FACT SHEET

Radiation Standards and Organizations Provide Safety for Public and Workers

January 2006

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Key Facts

■ Scientists have studied radiation effects for more than 100 years, and stringent safety regulations have governed man-made uses of this energy for nearly as long. Two new reports provide strong confirmation that the risk of health effects from exposure to low levels of radiation is small. They also conclude that current radiation protection standards for workers and the public remain valid.

■ The Nuclear Regulatory Commission, the Environmental Protection Agency, and the departments of Energy and Transportation are the principal federal agencies responsible for establishing radiation protection regulations. These agencies work with international organizations to ensure their regulations are based on internationally recognized scientific studies.

■ The National Academy of Sciences in June 2005 released its report from the Biological Effects of Ionizing Radiation Committee VII (BEIR VII), "Health Risks From Exposure to Low Levels of Ionizing Radiation." The BEIR VII report will serve as the updated scientific basis for radiation safety standards in the United States for the next decade.

■ The International Agency for Research on Cancer studied the effects of exposure to low levels of radiation on more than 400,000 nuclear workers in 15 countries. The study panel concluded that its results are "statistically compatible with the current bases for radiation protection standards."

■ The NRC's annual limit for occupational exposure to radiation is 5,000 millirem (mrem). The average U.S. nuclear power plant worker receives 160 mrem. A typical X-ray, by comparison, provides 10 mrem.

■ The average American receives radiation exposure of about 360 mrem annually from all sources, according to the National Council on Radiation Protection and Measurements.[1] More than 80 percent of that comes from nature—from radon in the air, from rocks and soil, and from outer space. The average public exposure from the nuclear fuel cycle is 0.5 mrem per year.

Where Does Radiation Come From?

Individuals are exposed to radiation from a variety of sources, both natural and man-made. There are two categories of radiation: ionizing and non-ionizing.

Ionizing radiation removes electrons from atoms, causing the atoms to become electrically charged ions. Its uses include X-rays and other medical procedures, as well as nuclear power plants.

Non-ionizing radiation does not remove electrons from the atoms it encounters. Examples include radio waves and microwaves, as well as visible and ultraviolet light. Its uses include radar, lasers and microwave heating.

Ionizing radiation is detected easily. Measurements of this radiation are based on the energy it deposits in the body or in a particular part of the body.

On average, 82 percent of an individual's exposure comes from naturally occurring radiation from the earth, in the air and water, from outer space, and in our own bodies.[2]

Medical uses of radiation account for the majority of manmade radiation exposure. Although the average annual medical exposure is about 54 mrem per year, the range is large, depending on what type of medical procedures are administered. For example, a chest X-ray is about 10 mrem; a single CT scan is 1,000 mrem or more.

The entire nuclear energy fuel cycle (including uranium mining, fuel fabrication, nuclear power generation and waste disposal) produces less than 1 percent of overall human exposure—less than 0.5 mrem per year.

One roundtrip flight between New York City and Los Angeles would provide a dose of 2 mrem to 5 mrem.[3]

Who Sets Radiation Standards?

International Standards

Three international organizations recommend radiation protection levels: the International Commission on Radiological Protection (ICRP), the International Atomic Energy Agency (IAEA) and the International Commission on Radiation Units and Measurements (ICRU).

ICRP. The Second International Congress of Radiology established the ICRP in 1928. Although initially concerned with the safety of medical radiology, it now covers safety for all sources of radiation. Its mission is "to deal with the basic principles of radiation protection and to leave to various national protection committees the responsibility of introducing the detailed technical regulations, recommendations or codes of practice best suited to the needs of their individual countries."

The ICRP is the principal source of recommendations on safe radiation levels. Members come from many countries and include scientists, physicians and engineers.

The ICRP issued its most recent full set of recommendations in 1990. The next full set is planned for release in 2007.

IAEA. Organized in 1956 to promote the peaceful uses of nuclear energy, the IAEA is a specialized agency of the United Nations.

The IAEA applies radiation protection standards to its own operations and to operations it assists or with which it is directly associated. Countries receiving assistance are required to observe relevant health and safety measures prescribed by the organization.

All of the 124 member nations have representatives in the IAEA General Conference, the governing body that determines policy. Smaller executive bodies within the IAEA, such as the Scientific Advisory Committee, consist of scientists, engineers and administrators from member states. The IAEA publishes both standards and recommendations, in addition to books on nuclear science and technology written by consultants or groups of experts invited from member states.

ICRU. Created in 1925, the ICRU develops international recommendations regarding quantities and units of radiation and radioactivity, procedures for their measurement and application in clinical radiology and radiobiology, and physical data needed to ensure uniformity in reporting on their applications.

