University of Aberdeen

Ionising Radiation Safety Arrangements

APPENDIX 1 Radiation risk and dose units

Version 3

May 2017

Authorised by Radiation Hazards Sub Committee

APPENDIX 1

Radiation risk and dose units

The laws that govern and promote the safe use of ionising radiation have been written on the premise that for any dose of ionising radiation there is a detrimental effect and the greater the dose the grater the effect.. Radiation affects can be divided into **Deterministic effects** and **Stochastic effects.**

Deterministic effects only occur above a certain dose threshold and include radiation burns, radiation sickness and radiation induced cataracts. Dose limits for UK workers have been set below the threshold where these effects occur and it would be extremely unlikely if anyone undertaking work within the University will experience a deterministic radiation effect as long as local rules and other safety procedures are followed.

Stochastic effects are not certain to occur but as exposure to ionising radiation increases the probability of experiencing a stochastic effect will increase. The stochastic effect we are mainly concerned with is cancer induction. Radiation protection arrangements within the University have been develop to reduce the risk of stochastic effects to a acceptable level.

Quantifying radiation dose can be a complex subject; even the number of different radiation units that have been defined is confusing. The sections below describe three units for quantifying radiation dose that will be of use when considering radiation doses.

Absorbed dose

The absorbed dose, the energy absorbed by a medium from the radiation beam. The absorbed dose is a measure of the energy deposited in the medium. Absorbed dose is measured in Grays defined as Joules per kilogram (J/Kg)

Equivalent dose

Although absorbed dose is a very useful quantity it does not reflect the amount of biological damage caused. It has been found that 0.05 Gy of alpha particles can do as much biological damage as 1 Gy of gamma radiation. The quantity that has been defined to take this into account this is known as the equivalent dose. The equivalent dose is simply the absorbed dose multiplied by a radiation-weighting factor (wR) which reflects the ability of a particular type a radiation to cause biological damage. Equivalent doses are measured in sieverts (Sv).

$$\text{equivalent dose (Sv)} = \text{absorbed dose (Gy)} \times \; w_R$$

Table A1.1 lists the various weighting factors If we are considering the radiation dose to a single organ such as the eye or skin then we used equivalent dose.

Type of radiation	wR
X-rays, γ-rays and electrons	1
Protons	5
Thermal neutrons	5
Fast neutrons	5-20*
α-particles	20

*Depending on energy

Table A1.1 - radiation weighting factors

Effective dose

Different organs and tissues have different sensitivities to radiation. Also the body is not always uniformly exposed. The measurement that takes into account these effects is termed effective dose. Each tissue or organ is given a weighting factor w_T depending on the susceptibility of that organ and the total effective dose is calculated as:

$$E_{eff} = \sum_T D_T w_T$$

Where D_T is the equivalent dose in tissue T. Table 3 lists the various tissue weighting factors:

Organ/tissue	Weighting factor w_T
Gonads	0.08
Red bone marrow	0.12
Colon	0.12
Lungs	0.12
Stomach	0.12
Bladder	0.04
Breast	0.12
Liver	0.04
Oesophagus	0.04
Thyroid	0.04
Skin	0.01
Bone surfaces	0.01
Remainder	0.12
TOTAL	1.00

Table A1.2 - Tissue weighting factors.
Taken from ICRP report 103

Effective dose is a measure of risk, an effective whole body dose of 1Sv corresponds to a risk of cancer induction of approximately 1 in 20. The limit for UK workers is 20mSv per year which corresponds to a risk of approximately 1 in 1000. These risk factors are averaged over a large population of all age groups and gender and should not strictly speaking be used to quantify radiation risk to individuals.