

IONISING RADIATION

We live in a world of radiation

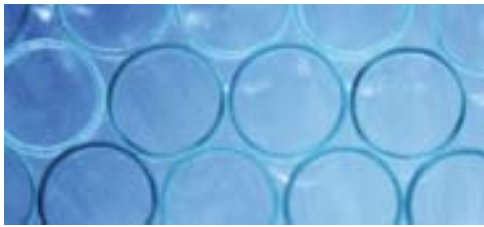
Ionising radiation comes from many sources, including outer space, the sun, the rocks and soil beneath our feet, the buildings we live in, the air we breathe, the food and drink we ingest and even our own bodies.



NUCLEAR MEDICINE SAVES LIVES

Nuclear medicine uses ionising radiation to diagnose and treat illnesses such as cancer and heart disease.





IONISING RADIATION

We live in a world of radiation

Radiation is all around us all day, every day. It sustains our lives. We see because our eyes detect and analyse the radiation we call light. Infra-red radiation, whether from the sun or from a glowing fire, keeps us warm. We often cook with microwaves. Radio waves allow us to communicate sound or pictures over huge distances. Ultra-violet radiation can be used for sterilising medical equipment. All living things rely on some form of radiation for their existence.

In the twentieth century, we recognised a type of radiation known as ionising radiation. This naturally occurring radiation comes from many sources, including outer space, the sun, the rocks and soil beneath our feet, the buildings we live in, the air we breathe, the food and drink we ingest and even our own bodies. These sources combine to give us our naturally occurring background radiation dose. In Australia the average background radiation dose is approximately 1.5 mSv per year.

Cosmic radiation dose rates at different altitudes

Supersonic aircraft

15,000 m
13 µSv per hour

International air travel

8,000 m
3.7 µSv per hour

La Paz, Bolivia

(highest city)
3,900 m
0.23 µSv per hour

Mexico City

2,240 m
0.09 µSv per hour

Sea level

0.03 µSv per hour

RADIATION DOSES

1000 microsieverts (µSv) =

1 millisievert (mSv)

1000 millisieverts = 1 sievert (Sv)

Ionising radiation and radioactive materials are widely used in medicine, industry, agriculture, environmental studies, pollution control and research. These uses benefit each of us individually and the Australian community as a whole.

Humans have increased their radiation dose through a variety of activities. One is living indoors. In surrounding ourselves with bricks and mortar, we increase the concentration of a radioactive gas called radon in the air we breathe. Radon arises naturally from the radioactive decay of uranium and thorium, normally present in rocks, soil, bricks, mortar, tiles and concrete.

Reducing ventilation in order to conserve energy may increase radon concentrations even further. Using bore water, especially in a hot shower or in thermal springs, also increases your radiation dose.

Another source of radiation is medical use – X-rays in radiography and tomography and radioactivity in nuclear medicine. Some therapeutic uses of radiation give a dose to certain organs many times higher than our annual background radiation dose.

Small extra doses of radiation occur in a number of ways. The higher you go, the less shielding the atmosphere affords from cosmic rays. On a mountain top the air may be cleaner, but the radiation dose is higher. Air travel increases radiation dose; astronauts receive even higher doses. Fallout from atmospheric nuclear testing in the 1950s and 1960s is still present in the environment. Many industries release otherwise locked-in radioactivity into the environment. This is especially true of coal-burning plant, and to a lesser extent the fertiliser, mining and building industries.

Other common sources of radiation are some older luminescent clocks, watches, compasses and gunsights, exit signs, certain paints and pigments, dental porcelain, fire alarms, smoke detectors and television sets. Their contribution to our radiation exposure is very small.

Although some radiation is capable of travelling large distances, it may be stopped by appropriate absorbers. Starlight traverses galaxies, but may be stopped by a piece of paper. Radio waves, too, are capable of travelling great distances, but may be absorbed by materials such as metals. Like light, ionising radiation travels in straight lines until absorbed or deflected. The material used to absorb ionising radiation depends on the type and energy of the radiation.

