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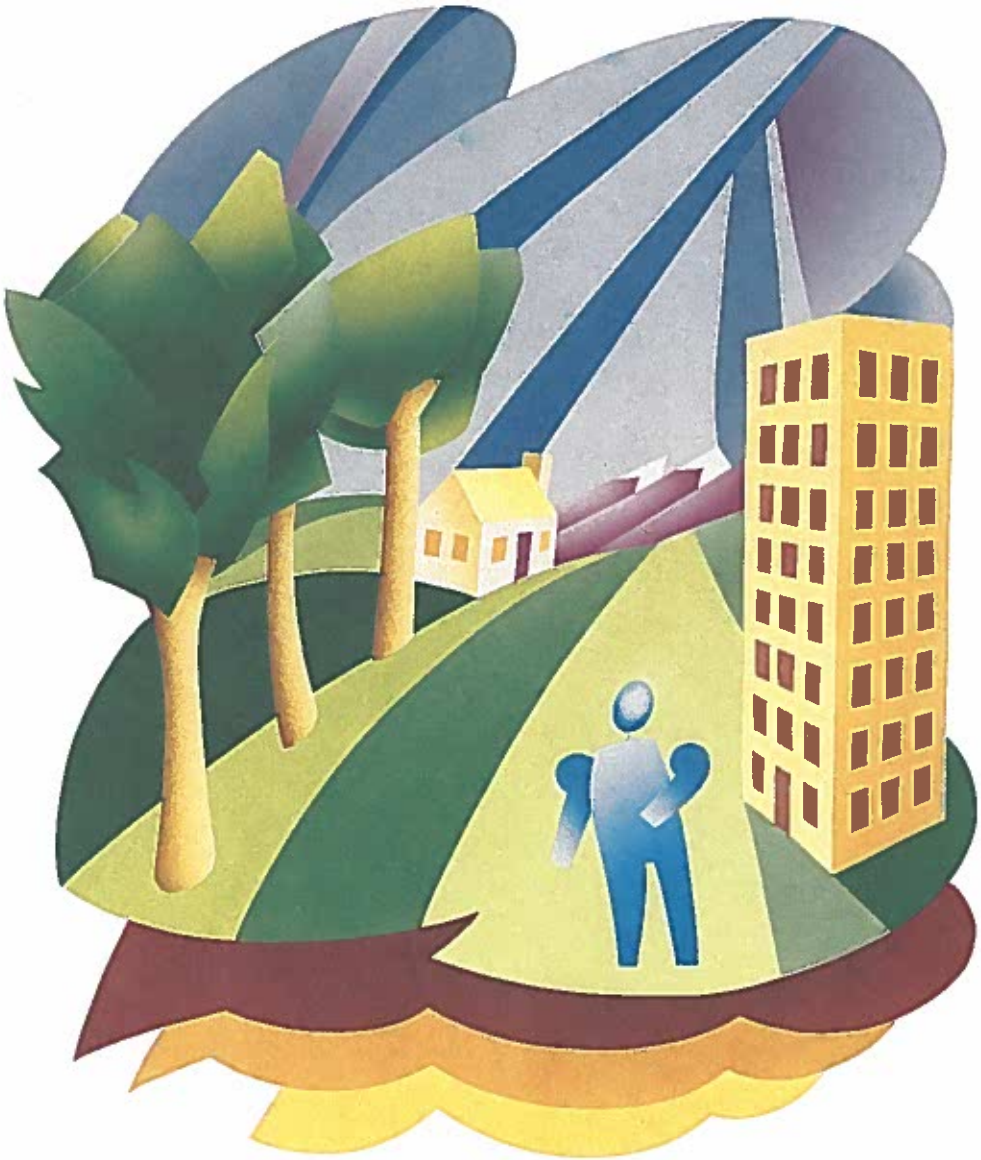
United States
Enviromental Protection
Agency

Air and Radiation
(6602J)

