RADIOLOGICAL COUNCIL

RADIATION SAFETY ACT
RADIATION SAFETY (QUALIFICATIONS) REGULATIONS 1980

INDUSTRIAL RADIOGRAPHY ASSISTANTS EXAMINATION SYLLABUS

Examinees for the Industrial Radiography Assistants Examination are expected to know general principles of radiation safety matters as well as the requirements of the Act and regulations relating to the possession, transportation, storage, disposal and use of radioactive substances and to the use of equipment capable of producing ionising radiation.

The examination comprises two sections:-

- Core Paper – closed book, one hour multiple choice examination covering general radiation safety; and
- Main Paper – Open book, one hour multiple choice and short answer written paper covering the safe use of industrial radiography equipment.

1. CORE PAPER

Legislation - Radiation Safety Act 1975
- Radiation Safety (General) Regulations 1983

Dose limits - radiation workers
- non radiation workers

Radiation types and properties
Background radiation
Quantities & units of measurement
Biological effects
Radiation risk
Basic radiation safety calculations
Inverse square law
Pro rata dose calculations
Personal radiation monitoring
Principles of protection

1.1 Types of radiation

- Ionising radiation: radiation with sufficient energy to knock electrons out of atoms, thereby having the potential to cause biological damage. Examples include alpha and beta particles, neutrons, protons, cosmic rays, and sufficiently energetic electromagnetic radiation such as x-rays and gamma rays.
- The electromagnetic (e-m) radiation spectrum (in increasing order of energy): radio, microwave, infrared light, visible light, ultraviolet light, x- and gamma rays.
- Ionisation threshold for electromagnetic radiation: e-m radiation that is less energetic than ultraviolet light will not cause ionisation.

1.2 Radiation dose

- Absorbed dose: measures the amount of energy deposited by ionising radiation in a given mass. SI unit: joules per kilogram (J/kg), also called grays (Gy).
- Effective dose: measures the biological detriment (i.e. damage) caused by a given absorbed dose. It is calculated by multiplying the absorbed dose by factors that account for the damaging power of the radiation and the susceptibility of the organs that have been irradiated. SI unit: sieverts (Sv).
- Natural background radiation dose: typically about 2000 μSv per year. Sources of background radiation include naturally occurring radioactive materials (some of which occur within the human body) and cosmic radiation. Artificially produced radiation such as generated by an x-ray machine or a nuclear reactor is not classified as background radiation.

1.3 Biological effects of ionising radiation

Ionising radiation can cause the following biological effects:

- Cancer. The risk of developing cancer is considered to increase with radiation dose, apparently without a threshold. That is, any dose, however small, is assumed to carry an associated risk.
- Genetic damage. The risk of genetic defects is considered to increase with radiation dose, apparently without a threshold.
- Cell damage. Living cells can be damaged by radiation, and will die if overexposed.
- Burns. Burns will occur when a threshold absorbed dose (about 3 Gy) is exceeded.
- Death. The lethal whole body effective dose is considered to be about 5 Sv. A majority of people who receive a dose of this magnitude over a relatively short time span will die from cell damage caused by the radiation. A corresponding absorbed dose delivered to only part of the body will probably cause burns but will not necessarily be lethal.

1.4 Dose limits

A dose limit is the maximum amount of radiation (above natural background) that a person is legally permitted to receive. The following dose limits were recommended by the International Commission for Radiological Protection in 1990 and adopted as a legal requirement in Western Australia:

- Radiation workers: 20 mSv per year, averaged over any 5 year period, with a maximum of 50 mSv in any one year.
- Members of the public: 1 mSv per year, averaged over any 5 year period, with a maximum of 5 mSv in any one year.

1.5 Dose calculations

Multipliers

micro (μ): one millionth.
milli (m): one thousandth.

e.g. 10 Sv = 10,000 mSv = 10,000,000 μSv.

Dose = dose rate x time

Note: Dose rate is dose received per time unit.

Ex. 1. What is the radiation dose received by a person exposed to a dose rate of 2.5 μSv per hour for one working week? (Assume that a working week has 40 hours.)

Dose = 2.5 μSv/h x 40 h = 100 μSv (hours cancel out to leave μSv)

Ex. 2. What radiation dose is received by a person exposed to 100 μSv per week for one working year? (Assume that a working year has 50 weeks.)

