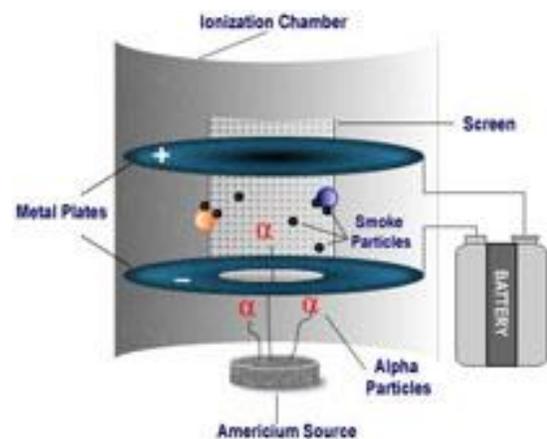


## 1) Smoke Detectors

- Most smoke detectors which operate alarms contain an artificially produced radioisotope: americium-241.
- Americium-241 is made in nuclear reactors, and is a decay product of plutonium-241.
- Smoke detectors/alarms are important safety devices, because of their obvious potential to save lives and property.
- There are two types of smoke detector commonly available in many countries. One type uses the radiation from a small amount of radioactive material to detect the presence of smoke or heat sources. These 'ionization chamber' smoke detectors are the most popular, because they are inexpensive and are sensitive to a wider range of fire conditions than the other type. They contain some americium.
- The other type of detector does not contain radioactive material; it uses a photoelectric sensor to detect the change in light level caused by smoke. This type is more expensive to purchase and install, and is less effective in some circumstances.
- The element americium (atomic number 95) was discovered in 1945 during the Manhattan Project in USA. The first sample of americium was produced by bombarding plutonium with neutrons in a nuclear reactor at the University of Chicago.
- Americium-241, with a half-life of 432 years, was the first americium isotope to be isolated, and is the one used today in most domestic smoke detectors.
- Am-241 decays by emitting alpha particles and gamma radiation to become neptunium-237.
- Americium dioxide, AmO<sub>2</sub>, was first offered for sale by the US Atomic Energy Commission in 1962 and the price of US\$1500 per gram has remained virtually unchanged since. One gram of americium oxide provides enough active material for more than three million household smoke detectors.
- The vital ingredient of household smoke detectors is a very small quantity of Am-241 as americium dioxide (AmO<sub>2</sub>).
- The alpha particles emitted by the Am-241 collide with the oxygen and nitrogen in air in the detector's ionization chamber to produce charged particles (ions).
- A low-level electric voltage applied across the chamber is used to collect these ions, causing a

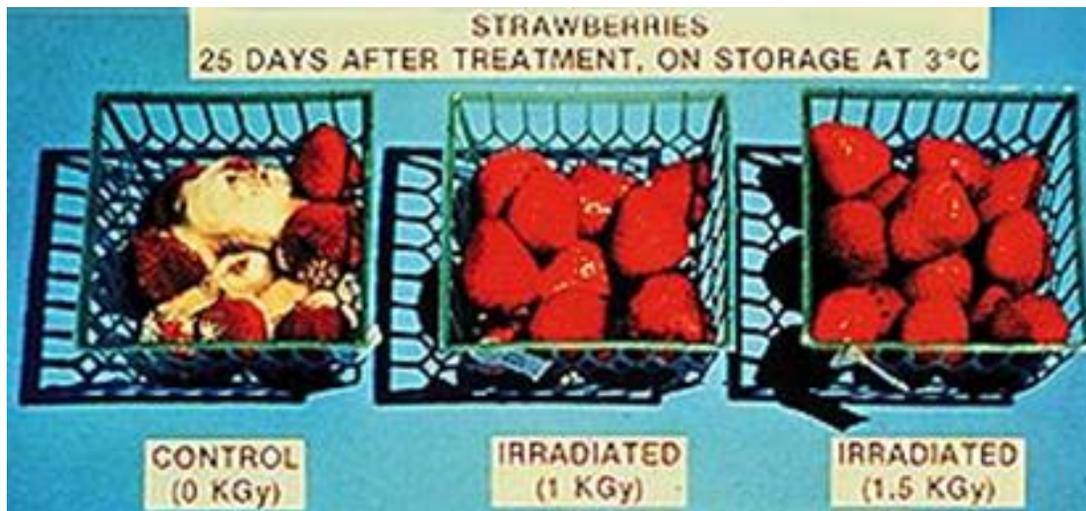


steady small electric current to flow between two electrodes. When smoke enters the space between the electrodes, the smoke particles attach to the charged ions, neutralizing them. This causes the number of ions present – and therefore the electric current – to fall, which sets off an alarm.