EPA 402-K-92-004
August 1993

EPA

Radiation: Risks and Realities



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It comes from outer space, the ground, and even from within our own bodies. Radiation is all around us and has been present since the birth of this planet. Naturally-occurring radioactive materials were discovered in 1896. Less than 50 years later, the physicist Enrico Fermi split the atom, producing the first man-made radioactive materials. Today, both man-made and natural radiation are part of our lives. We use radioactive materials for beneficial purposes, such as generating electricity and diagnosing and treating medical problems. For example, Americans receive 200 million x-rays every year. Though radiation offers many benefits, exposure to it can also threaten our health and the quality of our environment. ■ *We cannot eliminate radiation from our environment. We can, however, reduce our risks by controlling our exposure to it. This booklet discusses the major sources and uses of radiation, the risks from exposure, and how we can limit and reduce these risks.*

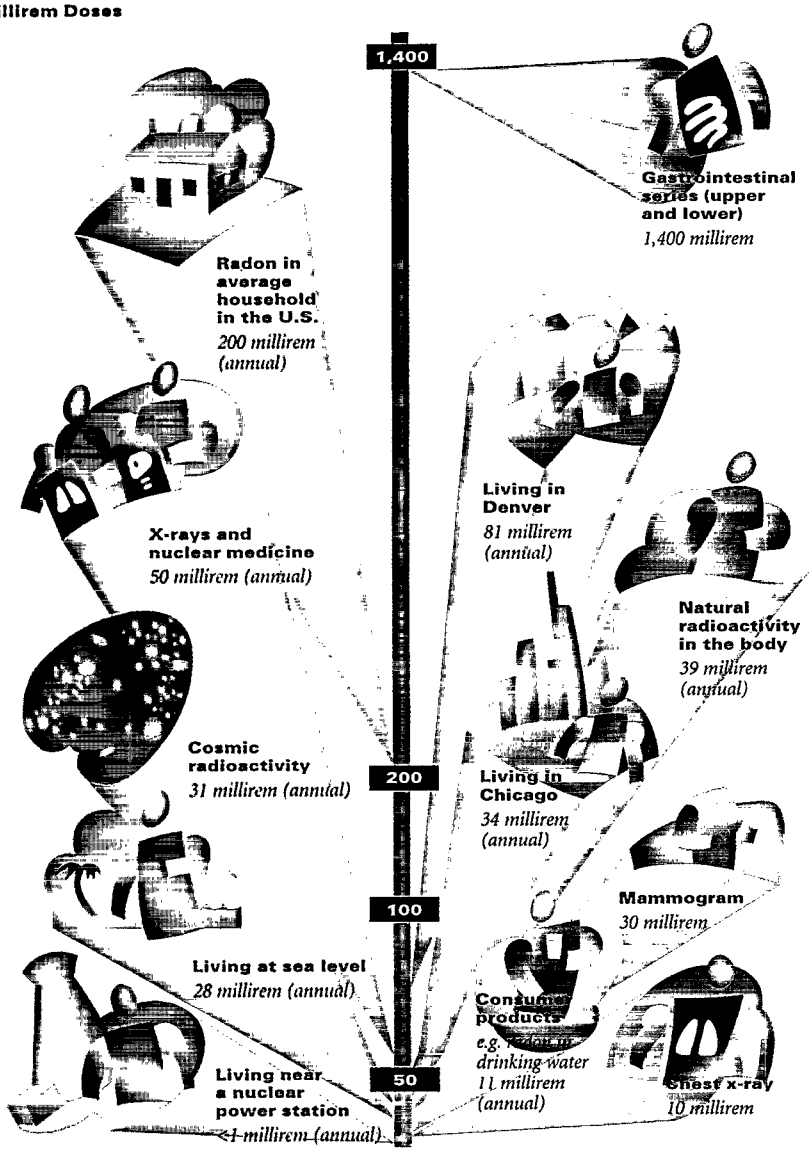
Matter is composed of atoms. Some atoms are unstable. As these atoms change to become more stable, they give off invisible energy waves or particles called radiation.