Cancer risk

Risk estimates for cancer following exposure to ionising radiation are the subject of ongoing detailed studies. Existing estimates are based largely on information of the cancer rates in the survivors of the atom bombs at Hiroshima and Nagasaki and a few other groups of people subjected to single or multiple doses of large size given quickly.

Present evidence indicates that the damaging after-effects of radiation exposure are greatly reduced when the dose is delivered in small amounts spread over a long time period. Nevertheless, for the purposes of radiation protection, it is assumed that any radiation dose, however small, can have some effect and protective measures are put in place for radiation workers. International studies of large groups of workers in the nuclear industry (who receive low doses spread over several years) generally agree with existing risk estimates.

A local study was completed for workers at Sydney's Lucas Heights Science and Technology Centre using data from workers employed between 1957 and 1998. Analysis showed that the mortality rate from all causes was approximately 30% lower than that for the Australian population and incidence rates were approximately 20% and 15% respectively below the NSW rates.¹

There are a number of locations in the world in countries such as Brazil, India, China, France and Russia where the external natural background exposure is very high, being 10 to 15 times the Australian background level. Studies in these areas have not detected higher cancer rates. Current international risk estimates indicate an overall lifetime chance of dying of radiation-induced cancer as roughly one in two hundred. Compare this with the fact that one in every four females and one in every three males in Australia will develop cancer in the normal course of a lifetime.

¹ The Retrospective Cohort Study of Cancer Incidence and Mortality among Nuclear Industry Workers at Lucas Heights Science and Technology Centre Rima R Habib 2001

IONISING RADIATION

QUESTIONS AND ANSWERS

What is radiation?

Radiation includes electromagnetic radiation (such as light and heat, microwaves, radiowaves, ultra-violet, X-rays and gamma rays) and particles (such as alpha, beta and neutrons) which are emitted by some materials and carry energy.

What is the difference between radiation and radioactivity?

A radioactive atom is unstable because it contains extra energy. When this atom 'decays' to a more stable atom, it releases this extra energy as ionising radiation or more simply, 'radiation'.

How is ionising radiation different from other types of radiation?

Ionising radiation is radiation which can knock electrons out of atoms, either by direct interaction with the atoms or by other methods. Alpha and beta particles, neutrons and X- and gamma rays are examples of ionising radiation.

Is there more than one kind of ionising radiation?

Yes. In addition to X-rays, three are common. They are called alpha, beta and gamma. Alpha particles (helium nuclei) may be stopped by paper, beta rays (high speed electrons) are stopped by perspex, while gamma rays (like X-rays) may need lead or concrete to stop them, but can be stopped by any material, even water, providing there is enough of it.

Will these ionising radiations make me radioactive?

No, just as light will not make you glow in the dark and a chest X-ray will not make you radioactive.

If ionising radiation does not make things radioactive, how do items become radioactive in a reactor?

In a reactor there are billions of free nuclear particles called neutrons. When absorbed by a material they may make it radioactive, i.e. it emits its own radiation. (This is how radioisotopes are made.)

But surely radiation builds up in the body until it gets to a point where it kills you?

Ionising radiation does not build up in your body any more than light which falls on you builds up. The radiation that reaches you is gone a fraction of a second later. Radiation effects may appear following exposure to high doses in a short time, just as a bad dose of sunburn results from too much exposure to sunlight too quickly. Too much sun eventually damages the skin, even tanned skin. Similarly, long term exposure to ionising radiation at high levels may cause permanent damage to the body. National and international dose limits for occupationally exposed workers and members of the public are many times lower than these high levels. In addition, the goal of radiation protection is to keep long term environmental exposure, above normal background radiation, to a minimum.

Well, if radiation does not build up within the body, how does it harm a person?

Radiation carries energy which may damage living cells in the same way as tobacco smoke, asbestos or ultraviolet light. If the dose is low or is delivered over a long time there is an opportunity for the body cells to repair. There is only a very small chance that some cells may have been damaged in such a way that effects such as cancer appear in later life.

Where does my annual radiation dose come from?