The ICRU's operating policy states: "It is the responsibility of national organizations to introduce their own detailed technical procedures for the development and maintenance of standards. However, it urges that all countries adhere as closely as possible to the internationally recommended basic concepts of radiation quantities and units."

The ICRU consists of members, senior advisers, consultants and representatives of report committees in 12 countries. The report committees consist of scientists, engineers and physicians—primarily from colleges and universities, with some from government and industry.

U.S. Standards

U.S. groups involved with recommending radiation standards

include the National Council on Radiation Protection and Measurements (NCRP) and federal and state agencies.

NCRP. The NCRP began its work in 1929 as the Advisory Committee on X-ray and Radium Protection. Congress chartered the organization in 1964 as the NCRP to address the scientific and technical aspects of radiation protection. The nonprofit corporation is not a federal agency, although its recommendations are part of the basis of federal, state and local regulations dealing with radiation hazards.

The NCRP consists of members and those participants who serve on its scientific committees. The organization draws its members from public and private universities, medical centers, national and private laboratories, the government and industry solely on the basis of their scientific expertise. Experts in particular areas of interest form the individual committees.

EPA. The Environmental Protection Agency is responsible for recommending federal guidance on radiation protection for use by federal agencies in their regulatory processes and for establishing standards to protect the general environment from radioactive material under a variety of authorities, including the Clean Air Act, Safe Drinking Water Act, Superfund and Atomic Energy Act.

NRC. In 1946, Congress established the Atomic Energy Commission (AEC) to regulate commercial nuclear technologies. Congress abolished the AEC in 1974 and replaced it with the Nuclear Regulatory Commission. The NRC's mission is to protect public health and safety. To accomplish this, the NRC prescribes and enforces separate limits on the amount of radiation that workers and members of the public can receive from all pathways, such as air and water. These regulations apply to operators of nuclear power plants, as well as industrial and medical facilities licensed to use man-made radioactive materials. The NRC bases its regulations on recommendations made by the NCRP and the ICRP, and on the EPA's federal guidance and standards.

Sources of Data Used to Set Radiation Standards

Two series of reports provide much of the data used in setting radiation standards. The reports are produced by National Academy of Sciences (NAS)/BEIR and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

- ***The BEIR Reports.*** NAS chartered the first BEIR report in 1956 and has chartered six additional reports. These documents provide a quantitative basis for limiting the radiation exposure of the entire population. They focus on risk factors—the probability of health effects associated with a given dose of radiation.
- ***The UNSCEAR Reports.*** UNSCEAR produces reports on the sources of radiation exposure around the world and estimates of radiation risk. In 1988, an UNSCEAR report stated that, because of new dosimetry, risk estimates from high exposure to radiation had increased. The report also changed the dose projection model used to calculate lifetime risk. These are similar to the conclusions in the 1990 BEIR V report. In 2000, UNSCEAR issued its next report, which made no substantial change to the risk estimates.

Both UNSCEAR and NAS consider new data as they become available from studies of workers and members of the public, as well as from biological research. When the data indicate a need to revise risk estimates, the committees prepare new reports to reflect this. UNSCEAR will issue its next comprehensive review of radiation issues in 2006 or 2007.

National Academies Study Radiation Risk

In June 2005, NAS released its report from the Biological Effects of Ionizing Radiation Committee VII. The BEIR VII report—"Health Risks From

Exposure to Low Levels of Ionizing Radiation"—is the updated scientific basis for radiation safety standards in the United States.

The BEIR V report defined low-level radiation as anything below 10,000 mrem. The report based its findings on revised dose estimates for the survivors of the Hiroshima and Nagasaki atomic bombs. The survivors were exposed to both acute doses (i.e., doses delivered in seconds or minutes) and doses spread over months and years.

NAS formed the BEIR VII committee in 2000 to review the large body of scientific research on radiation health effects that has accumulated over the past 15 years.[4] The committee concluded that the additional data have bolstered confidence in previous estimates of health risks, including the risk of developing cancer, as a result of exposure to radiation.

"In general, BEIR VII supports previously reported risk estimates for cancer and leukemia, but the availability of new and more extensive data have strengthened our confidence in these estimates," said Dr. Richard Monson, chairman of the BEIR VII committee and associate dean at the Harvard School of Public Health.