There are different types of radiation, some more energetic than others. One type of radiation, non-ionizing radiation, has enough energy to move atoms but not enough to alter them chemically. This booklet discusses the most energetic form, known as ionizing radiation, which from here on will be referred to simply as radiation.

We measure radiation dose in units called rem[1] (small doses are measured in millirem; one rem = 1,000 millirem). Scientists estimate that the average person in the United States receives a dose of about 360 millirem of radiation per year. Eighty percent of that exposure comes from natural sources: radon gas, the human body, outer space, and rocks and soil. The remaining 20 percent comes from man-made radiation sources, primarily medical x-rays.

RELATIVE DOSES FROM RADIATION SOURCES

Millirem Doses

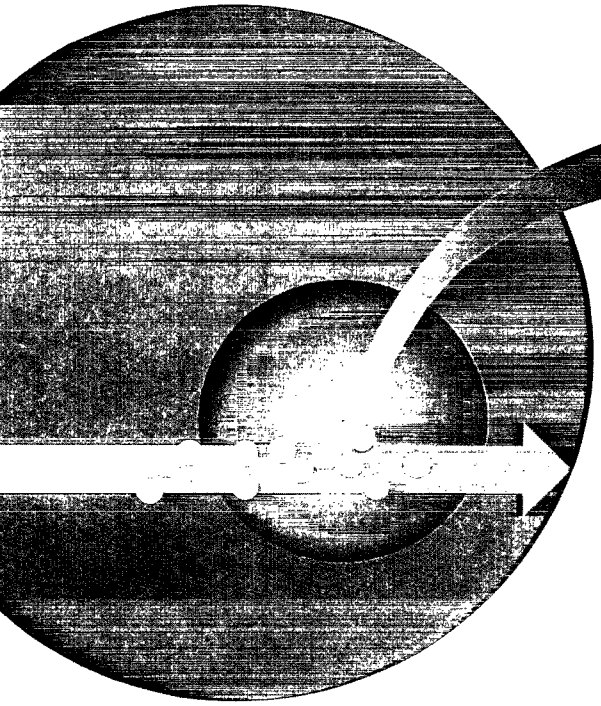


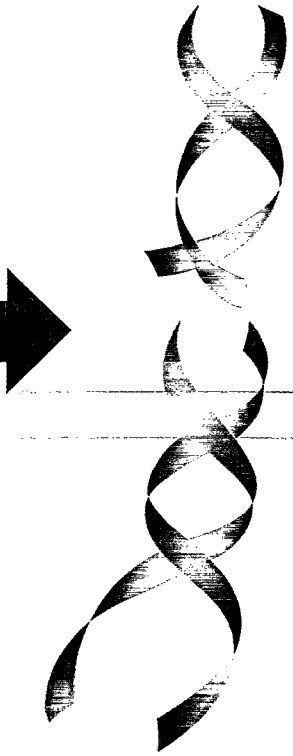
The average annual radiation exposure for a person living in the U.S.A. is 360 millirem.

Over 80 percent of our exposure to radiation comes from natural sources. Our own bodies, which contain the radioactive element potassium, account for 11 percent of our total exposure. Another three percent of our exposure to radiation comes from consumer products. Many of the sources of radiation shown here are discussed in this booklet.

[1] Other countries, as well as the scientific community in the U.S., measure radiation dose in units called sieverts.

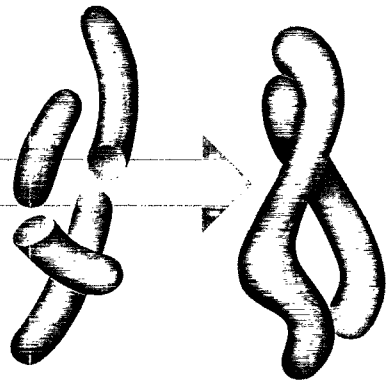
▼ *1. When radiation penetrates a human cell, it may damage molecules in its path.*





▲ **DNA MOLECULE**

▼ *2. If a DNA molecule is damaged, the chromosome containing that DNA molecule may break apart.*



▲ *3. The chromosome may then recombine abnormally.*

This change in chromosome structure may lead to the death of the cell or the formation of a cancerous cell.

