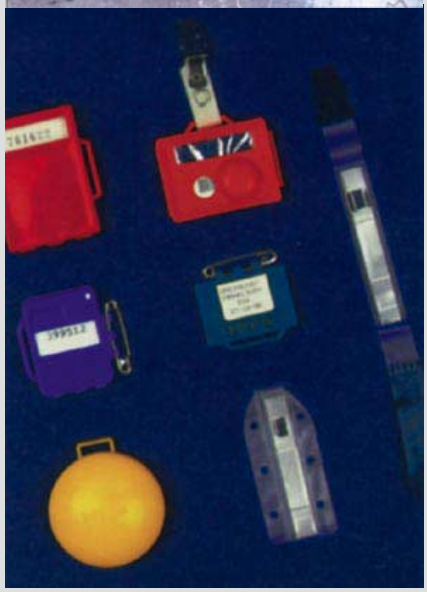
Chapter 9 Occupational exposure to radiation

Exposure to ionizing radiation occurs in many occupations. Artificial sources of radiation are commonly used in the manufacturing and service industries, in areas of defence, in research institutions, and in universities, as well as in the nuclear power industry. Moreover, we have seen in Chapter 8 that they are extensively used by physicians and health professionals.

Some workers are also exposed to natural sources of radiation in such circumstances that a measure of supervision and protection is required. This is particularly true of exposure to radon in mines and in ordinary premises throughout areas where radon levels are high. With the relatively high dose rates experienced in air travel due to elevated levels of cosmic rays at flying altitudes, some consider that supervision is also required for air crew, although it is less clear to what extent their exposures can readily be reduced.

Industrial radiographer wearing TLD badge



Film and TLD dosimeters

Many people who are exposed to radiation in their work wear personal monitoring devices (or dosimeters) such as a small photographic film or some thermoluminescent material in a special holder. There is also increasing use of electronic devices for this purpose. These register the radiation incident on the body from external sources and yield an estimate of the dose received by the wearer.

For airborne activity in the workplace, whether of artificial or natural origin, it is usually best to sample the air that the worker breathes, measure it, and then estimate the internal dose. In some cases, it may be possible to measure activity in excreta and infer the dose or indeed measure the activity in the body directly with sensitive detectors. The objective always is to get the best possible estimate of dose.

Common uses of radiation in industry

Radiography of welds and joints

Security inspection of bags and parcels

Level gauging of container contents

Sterilization of some medical supplies

Static elimination in paper production

Analysis of specimens for quality control

Average annual effective doses in different occupations (UNSCEAR)

Data for 1990–1994 Source: UNSCEAR Report 2000, Vol. 1, Annex E, Tables 12, 16, 22 and 43

Source	Dose (mSv)
Artificial sources	
Nuclear industry	
Uranium mining	*4.5*
Uranium milling	*3.3*
Enrichment	*0.1*
Fuel fabrication	*1.0*
Nuclear reactors	*1.4*
Reprocessing	*1.5*
Medical uses	
Radiology	*0.5*
Dentistry	*0.06*
Nuclear medicine	*0.8*
Radiotherapy	*0.6*
Industrial sources	
Irradiation	*0.1*
Radiography	*1.6*
Isotope production	*1.9*
Well-logging	*0.4*
Accelerators	*0.8*
Luminizing	*0.4*
Natural sources	
Radon sources	
Coal mines	*0.7*
Metal mines	*2.7*
Premises above ground (radon)	*4.8*
Cosmic sources	
Civil aircrew	*3.0*

Artificial sources

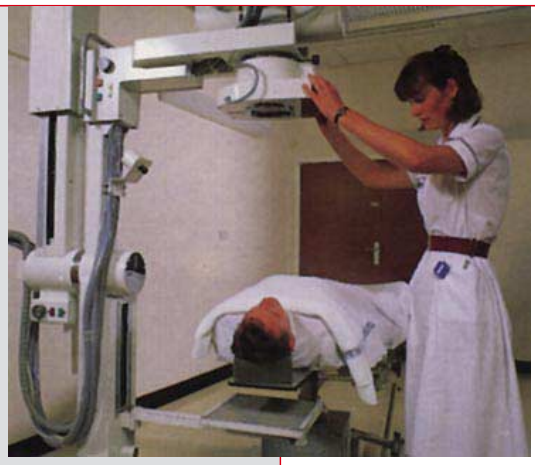
There are about 800 000 workers in the nuclear industry worldwide, and over 2 million workers exposed in medical facilities. UNSCEAR has compiled data on doses received by these workers and others such as industrial radiographers. The collective dose to nuclear industry workers is about 1400 man Sv, while that for medical radiation workers is about 800 man Sv. There are fewer workers in industrial uses of radiation, therefore the collective dose is lower at about 400 man Sv. However, these workers get the highest individual doses in some countries.