BEIR VII*: *Major Findings [5]

- One percent of individuals receiving a dose of 10,000 mrem would be expected to develop cancer, compared with the 42 percent likely to develop cancer from other causes. A 10,000-mrem dose is twice the NRC's annual occupational limit. (The average U.S. nuclear power plant worker receives an annual exposure of 160 mrem, 3 percent of the NRC's dose limit.)
- The committee said it is difficult to estimate cancer risk from radiation doses of 10,000 mrem or less. However, the committee said the BEIR VII study continues to support the "linear-no-threshold model" for radiation exposure. The model holds that risk declines commensurate with lower radiation exposures; very low exposures mean that the risk to an individual is very low, but cannot be assumed to be zero. "The preponderance of information indicates that there will be some risk, even at low doses, although the risk is small," Monson said.
- Studies of children whose parents were exposed to radiation have found no adverse health effects attributable to radiation. "However, studies of mice and other organisms have produced extensive data showing that radiation-induced cell mutations in sperm and eggs can be passed on to offspring," the committee said. "There is no reason to believe that such mutations could not also be passed on to human offspring," the committee said, adding that the failure to observe such effects in human studies probably reflects that the genetic risks are very small.

International Study Of Nuclear Workers

A study by the International Agency for Research on Cancer (IARC) also supports current radiation protection standards.

The study—"Risk of Cancer After Low Doses of Ionizing Radiation: Retrospective Cohort Study in 15 Countries"—appeared in the June 2005 British Medical Journal.[6] The study sought to determine whether workers with higher radiation doses have a higher risk of cancer, including leukemia.

The IARC study panel gathered radiation exposure data on more than 400,000 nuclear workers in 15 countries: Australia, Belgium, Canada, Finland, France, Hungary, Japan, Lithuania, Slovak Republic, South Korea, Sweden, Switzerland, the United Kingdom and the United States. In the United States, 50,000 nuclear power plant workers were included in the study.

All individuals had worked for at least one year in environments that have the potential for radiation exposure—nuclear power plants, nuclear technology research, waste management,

radioisotope production, fuel fabrication or weapons facilities. The statistical models used in the study accounted for such factors as age, gender (90 percent of those in the study group were men), the time between radiation exposure and death, how long individuals worked in that environment, and socioeconomic status.

Study Finds Small Increase in Cancer Risk

The panel estimated that radiation exposure could be responsible for 1 percent to 2 percent of cancer deaths among nuclear workers. In other words, these workers may have a 1 percent to 2 percent increased risk of dying from cancer compared with non-nuclear workers.

The results confirm that current radiation protection standards keep workers safe. "We have provided radiation risk estimates from the largest study of nuclear workers conducted so far," the panel wrote. "These estimates are higher than, but statistically compatible with, the current bases for radiation protection standards."

Limitations of IARC Study

As the journal article noted, the IARC study had certain limitations.

- It did not consider the possible contribution to cancer risk from other factors, such as smoking or diet, because that information was not available.
- The study results reflect earlier, less stringent radiation protection standards, as well as today's standards. "Less than 5 percent of workers received cumulative doses of the order of [10,000 mrem] over their entire career and most of these doses were received in the early years of the industry, when protection standards were less stringent than today."
- Cancer mortality differed among the 15 countries, with Canada having the highest mortality. The panel could find nothing that might account for this. However, "[O]nly when we excluded Canada was the excess relative risk [of cancer mortality] no longer significantly different from zero," the panel wrote. In other words, reviewing aggregated data from 14 of the 15 countries—including the United States—the study did not demonstrate an increased risk of cancer mortality for nuclear workers.

IARC Study Supports Current Standards

Overall, the study concluded, "[The] findings are statistically compatible with the current bases for radiation protection standards."

"These results provide the most precise and comprehensive direct estimates of cancer risk after protracted exposure to low doses of ionizing radiation," said IARC Director Dr. Peter Boyle. "[T]hey strengthen the scientific basis of radiation protection standards for environmental, occupational and medical diagnostic exposures."

Conclusion

Taken together, the BEIR VII and IARC reports uphold the scientific foundation of our nation's radiation safety standards.

This fact sheet also is available at www.nei.org.

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[1] NCRP Report No. 93.
[2] "Health Risks From Exposure to Low Levels of Ionizing Radiation," BEIR VII Report, 2005.
[3] "Facts About Radiation," Office of Civilian Radioactive Waste Management, *www.ocrwm.doe.gov/factsheets.*
[4] The academy's BEIR VI report addressed radiation exposure from radon.
[5] "BEIR VII: Health Risks From Exposure to Low Levels of Ionizing Radiation," Report in Brief, June 2005, The National Academies.
[6] BMJ, doi:10.1136/bmj.38499.599861.EO, published June 29, 2005.