RISKS FROM EXPOSURE TO RADIATION

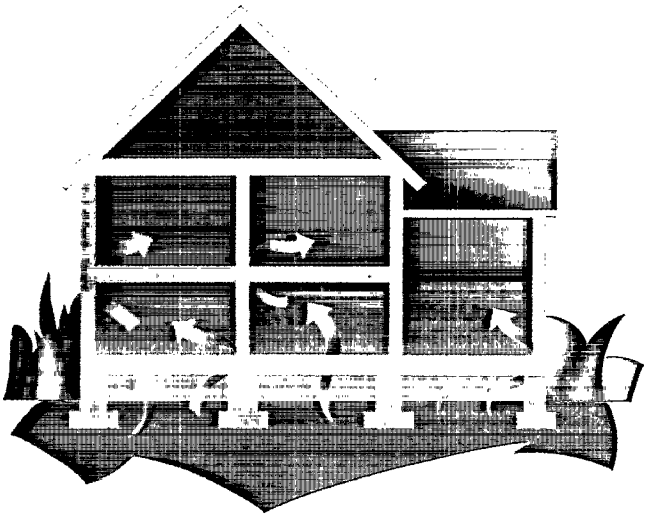
Radiation is a carcinogen. In this respect, it is similar to many hazardous chemicals found in the environment that can cause cancer. It may also cause other adverse health effects, including genetic defects in the children of exposed parents or mental retardation in the children of mothers exposed during pregnancy. However, the risk of developing cancer due to radiation exposure is much higher than the risk of these other effects.

Much of our knowledge about the risks from radiation is based on studies of over 100,000 survivors of the atomic bombs at Hiroshima and Nagasaki. In these studies, which have continued over the last 40 years, scientists have been able to observe the effects of a wide range of radiation doses, including doses comparable to an average person's lifetime dose from naturally-occurring background radiation (about 20,000 millirem). We have learned many things from these studies. The most important are:

1. The more radiation dose a person receives, the greater the chance of developing cancer.
2. It is the *chance* of cancer occurring, not the *kind* or *severity* of cancer, that increases as the radiation dose increases.
3. Most cancers do not appear until many years after the radiation dose is received (typically 10 to 40 years).

Current evidence suggests that any exposure to radiation poses some risk, i.e., there is no level below which we can say an exposure poses no risk. For the entire dose of radiation we accumulate over a lifetime from natural background radiation, the risk of developing cancer is estimated to be about one in one hundred. Based on this estimate, several percent of all fatal cancers in the U.S. are caused by background radiation. The additional contribution from all *man-made* sources of radiation is much smaller.

Naturally-occurring radiation accounts for approximately 80 percent of our exposure. Most of our exposure is to indoor radon, followed by radiation from outer space and from the earth's crust.



Radon accounts for over half of the radiation dose we receive. It can enter a house through cracks in basement walls or floors, construction joints, or gaps around pipes. Nearly one out of every 15 homes in the United States is estimated to have elevated radon levels.

RADON

Fifty-five percent of our exposure to natural sources of radiation usually comes from radon. Radon is a colorless, tasteless, and odorless gas that comes from the decay of uranium found in nearly all soils. Levels of radon vary throughout the country. Radon usually moves from the ground up and migrates into homes and other buildings through cracks and other holes in their foundations. The buildings trap radon inside, where it accumulates and may become a health hazard if the building is not properly ventilated.

When you breathe air containing a large amount of radon, the radiation can damage your lungs and eventually cause lung cancer. Scientists believe that radon is the second leading cause of lung cancer in the United States. It is estimated that 7,000 to 30,000 Americans die each year from radon-induced lung cancer. Only smoking causes more lung cancer deaths and smokers exposed to radon are at higher risk than nonsmokers.