- The radiation dose to the occupants of a house from a domestic smoke detector is essentially zero, and in any case very much less than that from natural background radiation. The alpha particles are absorbed within the detector, while most of the gamma rays escape harmlessly.
- The small amount of radioactive material that is used in these detectors is not a health hazard and individual units can be disposed of in normal household waste.
- Even swallowing the radioactive material from a smoke detector would not lead to significant internal absorption of Am-241. Americium dioxide is insoluble, so will pass through the digestive tract without delivering a significant radiation dose.
- Americium-241 is however a potentially dangerous isotope if it is taken into the body in soluble form. It decays by both alpha activity and gamma emissions and it would concentrate in the skeleton.
- The annual dose at 1m delivered by an average household smoke detector is ~100 times lower than the dose from natural background radiation.

## 2) Food Irradiation

- You are probably familiar with pasteurizing milk and pressure-cooking canned foods as ways to kill bacteria in food. Food irradiation is another way to kill bacteria and other pathogens such as mold and bacteria in our food. For example, irradiation can kill *E. coli*, *Campylobacter* and *Salmonella* bacteria. These bacteria make millions of people sick and send thousands of people to the hospital each year.



- Animal feed also can contain *Salmonella*. Irradiation can prevent the spread of these bacteria to livestock.
- Irradiating food protects people in this world -- and out of this world as well! NASA astronauts eat food that has been irradiated to avoid any chance of food-borne illness in space. U.S. Centers for Disease Control and Prevention (CDC) reports that when food irradiation is done well, it helps with food safety.
- Irradiation does not make food radioactive and preserves the nutritional value of the food.
- Irradiation slows down the aging of foods such as fruits and vegetables.
- Irradiating dry foods like spices and grains allows them to be stored for a long time. It also allows shipping of grains and spices over long distances.
- Irradiating food does not get rid of dangerous toxins that are already in food. In some cases, the bacteria themselves are not dangerous, but they produce toxins that are. *C. botulinum* is one of these bacteria. It grows in canned food that is not completely sterilized. Its toxin causes botulism, which can kill.
- Irradiation can alter slightly the flavor of some foods. The change is similar to the way pasteurization alters the taste of milk.

- Currently, food irradiators use one of three kinds of radiation: gamma rays (from cobalt-60 sources), electron beams, or x-rays.
- All three methods work the same way. Bulk or packaged food passes through a radiation chamber on a conveyor belt. The food does not come into contact with radioactive materials, but instead passes through a radiation beam, like a large flashlight. The ionizing radiation sends enough energy into the bacterial or mold cells to break chemical bonds. This damages the pathogens enough that they die or can no longer multiply and cause illness or spoilage.
- U.S. FOOD AND DRUG ADMINISTRATION (FDA), CENTER FOR FOOD SAFETY AND APPLIED NUTRITION (CFSAN) FDA has approved food irradiation methods for a number of foods.
- Irradiation can be used on herbs and spices, fresh fruits and vegetables, wheat, flour, pork, poultry and other meat, and some seafood.
- FDA requires that irradiated food labels contain both a logo and a statement that the food has been irradiated. U.S. DEPARTMENT OF AGRICULTURE (USDA) USDA works with FDA to promote food irradiation where it is appropriate. USDA also controls the use of the word "organic" on food labels.
- Foods which have been irradiated, no matter how they are grown or produced, cannot be labeled as USDA certified organic.

