Natural and Man-Made Radiation Sources

All living creatures, from the beginning of time, have been, and are still being, exposed to radiation.

This chapter will discuss the sources of this radiation, which are:

- Natural Background Radiation
- Man-Made Sources of Radiation

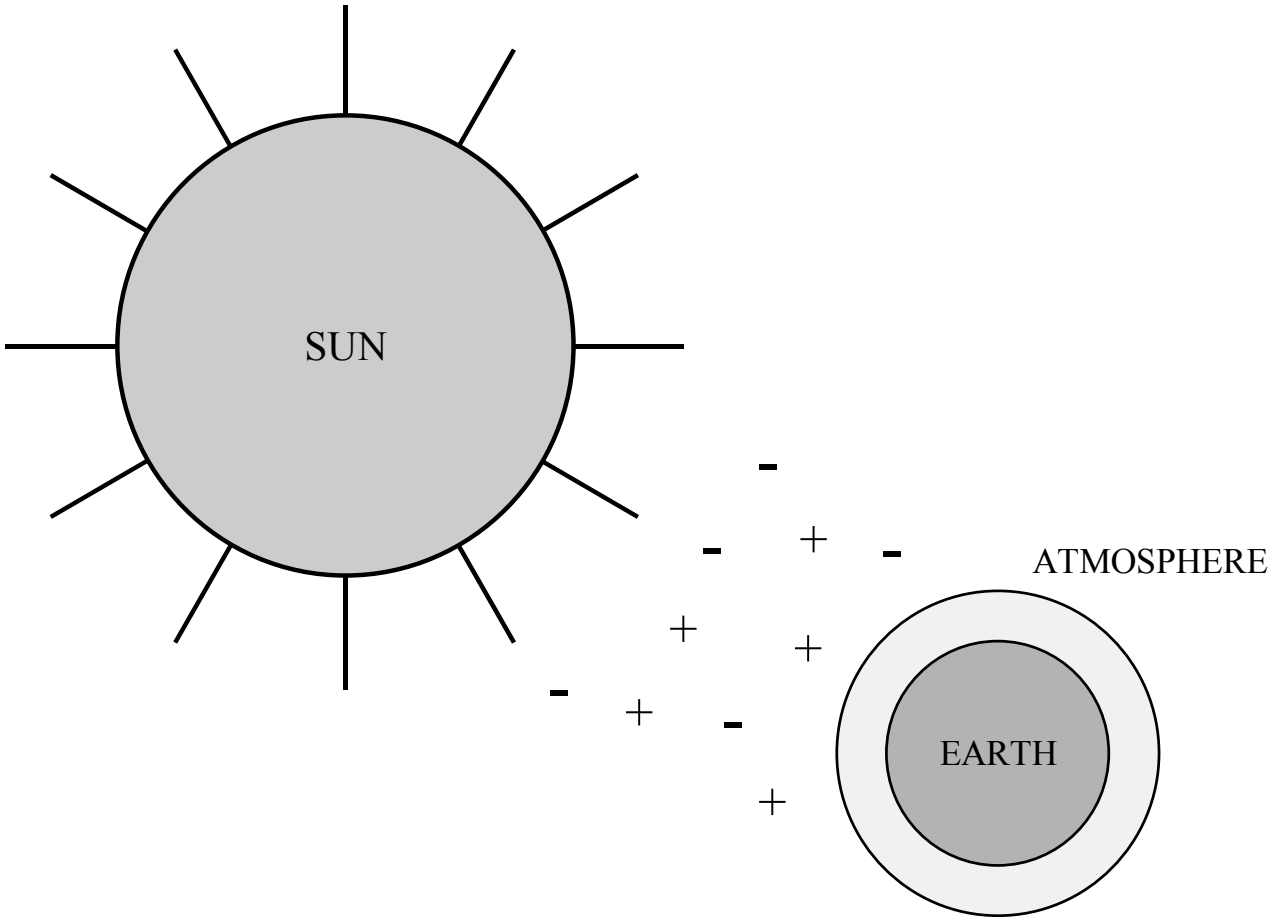
Natural Background Sources:

Cosmic Radiation
Terrestrial Radiation
Internal Radiation

Natural background radiation comes from three sources:

- Cosmic Radiation
- Terrestrial Radiation
- Internal Radiation

Cosmic Radiation



The earth, and all living things on it, are constantly bombarded by radiation from space, similar to a steady drizzle of rain. Charged particles from the sun and stars interact with the earth's atmosphere and magnetic field to produce a shower of radiation, typically beta and gamma radiation. The dose from cosmic radiation varies in different parts of the world due to differences in elevation and to the effects of the earth's magnetic field.

Terrestrial Radiation

Radioactive material found in:

Soil

Water

Vegetation

Radioactive material is also found throughout nature. It is in the soil, water, and vegetation. Low levels of uranium, thorium, and their decay products are found everywhere. Some of these materials are ingested with food and water, while others, such as radon, are inhaled. The dose from terrestrial sources also varies in different parts of the world. Locations with higher concentrations of uranium and thorium in their soil have higher dose levels.