CONTROLLING THE RISKS FROM RADON EXPOSURE

Radon is found all over the United States. Scientists estimate that nearly one out of every 15 homes in this country has radon levels higher than four picocuries per liter, the level above which EPA recommends that homeowners take corrective action. Picocuries per liter is how radon in the air is measured. Testing your home is the only way to know if you and your family are at risk from radon.

Testing for radon is easy and only takes a few minutes of your time. There are many kinds of low-cost, "do-it-yourself," EPA-approved or state-certified radon test kits available through the mail or from retail outlets. You can also hire a professional to do the testing. EPA recommends choosing a state-certified and/or EPA-listed measurement company.

If you find high radon concentrations, you can reduce them in a variety of ways. Reduction methods can be as simple as sealing cracks in floors and walls or as complex as installing systems that use pipes and fans to draw radon out of the building.

EPA has a National Radon Program to inform the public about radon risks, train radon mitigation contractors, provide grants for state radon programs, and develop standards for radon-resistant buildings. EPA works with health organizations, state radon programs, and other federal agencies to make the program as effective as possible.

For more information about radon, its risks, and what you can do to protect yourself, call 1-800-SOS-RADON or contact your state's radon office and request a free copy of EPA's *A Citizen's Guide to Radon.* A list of state radon contacts is provided on the back cover of this booklet.

RADIATION FROM THE GROUND AND OUTER SPACE

Radon gas is not the only source of natural radioactivity. We receive about eight percent of our exposure to radiation from other radioactive elements in the earth's crust, such as thorium and potassium. Radiation levels from these sources vary in different areas of the country.

Another eight percent of our radiation exposure comes from outer space. This cosmic radiation originates in our galaxy, other galaxies, and our own sun. Our exposure to cosmic radiation depends in part on the elevation where we live. For example, people who live in Denver, Colorado, which is more than 5,000 feet above sea level, are exposed to more cosmic radiation than people living in Chicago, Illinois. Because Chicago is only approximately 1,000 feet above sea level, it has a thicker atmosphere, which can filter out more cosmic radiation than Denver's thinner atmosphere.

Controlling exposure to these forms of natural radiation would not be practical.

Since the discovery of radiation, people have benefited from the use of radiation in medicine and industry. Man-made sources of radiation account for about 20 percent of our total exposure to radiation.

X-rays are a type of radiation and are also an important tool in medical diagnoses. Doctors and patients should weigh the benefits and risks of medical treatment involving radiation.

RADIATION IN MEDICINE

Radiation used in medicine is the largest source of man-made radiation to which people in the United States are exposed. Most of our exposure is from diagnostic x-rays. Physicians use x-rays in more than half of all medical diagnoses to determine the extent of disease or physical injury. Radiation is also used in cancer treatments, where precisely targeted radiation destroys diseased cells without killing nearby healthy cells. Radiopharmaceuticals, another medical treatment, are used to locate tumors in a patient's body and to treat cancer. One-third of all successful cancer treatments involve radiation.

CONTROLLING THE RISKS OF MEDICAL RADIATION

The Food and Drug Administration (FDA) and other federal and state agencies regulate medical procedures that use radiation. EPA and these agencies also issue guidance designed to reduce unnecessary use of radiation in diagnosis and treatment and to ensure that technicians, equipment, and techniques meet standards that minimize radiation exposure.

Patients and health care providers must make the decision to use radiation on a case-by-case basis. Since any radiation exposure carries some risk, it is necessary to decide whether the benefits of radiation justify its use. Before receiving x-rays or any other type of medical treatment involving radiation exposure or dose, it is sensible to discuss the need for and benefits of the procedure and its alternatives with your physician.

