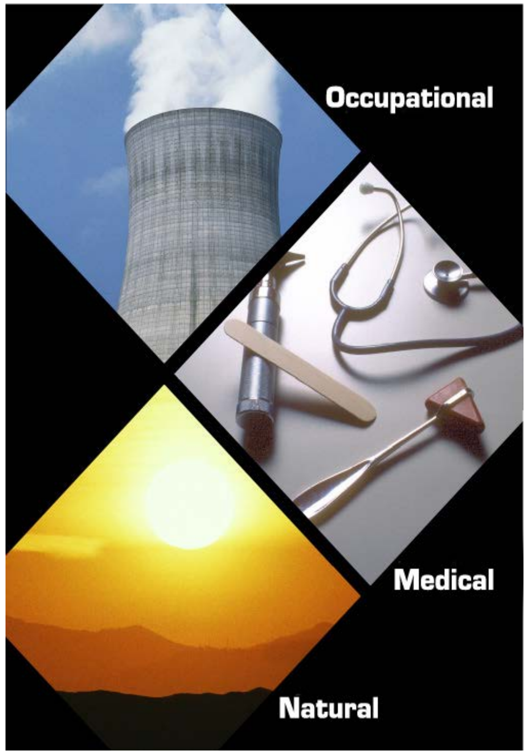
Radiation in Perspective



The U.S. Department of Energy

Office of Environment, Health, Safety & Security

Office of ES&H Reporting and Analysis

Ionizing Radiation and You

Ionizing radiation is a part of our environment and part of our lives. We regularly encounter it from both natural and man-made sources. In fact, humans and all other life on earth have evolved with routine exposure to the natural sources of radiation in our environment.

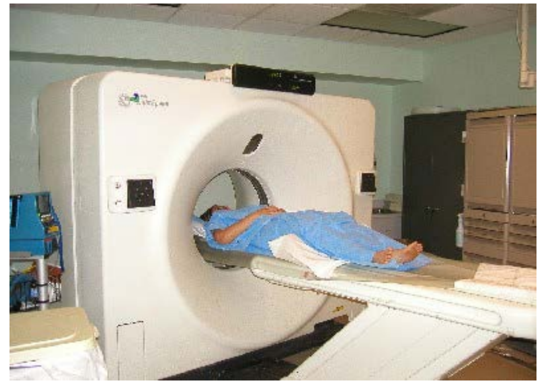
Humans, animals, and plants contain small amounts of naturally radioactive forms of potassium and carbon. Other natural sources of radiation include cosmic rays from outer space and radioactive minerals and radon gas in our soil, water, air and in some building materials such as granite and brick.

The Table below shows radiation doses associated with some common sources in U.S. units of millirem (mrem) and international units of millisieverts (mSv) (1 rem = 1,000 mrem; 1 Sv = 1,000 mSv; 1 Sv = 100 rem). The "average" American receives about 620 mrem (6.2 mSv) per year from all sources of radiation. This includes, on average, about 310 mrem (3.1 mSv) from naturally occurring sources and about 310 mrem (3.1 mSv) from man-made sources and applications.

Source/Activity	*U.S. Average Dose/ year (or as noted)*
3-hour jet plane ride	1 mrem (0.01 mSv)
Building materials	7 mrem (0.07 mSv)
Chest x-ray	10 mrem (0.1 mSv)
Soil	21 mrem (0.21 mSv)
Internal to our body	29 mrem (0.29 mSv)
Cosmic radiation	33 mrem (0.33 mSv)
Smoking 20 cigarettes/day	36 mrem (0.36 mSv)
Per mammogram	42 mrem (0.42 mSv)
Radon gas	228 mrem (2.28 mSv)
Per CT Scan, cardiac	2,000 mrem (20 mSv)

Credit: Effective doses (mSv) courtesy of the National Council on Radiation Protection and Measurements, Ionizing Radiation Exposure of the Population of the United States, Report No. 160, 2009.

We use man-made sources and applications of ionizing radiation such as power plants, smoke-detectors, x-rays, CT scans, and nuclear medicine procedures to improve our quality of life. Some people receive occupational exposures as a result of their work; jet crews, nuclear plant personnel, and medical staff are examples.



Medical Application - a CT Scan in Progress

Why are we concerned about exposure to ionizing radiation?

Ionizing radiation is energy and particles given off by unstable atoms in a natural process to become stable. When we are exposed to this radiation – from natural sources in our environment, from the work that we do, or as a result of medical necessity – there is a potential for biological damage to our cells and their DNA (genetic material) from the energy absorbed. Such damage can result in undesirable health effects – an increased risk of illness, or even death, resulting from the exposure.