The major isotopes of concern for terrestrial radiation are uranium and the decay products of uranium, such as thorium, radium, and radon.

Internal Radiation

Potassium-40

Carbon-14

Lead-210

In addition to the cosmic and terrestrial sources, all people also have radioactive potassium-40, carbon-14, lead-210, and other isotopes inside their bodies from birth. The variation in dose from one person to another is not as great as the variation in dose from cosmic and terrestrial sources. The average annual dose to a person from internal radioactive material is about 40 millirems/year.

Man-made radiation sources result in exposures to:

Members of the public

Occupationally exposed individuals

Although all people are exposed to natural sources of radiation, there are two distinct groups exposed to man-made radiation sources. These two groups are:

- Members of the public
- Occupationally exposed individuals

A member of the public is defined in 10 CFR Part 20 as any individual except when that individual is receiving an occupational dose.

Occupational dose is the dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material. This does not include the dose received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive materials from voluntary participation in medical research programs, or as a member of the public.

Man-made radiation sources that result in an exposure to members of the public:

Tobacco
Televisions
Medical X-rays
Smoke detectors
Lantern mantles
Nuclear medicine
Building materials

By far, the most significant source of man-made radiation exposure to the public is from medical procedures, such as diagnostic X-rays, nuclear medicine, and radiation therapy. Some of the major isotopes would be I-131, Tc-99m, Co-60, Ir-192, Cs-137, and others.

In addition, members of the public are exposed to radiation from consumer products, such as tobacco (thorium), building materials, combustible fuels (gas, coal, etc.), ophthalmic glass, televisions, luminous watches and dials (tritium), airport X-ray systems, smoke detectors (americium), road construction materials, electron tubes, fluorescent lamp starters, lantern mantles (thorium), etc.

Of lesser magnitude, members of the public are exposed to radiation from the nuclear fuel cycle, which includes the entire sequence from mining and milling of uranium to the actual production of power at a nuclear plant. This would be uranium and its daughter products.

The final sources of exposure to the public would be shipment of radioactive materials and residual fallout from nuclear weapons testing and accidents, such as Chernobyl.

Occupationally Exposed Individuals:

Fuel cycle
Radiography
X-ray technicians
Nuclear power plant
U.S. NRC inspectors
Nuclear medicine technicians

Occupationally exposed individuals, on the other hand, are exposed according to their occupations and to the sources with which they work. Occupationally exposed individuals, however, are monitored for radiation exposure with dosimeters so that their exposures are well documented in comparison to the doses received by members of the public.

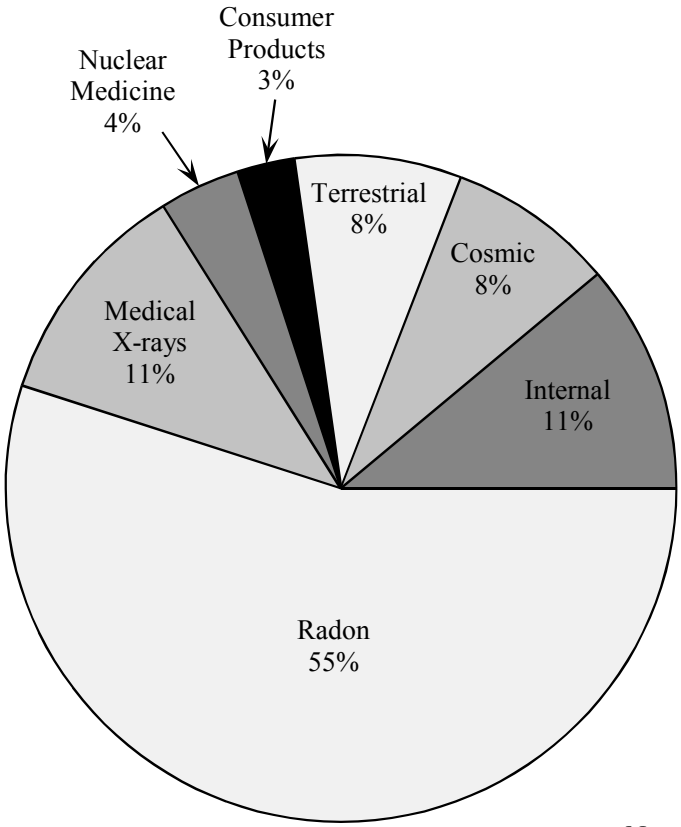
Some of the isotopes of concern would be uranium and its daughter products, cobalt-60, cesium-137, americium-241, and others.

Ionizing Radiation Exposure to the Public

Man-Made Radiation Sources:
Medical X-rays
Nuclear Medicine
Consumer Products
Other

Total of 18%

Other < 1%
This includes:
Occupational - 0.3%
Fallout - < 0.3%
Nuclear Fuel Cycle - 0.1%
Miscellaneous - 0.1%



Natural Radiation Sources:
Radon
Internal
Terrestrial
Cosmic

Total of 82%

The above chart is taken from the National Council on Radiation Protection and Measurements (NCRP) Report No. 93, *Ionizing Radiation Exposure of the Population of the United States*, 1987.