### What Foods Can Be Irradiated?

Approval Year	Food	Dose (kGy)	Purpose
1963	Wheat Flour	0.2-0.5	Control of mold
1964	White Potatoes	0.05-0.15	Inhibit sprouting
1986	Pork	0.3-1.0	Kill Trichina parasite
1986	Fruit and Vegetables	1.0	•Insect Control •Increase Shelf Life
1986	Herbs and Spices	30	Sterilization
1990(FDA) 1992(USDA)	Poultry	3(FDA) 1.5-3(USDA)	Bacterial pathogen reduction
1997(FDA) 1999(USDA)	Meat	4.5	Bacterial pathogen reduction

### 3) Tritium in Exit Signs

- Exit signs are mounted in almost every building we enter; schools, grocery stores, movie theaters and shopping malls. Many exit signs contain tritium, the radioactive form of hydrogen.
- They light the sign without batteries or electricity.
- Using tritium in exit signs allows the sign to remain lit if the power goes out as it might if there is a storm or a fire.
- Tritium is most dangerous when it is inhaled or swallowed.
- When tritium is mixed with certain chemicals, it creates a continuous, self-powered light source. Tritium exit signs are used when dim light is needed, but using batteries or electricity is not possible.
- Tritium can be naturally produced or man-made. Exit signs use man-made tritium.
- Because a damaged tritium exit sign will have relatively high levels of tritium in it, you should leave the area immediately and call for help.
- Damage to tritium exit signs is most likely to occur when a sign is dropped during installation or smashed in the demolition of a building.
- Unwanted tritium exit signs may not be put into ordinary trash.
- Tritium exit signs that are illegally put in ordinary landfills can break and contaminate the groundwater.
- Tritium exit signs require special disposal. The person who was put in charge of the tritium exit signs when they were purchased is responsible for disposing of them. That person must follow special rules for their disposal.
- Tritium has a half-life of 12.32 years meaning that it loses half its brightness in that period.
- It emits beta particles, which are most harmful when inhaled or swallowed. Internal contamination occurs when people swallow or breathe in radioactive materials, or when radioactive materials enter the body through an open wound or are absorbed through the skin. Tritium must be ingested in large amounts to pose a significant health risk.



#### 4) Medical X-Rays

From broken bones to life threatening illnesses, x-rays help doctors detect numerous medical conditions. They are used as • Medical X-Rays. • Dental X-Rays. • Mammography. • CT Scans. • Fluoroscopy.



- Medical x-rays are used to see what is happening inside the body. As x-rays pass through objects, including internal organs, body tissue, and clothing, they project a picture onto film or a detector linked to a computer monitor. In general, denser objects, like bones, absorb more radiation, reducing the amount of radiation that passes through to the detector. This is why bones appear white on x-ray images.
- Radiologists can read these images to diagnose medical conditions or injuries.
- A conventional (or regular) medical x-ray produces a two-dimensional picture that can help find fractures (broken bones), tumors and foreign objects.
- **Medical x-rays** are also used in other types of examinations and procedures, including CT scans and fluoroscopy.
- Different imaging procedures expose patients to different amounts of radiation.
- Conventional and dental x-ray procedures and mammography use relatively low amounts of radiation.
- CT scans and fluoroscopic procedures involve multiple exposures and/or a longer exposure to radiation resulting in higher doses.
- Medical imaging is a very powerful and valuable technique that can provide important and lifesaving information.
- **Dental x-rays** let your dentist see the condition of your teeth from the crown to the roots. They also show the bones of the jaw and the overall condition of the bones of your face. During a dental x-ray, radiation passes through your cheek, gums and teeth to strike the special x-ray film clamped between your teeth. Newer x-ray machines use digital imaging instead of film. All types of dental x-rays use a small amount of radiation to take the pictures. X-ray of hands and fingers. A typical x-ray machine with protection wall for a radiologic technologist.
- **Computed tomography** scans (also known as CT scans, CAT scans or computed axial tomography scans) are advanced x-ray procedures that create cross-sectional views and three dimensional images of a patient's internal organs. When a person has a CT scan, many x-rays of their body or body part are taken at nearly the same time.