The major part derives from the decay of natural radioactivity in the earth, most of it from uranium and thorium. This gives rise to a radioactive gas called radon in the air we breathe. Radon is present in all buildings. Smaller and roughly equal parts of everyday radiation come from cosmic rays and from the natural radioactivity of our food and drink. Some other radiation is man-made.

What are the man-made sources of my radiation dose?

Medical uses of ionising radiation are the major items. These include the use of X-rays for radiography and tomography, and radioactivity in nuclear medicine.

Can you put some figures on these natural background and man-made radiation doses?

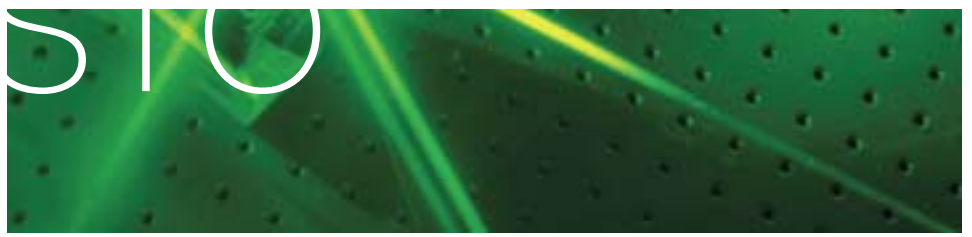
On average, Australians receive 1500 microsieverts a year from natural background radiation. Your additional dose from the medical use of radiation would depend on your medical history. The dose from a chest X-ray would be very small, about 1.5% of the annual dose due to natural background radiation, while multiple X-rays, in conjunction with a barium enema, may be several times larger than the annual background dose. Radiation doses in cancer therapy may be larger still.

When you say 'on average' does this mean that some people get more radiation than others?

Yes. Cosmic rays vary with latitude, with height above sea level and with sun spot activity. Some rocks, like granite, and beach sands are more radioactive than other parts of the earth. Some foods, like olives and brazil nuts, accumulate more radioactivity than others. But the most important variation is in varying radon levels, brought about by differences in building materials, ventilation and water supplies. It is common for the radon dose to vary by a factor of five, both up and down from the average.

Surely it is dangerous for anyone to experience these higher levels of radiation dose?

When whole populations exposed to high background doses are compared to those exposed to low background doses, health differences are not detected. The human race has evolved over millions of years in this radioactive environment.



How much do the operations of ANSTO contribute to the radiation doses of nearby residents?

The dose that a member of the community living near ANSTO would receive from our operations is very small. Those people living close to the buffer zone (which extends to 1.6km from the reactor) would receive less than 10 microsieverts per year. This is only 0.7% of the average natural background radiation in Australia. People living further away would receive proportionately less.

This 10 microsieverts maximum dose is about the same as the dose received from cosmic rays during a return flight between Sydney and Melbourne, or one-twentieth of the additional annual dose if a resident of Sydney were to move to a town at a higher altitude such as Katoomba.

Did you suggest earlier that if I get a radiation dose more quickly it will do more damage?

Yes, over an extended period, the body can repair most small damage from almost any cause, including radiation. But if the dose is acute, that is, all received in one short period, more serious damage may occur.

What kinds of radiation damage can occur?

There are two kinds: damage to the cells of your body, which may put you at risk (somatic effects); and damage to your reproductive cells, which may put some of your descendants at risk (hereditary effects). There are many different somatic effects, but the most important long term effect is cancer induction.

How can I tell when I am being subjected to radiation?

Only by using appropriate instruments such as a geiger counter, since none of our five senses sight, hearing, touch, taste or smell enable us to detect ionising radiation.

RADIATION MEASUREMENTS

How are radiation doses measured, and what are the safe limits?

Radiographers, workers in the nuclear industry and radiation workers in general wear a personal dosimeter to record their radiation doses.