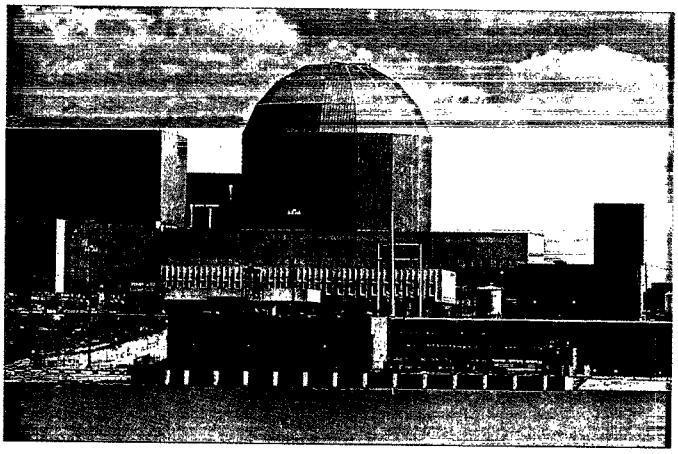
NUCLEAR POWER

Nuclear power reactors, which use uranium, supply the United States with about 20 percent of its electricity. Our ability to produce power using radioactive materials reduces our reliance on fossil fuels. Nuclear power plant operations account for less than a hundredth of a percent of the average American's total radiation exposure. Workers at nuclear power plants receive higher doses of radiation, but the overall risk to the population is extremely low.

CONTROLLING THE RISKS OF NUCLEAR POWER

In 1979, EPA issued environmental standards that protect the public from radiation from the many kinds of facilities that contribute to the production of electricity through the use of nuclear energy. Additionally, in 1987, EPA issued guidance for Federal agencies to use in the development of radiation exposure standards for workers. These standards limit the amount of radiation that workers in medicine, nuclear power, industry, mining, and waste management may receive. Finally, in 1989, under the Clean Air Act, EPA published standards limiting radionuclide emissions from all Federal and industrial facilities.

The Nuclear Regulatory Commission (NRC) is the federal agency responsible for implementing EPA's radiation exposure standards through regulation of nuclear power reactors and many other uses of radiation. The Department of Energy (DOE) also implements these standards at facilities under their supervision.



RADIOLOGICAL EMERGENCIES

Although accidents at nuclear power plants are rare, past emergencies have contributed to public perceptions that nuclear power is unsafe. One such emergency was the release of radioactive material from the nuclear reactor core at Three Mile Island (TMI) in 1979.

Since the TMI accident, the NRC has strengthened regulations covering plant design, training, and operations. In addition, all domestic nuclear power plants now must have emergency plans that protect the public from radiation exposure. EPA determines the exposure level at which actions to protect the public in the event of a release or potential release of radioactive material into the environment are recommended. Several Federal agencies respond to radiological emergencies, including EPA, NRC, the Federal Emergency Management Agency, the DOE, the Department of Health and Human Services, and the Department of Agriculture. In addition, state and local governments have primary responsibility for protecting the public and environment in the case of a radiological emergency.

Even if a release has not occurred, a nuclear power plant may temporarily shut down to prevent a release from occurring. If a release does occur, regulations require the facility to notify proper authorities.

The Department of Energy's nuclear weapons complex consists of 16 major sites across the United States, such as this one in Hanford, Washington. Many of these sites are contaminated with radioactive wastes from nuclear weapons production. EPA is setting the criteria that DOE and the states will use to clean up the contamination at these facilities.

RADIOACTIVE WASTE

Any activity that uses radioactive materials generates radioactive waste. Mining, nuclear power, defense, nuclear medicine, and scientific research all produce radioactive waste that must be disposed of properly. Some activities produce low-level waste, which includes rags, equipment, and protective clothing contaminated with radioactive material. Others generate more highly radioactive waste, such as used fuel from reactors or waste from the manufacture of nuclear weapons.

Radioactive waste can remain radioactive for anywhere from days to hundreds or even thousands of years. If this waste is not properly isolated from the public and the environment, it may contaminate air, soil, and water supplies.

CONTROLLING THE RISKS OF RADIOACTIVE WASTE

Several federal agencies and some states control the risks of radioactive waste by establishing appropriate disposal regulations and applying these to disposal facilities to effectively isolate the waste. EPA has already established environmental standards for the cleanup and disposal of radioactive mining wastes. EPA is also responsible for setting generally applicable environmental standards for disposal of other radioactive wastes, which will be implemented by NRC and DOE.