However, such risks are minimal at normal background radiation levels, at typical levels of medical exposure and at occupational exposure levels allowed by regulations. You can better understand the risks of exposure to ionizing radiation by comparing them with other risks, and you can learn how to manage and reduce your risks.

Exposure limits and radiation protection programs

Government agencies have established regulations that set exposure limits for ionizing radiation based on extensive research and recommendations from national and international scientific organizations. These limits are to protect individual workers, the public, and the environment, and are set at "acceptable" levels of risk similar to those for industrial activities (e.g., chemical, mining, and transportation industries).

The primary U.S. limit for occupational exposure to ionizing radiation is 5,000 mrem (50 mSv)/year. Exposure to minors and to the general public is limited to 100 mrem (1 mSv)/year. Medical exposure levels, however, are based on medical necessity as determined by the physician and patient. DOE radiation protection standards and exposure limits for workers are published in Title 10 Code of Federal Regulations Part 835 (see http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title10/10cfr835_main_02.tpl). The "DOE Occupational Radiation Exposure Report" (http://energy.gov/ehss/policy-guidance-reports/databases/occupational-radiation-exposure) provides an annual analysis and explanation of observed trends in occupational exposure across DOE. The data is used to improve safety and to manage radiological safety programs with reduced risk.

Many organizations, such as DOE, require formal radiation protection programs to implement regulations and help protect you. These programs are managed by competent and experienced professionals and technicians, who track and control exposures, monitor radiological conditions, and manage radiological work through standards, procedures, training, and administrative and engineering controls.

What are the concerns and risks with exposure to ionizing radiation?

With exposure to ionizing radiation, there is a chance that cells can be damaged, and that DNA can be changed permanently, be impaired in function, or cease to function. Some forms of damage to DNA can lead to uncontrolled cell division, resulting in certain types of cancer. At low doses (e.g., background radiation levels), our bodies readily repair most cell and DNA damage. At very high doses, the body's repair mechanisms may be overwhelmed.

According to the American Cancer Society, in the U.S. the chance of an individual contracting a fatal cancer from all causes (e.g., smoking, drugs, alcohol, pollution) is approximately 25 percent. [In this pamphlet we express risk as the chance of something occurring (25%, 25 out of 100), or, later, in terms of life shortening (estimated days of life expectancy lost).] By example, for a cumulative occupational dose of 1,000 mrem (10 mSv), the chance of eventually developing a fatal cancer can increase from 25% (as noted above) to 25.05%.

Most occupational exposures are below the occupational exposure limit of 5,000 mrem (50 mSv) per year. At this level, the probability of increased cancer risk – the primary low dose health effect – is so low that it cannot be measured against the normal incidence of cancer. It may or may not occur. Exposures at very high levels (where there can be immediate biological effects and measurable higher cancer risk) are infrequent and are considered abnormal occurrences.

While a routine medical exposure may increase the risk of cancer very slightly (on the order of nearly zero to a few percent), this potential must be balanced against the risk of not diagnosing or treating a disease.

Cancer risk can be evaluated based on effective dose. Effective dose considers the amount of radiation energy absorbed by exposed body tissues, the effectiveness of the radiation in causing damage, and the sensitivity to damage of different tissue types. An effective dose (and its risk) can be compared to other effective doses (and risks), such as the average effective dose (about 310 mrem; 3.1 mSv) received by a person in the United States per year from natural background radiation. During 2009, average occupational exposures reported by DOE were 62 mrem (0.62 mSv) and 180 mrem (1.8 mSv) by the Nuclear Regulatory Commission.

If a person is exposed to radiation from multiple sources, the total risk is based on the total dose – i.e., background + occupational + medical dose – and is cumulative over time. If you have medical and occupational doses, any health impacts are additive. You should work with your doctor and employer to manage your total dose to balance risks and benefits.

Reducing risk from ionizing radiation

In determining how increased radiation exposure can increase the chances of developing cancer over one's lifetime, there are several important concepts to consider:

1. Radiation exposure has the same biological effects for the same amount of dose regardless of the source of the radiation, and the effects are cumulative over a person's lifetime.
2. The relationship between dose and risk is not well understood at low dose levels because any risk at low levels is too small to be measured. To ensure safety and set regulatory limits, we conservatively assume that at low dose levels cancer risk increases as dose increases from zero (i.e., there is no threshold dose for effects).
3. The risk of harm from radiation depends on the amount of dose, the dose delivery rate, the type of radiation, the sensitivity of the tissue exposed, and the gender, age and health of the exposed person.
4. Radiation exposure is not the only cause of increased cancer risk. Many other factors like age, gender, ethnic origin, cancer type, diet, smoking, and stress affect estimates of cancer risk.
5. Cancers caused by radiation exposure cannot be distinguished from those caused by other environmental, chemical, or biological factors.
6. Cancers that might develop from a radiation exposure usually have a latency period (a delay in showing up) of 2 to 10 years after the exposure.