This chart shows that of the total dose of about 360 millirems/year, natural sources of radiation account for about 82% of all public exposure, while man-made sources account for the remaining 18%.

Radiation Exposure to the U. S. Population

The following table is extracted from material contained in NCRP Report No. 93, Ionizing Radiation Exposure of the Population of the United States, 1987.

The first column shows the sources of radiation exposure, and the second column shows an estimate of the number of people exposed to that source. For natural sources, the entire United States population is assumed to be exposed. The third column provides the average dose (in units of millirems) to those exposed (number in column 2). The last column averages the total dose from the specific source over the entire U. S. population. For natural sources, the third and fourth columns are identical.

Exposure Source	Population Exposed (millions)	Average Dose Equivalent to Exposed Population (millirems/year)	Average Dose Equivalent to U.S. Population (millirems/year)
Natural:			
Radon	230	200	200
Other	230	100	100
Occupational	0.93	230	0.9
Nuclear Fuel Cycle[1]	- - -	- - -	0.05
Consumer Products:			
Tobacco[2]	50	- - -	- - -
Other	120	5 - 30	5 - 13
Medical:			
Diagnostic X-rays[3]	- - -	- - -	39
Nuclear medicine[4]	- - -	- - -	14
Approximate Total	230	- - -	360

[1]Collective dose to regional population within 50 miles of each facility.
[2]Difficult to determine a whole body dose equivalent. However, the dose to a portion of the lungs is estimated to be 16,000 millirems/year.
[3]Number of persons unknown. However, 180 million examinations performed with an average dose of 50 millirems per examination.
[4]Number of persons unknown. However, 7.4 million examinations performed with an average dose of 430 millirems per examination.

COMPUTE YOUR OWN RADIATION DOSE

Cosmic radiation that reaches the earth at sea level: 27 mrem/yr

Based upon the elevation at which you live, add 1 mrem/yr for every 250 feet: _____

Examples: Atlanta - 1050 ft., Chicago - 595 ft., Dallas - 435 ft., Denver - 5280 ft., Las Vegas - 2000 ft., Minneapolis - 815 ft., Pittsburgh - 1200 ft., Washington, D. C. - 400 ft.

Based upon where you live, add the following for terrestrial radiation: _____

If you live in states that border the Gulf or Atlantic coasts (from Texas east and then north), add 23 mrem/yr
If you live in the Colorado Plateau area (around Denver), add 90 mrem/yr
If you live in middle America (rest of U. S.), add 46 mrem/yr

If you live in a stone, brick or concrete building, add 7 mrem/yr: _____

Radiation in our bodies from the food and water we ingest (potassium-40): 40 mrem/yr

Radiation from the air due to radon (U.S. average): 200 mrem/yr

Fallout from weapons testing: 1 mrem/yr
(actually less than 1 mrem/yr, but add 1 mrem/yr to be conservative)

If you travel on jet planes, add 1 mrem/yr per 1,000 miles of travel: _____

If you have porcelain crowns or false teeth, add 0.07 mrem/yr: _____

Some of the radiation sources listed result in an exposure to only part of the body. For example, false teeth result in a radiation dose to the mouth. The annual dose numbers given here represent the effective dose to the whole body.

If you use gas lantern mantles when camping, add 0.003 mrem/yr: _____

If you wear a luminous wristwatch (LCD), add 0.06 mrem/yr: _____

If you use luggage inspection at airports, add 0.002 mrem/yr: _____

If you watch television add 1 mrem/yr: 1 mrem/yr
(actually less than 1mrem/yr, but add 1 mrem/yr to be conservative)

If you use a video display terminal, add 1 mrem/yr: 1 mrem/yr
(actually less than 1 mrem/yr, but add 1 mrem/yr to be conservative)

If you have a smoke detector, add 0.008 mrem/yr/smoke detector: _____

Total yearly dose this page: _____

COMPUTE YOUR OWN RADIATION DOSE

(Continued)

Total from previous page: _____

If you wear a plutonium-powered cardiac pacemaker, add 100 mrem/yr: _____

For diagnostic X-rays, add an average of 50 mrem/yr per X-ray: _____
Examples of diagnostic X-rays are upper and lower gastrointestinal and chest X-rays

For nuclear medicine procedures, add an average of 430 mrem/yr per procedure: _____
An example of a nuclear medicine procedure would be a thyroid scan

If you live within 50 miles of a nuclear power plant, add 0.009 mrem/yr: _____

If you live within 50 miles of a coal-fired electrical utility plant, add 0.03 mrem/yr: _____

If you smoke, add an estimated 1,300 mrem/yr due to radon decay products: _____

YOUR AVERAGE TOTAL DOSE IN MILLIREMS PER YEAR: _____

Sources: National Council on Radiation and Measurement Reports 92, 93, 94, 95, and 100; the American Nuclear Society