Federal agencies regulate storage of high-level waste, which is currently placed in underground tanks or stored in pools of water. DOE is evaluating potential disposal sites for radioactive waste at Yucca Mountain, Nevada, and Carlsbad, New Mexico. These sites would be located thousands of feet underground and be subject to EPA performance requirements issued to prevent waste from escaping. In October 1992, Congress passed the Waste Isolation Pilot Plant (WIPP) Land Withdrawal Act. This Act gives EPA the responsibility to oversee DOE in the testing and operation of the WIPP. EPA is also charged with ensuring that WIPP complies with all federal environmental laws and regulations.

In addition to these disposal options, the federal government is investigating new technologies and disposal methods to treat or dispose of these wastes safely.

CONCLUSION

Natural sources of radioactivity are all around us, and man-made radioactive materials are a vital part of medicine and industry. Exposure to some radiation, natural or man-made, is inevitable. In living with radiation, we must understand the risks and benefits. It is also important to remember that many federal and state programs exist to protect the public from avoidable exposures to radiation.

MANY FEDERAL AGENCIES AND THE STATES HAVE IMPORTANT ROLES IN PROTECTION OF THE PUBLIC AND THE ENVIRONMENT FROM RADIATION

STATES

The states have agencies responsible for regulating the use of radiation and for addressing radiation questions and problems. They are the best first source of information about radiation issues which affect their constituents. The states regulate the use of x-ray machines. Some are also licensed to regulate other sources of radiation within their state on behalf of EPA, NRC, or the Occupational Safety and Health Administration (OSHA).

ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA issues standards and guidance to limit human exposure to radiation. EPA works with the public, industry, the states and other government agencies to inform people about radiation's risks and to promote actions that reduce human exposure. EPA also measures environmental levels of radiation and assesses radiation's effects on people and the environment.

NUCLEAR REGULATORY COMMISSION (NRC)

NRC implements EPA's and its own standards for protecting the public from radiation. NRC regulates the civilian uses of nuclear materials in the United States by: licensing facilities that possess, use, or dispose of nuclear materials; establishing standards governing the activities of licensees; and inspecting licensed facilities to ensure compliance with its requirements. These regulatory functions relate to both nuclear power plants and to other users of nuclear materials for purposes such as nuclear medicine at hospitals, academic activities at educational institutions, research work, and industrial applications such as gauges and testing equipment.

DEPARTMENT OF HEALTH AND HUMAN SERVICES (HHS)

HHS's Food and Drug Administration's Center for Devices and Radiological Health establishes standards for x-ray machines and other electronic products to ensure that human health is protected from the radiation produced by these products.

DEPARTMENT OF ENERGY (DOE)

DOE is responsible for the development of the disposal system for spent nuclear fuel from the nation's civilian nuclear power plants. This activity is totally funded by a tax paid by the users of nuclear-generated electricity. DOE is also responsible for the management and disposal of nuclear waste and other radioactive materials associated with nuclear weapons production at federally-owned facilities. The Department is working to clean up its present and former nuclear sites. DOE is cooperating with state governments and private industry to clean up other locations around the United States that were contaminated with radiation as a result of government programs. DOE also provides technical advice and assistance to states and the private sector in the management and disposal of low-level radioactive waste.

DEPARTMENT OF DEFENSE (DOD)

While DOE is responsible for the safe handling of radioactive material at defense production facilities, DOD is responsible for the safe handling and storage of nuclear weapons and other military uses of nuclear energy.

DEPARTMENT OF TRANSPORTATION (DOT)

DOT, in cooperation with NRC and the states, governs the packaging and transport of radioactive materials. The Department also regulates carriers of radioactive materials.

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

OSHA develops and enforces regulations to protect workers not covered by other agencies from radiation exposure.

