissue weighting factor for the tissue T.

From the definition of equivalent dose, it follows that:

$$E = \sum_T W_T \cdot \sum_R W_R \cdot D_{T,R}$$

where  $W_R$  is the radiation weighting factor for the radiation R and  $D_{T,R}$  is the average absorbed dose in the organ or tissue T. The unit of effective dose is  $J \cdot kg^{-1}$ , termed the sievert (Sv).

## 6. Committed equivalent dose

The quantity  $H_T(\tau)$ , defined as:

$$H_T(\tau) = \int_{t_0}^{t_0+\tau} \dot{H}_T(t) dt$$

where  $t_0$  is the time of intake,  $\dot{H}_T(t)$  is the equivalent dose rate at time t in an organ or tissue T and  $\tau$  is the time elapsed after an intake of radioactive substances. When  $\tau$  is not specified, it will be taken to be 50 years for those of age over 17, and to age 70 for those 17 or younger. The unit of committed equivalent dose is  $J \cdot kg^{-1}$ , termed the sievert (Sv).

## 7. Committed effective dose

The quantity  $E(\tau)$ , defined as:

$$E(\tau) = \sum_T W_T H_T(\tau)$$

where  $H_T(\tau)$  is the committed equivalent dose to tissue T over the integration time  $\tau$ . When  $\tau$  is not specified, it will be taken to be 50 years for those of age over 17, and to age 70 for those 17 or younger. The unit of committed effective dose is  $J \cdot kg^{-1}$ , termed the sievert (Sv).

## 8. Collective effective dose

The total effective dose S to a population, defined as:

$$S = \sum_i \bar{E}_i \cdot N_i$$

where  $\bar{E}_i$  is the average effective dose in the population subgroup i and  $N_i$  is the number of individuals in the subgroup. It can also be defined by the integral:

$$S = \int_0^\infty E \frac{dN}{dE} dE$$

where  $\frac{dN}{dE} dE$  is the number of individuals receiving an effective dose between E and E+dE. The

unit of collective effective dose is man · Sv.

## 9. Personal dose equivalent

The quantity defined for both strongly and weakly penetrating radiations as  $H_p(d)$ , the dose equivalent in soft tissue below a specified point on the body at an appropriate depth  $d$ . The relevant depths for the purposes of the Standards are generally  $d=10$  mm for strongly penetrating radiation,  $d=0.07$  mm for weakly penetrating radiation, and  $d=3$  mm for the lens of the eye. The unit of personal dose equivalent is  $J \cdot kg^{-1}$ , termed the sievert (Sv).

## 10. Ambient dose equivalent

The quantity  $H^*(d)$  at a point in a radiation field, defined as the dose equivalent that would be produced by the corresponding aligned and expanded field in the ICRU sphere at a depth  $d$  on the radius opposing the direction of the aligned field. This is an operational quantity introduced by the ICRU for the purpose of area monitoring. The recommended depths are  $d=10$  mm for strongly penetrating radiation,  $d=0.07$  mm for weakly penetrating radiation and  $d=3$  mm for the lens of the eye. The unit of ambient dose equivalent is  $J \cdot kg^{-1}$ , termed the sievert (Sv).

## 11. Directional dose equivalent

The quantity  $H'(d, \Omega)$  at a point in a radiation field, defined as the dose equivalent that would be produced by the corresponding expanded field in the ICRU sphere at a depth  $d$  on a radius in a specified direction  $\Omega$ . This is an operational quantity introduced by the ICRU for the purpose of area monitoring. The recommended depths are  $d=10$  mm for strongly penetrating radiation,  $d=0.07$  mm for weakly penetrating radiation and  $d=3$  mm for the lens of the eye. The unit of directional dose equivalent is  $J \cdot kg^{-1}$ , termed the sievert (Sv).

## 12. Organ dose

The mean dose  $D_T$  in a specified tissue or organ  $T$  of the human body, given by:

$$D_T = (1/m_T) \int_{m_T} D dm$$

where  $m_T$  is the mass of the tissue or organ and  $D$  is the absorbed dose in the mass element  $dm$ . The unit of organ dose is  $J \cdot kg^{-1}$ , termed the gray (Gy).

## 13. Kerma

The quantity  $K$ , defined as:

$$K = \frac{dE_{tr}}{dm}$$

where  $dE_{tr}$  is the sum of the initial kinetic energies of all charged ionizing particles liberated by

uncharged ionizing particles in a material of mass  $m$ . The SI unit of kerma is the joule per kilogram ( $\text{J} \cdot \text{kg}^{-1}$ ), termed the gray (Gy).

#### **14. Working level**

A unit for potential alpha energy concentration (i.e. the sum of the total energy per unit volume of air carried by alpha particles emitted during the complete decay of each atom and its progeny in a unit volume of air) resulting from the presence of radon progeny or thoron progeny equals to emission of  $1.3 \times 10^5$  MeV of alpha energy per liter of air. In SI units, the WL corresponds to  $2.1 \times 10^{-5} \text{ J} \cdot \text{m}^{-3}$ .

#### **15. Working level month (WLM)**

A unit of exposure to radon progeny or thoron progeny.

$$1 \text{ WLM} = 170 \text{ WL} \cdot \text{H}$$

One working level month is equivalent to  $3.54 \text{ mJ} \cdot \text{h} \cdot \text{m}^{-3}$ .