Dose = 100 μSv/week x 50 weeks = 5000 μSv (weeks cancel out to leave μSv)

Ex. 3. The Radiological Council has set a dose constraint of 2 mSv per year for some radiation workers. What weekly dose corresponds to this constraint? (Assume that a working year has 50 weeks.)

2 mSv = **?** mSv/week x 50 weeks (What number multiplied by fifty equals two?)
? = 2/50 = 4/100 = 0.04 mSv/week = 40 μSv/week.

Inverse square law

The intensity of radiation from a point source[1] decreases as the square of the distance from the source. For example, the intensity of radiation 2 m from a point source will be one quarter (½ x ½) of the intensity at 1 m, the intensity at 3 m will be one ninth (⅓ x ⅓) of the intensity at 1 m, and so on.

The following mathematical formula may be used for inverse square law calculations.

$$I(d) = I(d_{ref}) \times (d_{ref} / d)^2$$

In words, the intensity of radiation at a distance of d metres is the intensity at a reference distance of d_{ref} metres multiplied by a factor to account for distance. This factor is the *inverse* of the *square* of the relative distances of d and d_{ref} from the source. The reference distance is the distance at which the radiation intensity is known.

The same formula can be used to calculate doses and dose rates.

E.g. The dose rate 1 m from a radiation source is 40 μSv/h. What is the dose rate 2 m from the source?

In this case, the dose rate at one metre is known. Hence, d_{ref} is 1 m. The other distance, d, is 2 m.

[1] A radiation source can be considered to be a point if its maximum dimension is less than one tenth of the distance under consideration. Therefore, for an x-ray tube with a focal spot of 2 mm diameter, the inverse square law will work for distances of more than 2 cm from the focus.

Dose rate at 2 m = Dose rate at 1 m x (1 m / 2 m)^2 = 40 μSv/h x (1/4) = 10 μSv/h

1.6 Radiation protection

Three principles are employed to protect an individual from radiation exposure:

- *Decrease* ***time***: decreasing exposure time results in a proportional dose reduction;
- *Increase* ***distance***: increasing the distance between the radiation source and the individual results in a dose reduction that can be calculated by the inverse square law; and
- *Increase* ***shielding***: increasing the amount of shielding between the radiation source and the individual results in a dose reduction that can be calculated by considering the thickness of the shielding material.

It is worth memorising the phrase 'time, distance, shielding'.

1.7 Radiation monitoring

The regulations and the Radiation Safety Act require designated radiation workers to be monitored for radiation exposure. Monitoring is achieved by means of personal dosimeters such as film badges, TLD badges, OSL badges, and integrating dosimeters. Meters which measure dose rate (e.g. geiger counters) are *not* personal dosimeters. A radiation worker's employer is responsible for maintaining a record of the radiation doses received by each person employed. Personal dosimeters can be obtained by contacting a personal radiation monitoring service provider. A list of such service providers is available from the Radiological Council.

2. WRITTEN PAPER

2.1 Awareness of the Radiation Safety Regulations

Who is permitted to use radioactive substances / x-ray equipment.
Who must supervise assistants and the degree of supervision required.
Who could be prosecuted if assistants are not correctly supervised.
Who must wear a TLD, how they are used, and who must keep records.
Who must use an audible alarm and a survey meter.

2.2 Awareness of Transport Regulations

Who is allowed to transport radioactive substances.
Basic requirements for transport.

2.3 Awareness of NH&MRC Code of Practice

Working Rules and Emergency Procedures.
Radiation levels at boundaries.
Dose limits for workers/public.
Safety equipment required to be taken to a site.

2.4 Radiation Physics

Exposure rate from an Ir-192 source.
ALARA Principle.
Understanding of ionising radiation, gamma and x-radiation.
Absorbed dose.
Quality factor.
Dose equivalent.
Effect of different radiation doses on the body.
Three principles of radiation protection.
Environmental radiation / natural background.
Units of measurement - SI units.
Half Life.

2.5 Calculations

Inverse Square Law.
Exposure/time/distance calculations.

EXCLUSION

This syllabus does not relate to the actual manipulation of radioactive sources such as may be involved in loading of sources into source housings and the repair of defective housings containing sources.

Once approved, an industrial radiography assistant must work under the direction and immediate personal supervision of a licensed industrial radiographer, that is, the licensee must be present for all radiographic exposures made by assistants. All radiographic exposures must cease should the licensee be absent even if only temporarily for reasons such as film processing, image quality review, etc.