REGIONAL OFFICES

Providing Information on EPA's Radiation Protection Programs

REGION 1

U.S. EPA — Region 1
J.F.K. Federal Building
One Congress Street
Boston, MA 02203
617-565-4502

Connecticut

Maine

Massachusetts

New Hampshire

Rhode Island

Vermont

REGION 2

U.S. EPA — Region 2
26 Federal Plaza
New York, NY 10278
212-264-4110

New Jersey

New York

Puerto Rico

REGION 3

U.S. EPA — Region 3
841 Chestnut Street
Philadelphia, PA 19107
215-597-8326

Delaware

District of Columbia

Maryland

Pennsylvania

Virginia

West Virginia

REGION 4

U.S. EPA — Region 4
345 Courtland Street, NE
Atlanta, GA 30365
404-347-3907

Alabama

Florida

Georgia

Kentucky

Mississippi

North Carolina

South Carolina

Tennessee

REGION 5

U.S. EPA — Region 5
77 West Jackson Boulevard
Chicago, IL 60604
312-886-6175

Illinois

Indiana

Michigan

Minnesota

Ohio

Wisconsin

REGION 6

U.S. EPA — Region 6
1445 Ross Avenue
Dallas, TX 75202-2733
214-655-7223

Arkansas

Louisiana

New Mexico

Oklahoma

Texas

REGION 7

U.S. EPA — Region 7
726 Minnesota Avenue
Kansas City, KS 66101
913-551-7600

Iowa

Kansas

Missouri

Nebraska

REGION 8

U.S. EPA — Region 8
999 18th Street
Denver, CO 80202-2405
303-293-1713

Colorado

Montana

North Dakota

South Dakota

Utah

Wyoming

REGION 9

U.S. EPA — Region 9
75 Hawthorne Street
San Francisco, CA 94105
415-744-1048

Arizona

California

Hawaii

Nevada

REGION 10

U.S. EPA — Region 10
1200 Sixth Avenue
Seattle, WA 98101
206-442-7660

Alaska

Idaho

Oregon

Washington

FOR MORE INFORMATION...

NATIONAL RADON HOTLINE:
800-SOS-RADON

STATE AGENCIES PROVIDING RADON INFORMATION

Alabama	*800-582-1866*
Alaska	*800-478-4845*
Arizona	*602-255-4845*
Arkansas	*501-661-2301*
California	*800-745-7236*
Colorado	*800-846-3986*
Connecticut	*203-566-3122*
Delaware	*800-554-4636*
District of Columbia	*202-727-5728*
Florida	*800-543-8279*
Georgia	*800-745-0037*
Hawaii	*808-586-4700*
Idaho	*800-445-8647*
Illinois	*800-325-1245*
Indiana	*800-272-9723*
Iowa	*800-383-5992*
Kansas	*913-296-1560*
Kentucky	*502-564-3700*
Louisiana	*800-256-2494*
Maine	*800-232-0842*
Maryland	*800-872-3666*
Massachusetts	*413-586-7525*
Michigan	*517-335-8190*
Minnesota	*800-798-9050*
Mississippi	*800-626-7739*
Missouri	*800-669-7236*
Montana	*406-444-3671*
Nebraska	*800-334-9491*
Nevada	*702-687-5394*
New Hampshire	*800-852-3345*
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New Jersey	*800-648-0394*
New Mexico	*505-827-4300*
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North Dakota	*701-221-5188*
Ohio	*800-523-4439*
Oklahoma	*405-271-5221*
Oregon	*503-731-4014*
Pennsylvania	*800-237-2366*
Puerto Rico	*809-767-3563*
Rhode Island	*401-277-2438*
South Carolina	*800-768-0362*
South Dakota	*605-773-3351*
Tennessee	*800-232-1139*
Texas	*512-834-6688*
Utah	*801-538-6734*
Vermont	*800-640-0601*
Virginia	*800-468-0138*
Washington	*800-323-9727*
West Virginia	*800-922-1255*
Wisconsin	*608-267-4795*
Wyoming	*800-458-5847*

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