The average dose overall to occupationally exposed workers from artificial sources is less than 1 mSv in a year. The average in the nuclear industry tends to be a little higher than this, while the average for medical staff is slightly less. Doses have declined steeply in the last decade primarily because of the widespread introduction of ICRP recommendations and the BSS.

With the exception of mining, average doses from most types of occupational exposure from artificial sources, including the nuclear industry, are now below about 2 mSv in a year.

Doses in the health professions — medical, dental and veterinary — are generally very low, but there are still matters of concern. Some clinical procedures with diagnostic radiology require the physician to be close to the patient and at risk of appreciable exposure. X ray equipment and procedures in veterinary practices are frequently inadequate.

Natural sources

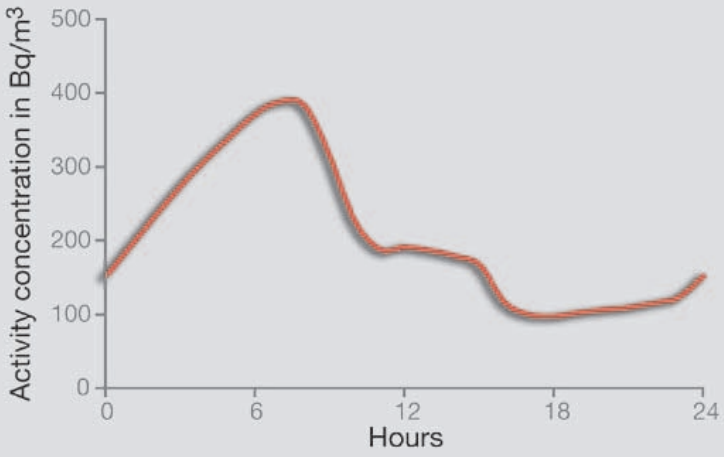


Medical radiographer wearing film badge

Occupational exposure to enhanced natural sources of radiation occurs mainly in mines, buildings and aircraft. Almost 4 million coal miners are monitored for radiation exposure. Fewer people (about a million worldwide) work in mines other than coal mines and in the processing of ores with levels of natural activity appreciably above average. The doses incurred are, nevertheless, monitored routinely.

Radon levels — and doses — are low in coal mines because the ventilation is usually good. Few if any miners exceed 15 mSv in a year. The state of ventilation in metal and other mines is not always as satisfactory, so the average dose is much higher and a fraction of the workforce does exceed this dose.

About one-fifth of the people considered to be occupationally exposed to enhanced natural radiation work in shops, offices, schools, and other premises in radon-prone areas. Within these areas, the average dose is appreciable. The average dose for such workers is almost 5 mSv per year — higher than for the other groups of occupationally exposed workers. However, it should be remembered that this group is unusual in that its members are identified, precisely because they receive high doses, rather than because they have the same occupation. Radon levels vary markedly from day to day because of the way buildings are heated and ventilated, so short measurements of radon in air may be misleading. The best remedy for high radon levels is the same as in houses — reduced air pressure under the floor.



Variation in indoor radon concentration in a house with moderate levels
J. Miles/NRPB

Doses to aircrew from cosmic rays depend on the routes flown and the amount of flying time. On average, the annual dose is around 3 mSv, but it could be twice as much for long flights continually at high altitudes. By the nature of the radiation and the operations, such doses are unavoidable.

Effective dose during air travel

Cities	Effective Dose (μSv)
Vancouver ➤ Honolulu	14.2
Frankfurt ➤ Dakar	16.0
Madrid ➤ Johannesburg	17.7
Madrid ➤ Santiago de Chile	27.5
Copenhagen ➤ Bangkok	30.2
Montreal ➤ London	47.8
Helsinki ➤ New York (JFK)	49.7
Frankfurt ➤ Fairbanks, Alaska	50.8
London ➤ Tokyo	67.0
Paris ➤ San Francisco	84.9

Source: Exposure of Aircraft Crew to Cosmic Radiation, a report of the EURADOS Working Group 5 to the Group of Experts established under Article 31 of the Euratom Treaty. European Commission

Total doses

The collective effective dose from occupational exposure to ionizing radiation is about 14 000 man Sv in a year worldwide, and workers can receive a few mSv in a year in some industries. Somewhat more than 80 per cent of this collective dose is from enhanced natural sources; less than 20 per cent is from man-made sources. The worldwide average dose to workers dealing with artificial sources is 0.6 mSv, and to workers exposed to natural sources it is 1.8 mSv. Combining these figures, the overall global average worker dose is 1.3 mSv per year. However, spread over the entire population, this implies an annual dose of about 0.002 mSv, a relatively minor contribution to the overall value of 2.8 mSv from all sources.