The National Standard for limiting occupational doses requires that all doses should 'be kept as low as reasonably achievable' (ALARA), and that doses received by radiation workers should not exceed 20,000 microsieverts (about 14 times the average annual natural background in Australia) to the whole body in one year. The Australian Radiation Protection and Nuclear Safety Agency prescribes an annual dose limit for members of the public of 1,000 microsieverts. This is a dose that may result from the use of ionising radiation but does not include background radiation doses or doses you may receive from medical procedures.

Typical doses received during various diagnostic X-ray examinations

Effective dose in microsieverts (µSv)

X-Rays: (conventional)

Chest	20
Leg or foot	20
Dental	5-10
Skull	70
Barium meal	2500
Intestine	3000
Mammography	400

X-Rays: (computerised tomography)

Routine head	2600
Routine abdomen	13000

Examples of Alpha, Beta & Gamma Emitters

α Emitter:

Americium-241 – used in smoke detectors

β Emitter:

Carbon-14 – used in carbon dating

γ Emitter:

Technetium 99m – diagnostic medical radioisotope

YOUR AVERAGE ANNUAL RADIATION DOSE

The average annual radiation dose per person per year is approximately 1500 microsieverts (µSv) plus any exposure from medical procedures.

Some naturally occurring radiation sources

+50 µSv Travel and power stations

Such as air travel and coal-fired power stations

+300 µSv Cosmic rays

If you live 1000 metres above sea level add 200µSv – more if higher

+400 µSv Food and drink

Mostly from naturally occurring radioactive potassium-40 and polonium-210.

Some foods concentrate more radioactivity than others, although generally not enough to make a significant difference to this total.

+800 µSv Terrestrial radiation

Long-lived radioactive materials like uranium and thorium occur in the environment. They emit ionising radiation that contributes 600 µSv a year to your average terrestrial radiation dose. This radiation comes from rocks and soils, and from building materials like bricks, mortar, concrete and tiles.

Radon and Thoron are naturally occurring radioactive gases. Both these gases are present in the air you breathe. The major part of your average terrestrial radiation dose (200 µSv a year) therefore derives from the decay of radon and thoron in your lungs.

In the open, these gases are diluted by the wind mixing them in the atmosphere. Indoors they may concentrate in still air.

Deduct 10% if you live in a wooden house

Deduct 20% if you live in a tent

Deduct 50% or more if you live in the open

Add 10% or more if a building is made of granite

Add 100% or more if you keep doors and windows shut

Add 100% or more if you use bore water, especially in a hot shower. Because bore water has been underground, it contains radon that is released when the water emerges from the bore. The release is enhanced when the water emerges from the bore. The release is enhanced when the water is heated or divided into droplets; it is therefore most marked in a hot shower.

MEDICAL USES

Doses received by patients are classified separately because their exposures to radiation are justified on the grounds that such exposures pose a lesser threat to their welfare than does the risk of undiagnosed or untreated disease. No limits are set for diagnostic or therapeutic radiation exposures except that they should be as low as possible after considering risk-benefit factors. In nuclear medicine, the doses from diagnostic procedures are typically in the range 1,000-10,000 microsieverts (average 3,300 microsieverts). Doses from X-ray studies are generally slightly less.

When a nuclear medicine examination is proposed for a pregnant woman, care is taken to ascertain that the examination is required for a medical condition that requires prompt therapy. For these diagnostic examinations, the risk to the mother of not performing the examination must be greater than the radiation risk to the foetus. If an examination is performed the risk to the mother and foetus is kept as low as possible.

Medical radiation sources

The average dose from medical procedures in Australia is about 800 microsieverts (μSv) per person per year. Typical radiation doses for various medical procedures using radioisotopes are shown in microsieverts for each procedure listed.

Bone Scan 4600 μSv

Thyroid Scan 2600 μSv

Lung Scan (Ventilation & Perfusion)
2600 μSv

Liver Scan 1700 μSv

Kidney Scan 1400 μSv

Soft Tumours 40000 μSv

X-Rays (refer to table on page 4)

All figures are based on data from
Radiation Protection in Australasia, 2000

If you would like to receive updates on ANSTO's nuclear science and technology please email us at:
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