The benefits associated with the use of ionizing radiation must be weighed against the risks to individuals and to society from this use. Individuals should control and manage to low levels their exposures from all sources of radiation to reduce potential biological effects. We should always try to establish options where risks are "minimal" or "acceptable" to us. Some risks can be avoided by choosing not to participate in certain activities. Remember, regulators have established the various ionizing radiation exposure limits at levels that reflect an acceptable risk when compared to the benefit received (e.g., electrical power, improved health), and when compared to the risk levels accepted for other similar activities (e.g., chemical industry, mining, driving, flying).

We can reduce our exposure and our risks in many ways, for example:

- Reduce exposure to radon gas by having your house tested and, if radon is present, installing barriers or ventilation equipment to reduce the radon concentration in living areas.
- Work with your doctor to control medical exposure. Use medical procedures involving radiation only when they are essential to diagnose or treat an injury or illness.
- For medically-required exposures, ensure that the benefit to the patient outweighs the risk associated with the exposure.
- Work with your employer to use innovative techniques, engineering controls, and administrative controls to keep occupational exposures "As Low as Reasonably Achievable" (ALARA).

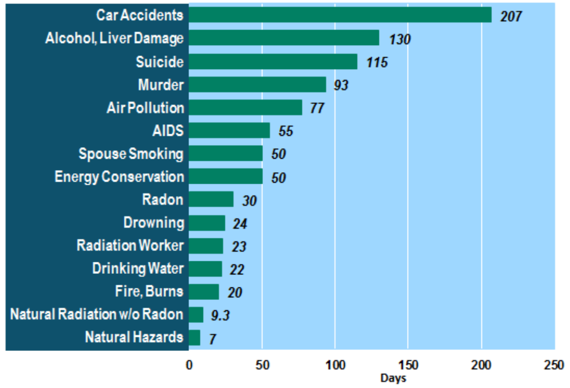
Risk perspective – it's relative!

There are activities or conditions that cause measurable and relatively large numbers of fatalities (e.g., driving, obesity and smoking), yet don't seem to worry us very much. On the other hand, some people fear other conditions (e.g., using nuclear power), even though their risk of harm is low. Risk assessment is the objective evaluation of a hazard – determining how a hazard really can affect us. Risk perception is the subjective view of a hazard – how we emotionally respond to it, our opinion of it, or how we feel about it. Risk-perception researchers have identified that risks from natural sources worry us less than those created through science and technology. Also, we tend to accept risks we've chosen and with obvious benefits rather than risks imposed on us. If you have a basic understanding of hazards and the risks associated with them (i.e., if you are risk-assessment capable), you can make informed decisions to manage your risks and adopt a more realistic risk perception. The following chart shows the relative impact of some of the common risks we face in the U.S.

The relative risks from radiation exposure can be compared to risks that we accept from non-radiological exposures and activities. Further, the health effects associated with low-level radiation exposures are not unique, and can be caused by a variety of other agents, such as chemicals and our bodies' responses to aging. Still, radiation is often viewed as a more significant hazard than it is. It is very useful to know what risks we are exposed to in our activities and how important each activity is to us.

With knowledge of the nature of ionizing radiation and its potential health effects, and how risk is expressed and managed, you are well on the way to being "risk informed" and taking an active role in managing your own safety and health concerns. You can help yourself establish a "risk assessment" that is consistent with your "risk perception."

Average days of life expectancy lost:



Credit: B.L. Cohen, Catalog of Risks Extended and Updated, Health Physics, 61(3):317-335, 1991.

Information Resources

The Health Physics Society Web site (http://hps.org/) provides information for the public on radiation and its effects. The site's "Ask the Experts" section (http://hps.org/publicinformation/ate/) answers questions related to medical, occupational, and natural aspects of ionizing radiation. You can find more details, definitions, and explanations at the Web sites listed below:

https://www.epa.gov/radiation
https://www.iaea.org/Publications/
http://ncrponline.org/
http://hps.org/
http://www.nrc.gov/about-nrc/radiation/rad-around-us.html
http://energy.gov/ehss/environment-health-safety-security
http://www.doh.wa.gov/portals/1/Documents/Pubs/320-063_bkvsman_fs.pdf
http://www.phyast.pitt.edu/~blc/Catalog_of_Risks.pdf

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