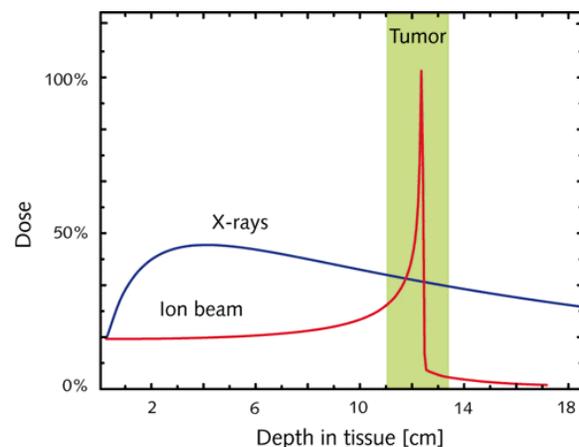
- CT scans are useful because they help doctors diagnose problems by creating very clear images of internal organs. The detailed images help identify problems inside the body, such as tumors or damage to organs.
- CT scans can also help doctors prepare for surgery by providing a map of the inside of the patient that surgeons can follow when operating.
- When a person has a CT scan, they are being exposed to more radiation than when they have a conventional x-ray. The radiation exposure of a CT scan can be up to several hundred times that of a conventional x-ray. Like any medical test, the beneficial information gained from a CT scan should outweigh the risk of radiation exposure from the test performed.
- **Fluoroscopy** is like a real-time x-ray movie. It can show the movement of a body part (like the heart) or the path that a medical instrument or dye (contrast agent) takes as it travels through the body.
- Unlike conventional x-rays, fluoroscopy uses an x-ray beam that is passed continuously through the body. The image is transmitted to a monitor so that doctors can see the body part and its motion in real-time.
- A medical instrument or dye is then added to show the function of the body part. The total exposure to x-rays depends on the length of time of the fluoroscopy procedure.
- Fluoroscopy is used in many types of examinations and procedures, including:
  - Viewing movement of materials through the stomach and intestines.
  - Directing the placement of a catheter during heart surgery.
  - Visualizing blood flow to organs.
  - Helping doctors properly set broken bones.

## 5) Radiation Therapy

- Radiation therapy is a cancer treatment that uses focused beams of radiation to shrink or kill tumors.
- Radiation therapy does not make patients radioactive.
- Radiation therapy (also known as external beam radiation therapy) uses high-energy (ionizing) radiation to shrink or kill tumors.
- Because radiation damages cells and destroys their ability to divide, external beam radiation therapy uses focused radiation beams produced by a machine outside the body to target tumor cells inside the body. These machines are called linear accelerators.
- The linear accelerator creates radiation beams that are aimed at the tumor. The radiation from these beams can also damage healthy cells.
- Before therapy, doctors carefully plan the best way to aim the radiation beam to damage the tumor as much as possible while doing as little damage to healthy cells as possible.
- There are many different types of radiation therapy that can be used to treat tumors. Some examples include:
  - Three-Dimensional Conformal Radiation Therapy (3D-CRT) – It uses specialized computers to get an accurate picture of the size, shape and location of the tumor. Doctors use these images to create a precisely focused treatment. 3D-CRT can use single or multiple x-ray beams to target the tumor.



- Proton Therapy – Proton therapy uses a beam of protons to target tumors. As opposed to x-rays, which deposit energy along their path, protons deposit the majority of their energy at the end of their path. Doctors use proton therapy with the goal of creating less damage to healthy tissue and more damage to the targeted tumor, where the proton beam ends.

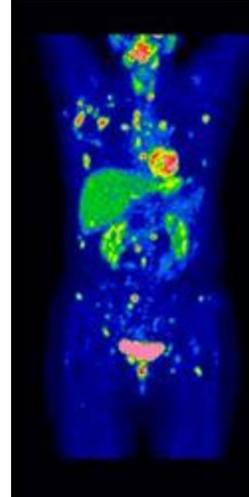


- Radiation therapy can cause side effects. Acute effects, such as hair loss or nausea, can occur during the period of treatment. Most acute effects disappear after treatment.

- Because radiation can also increase the risk of cancer, there is a small chance that the cancer treatment itself will produce another cancer years later. Cancer therapy patients are therefore screened frequently for cancer after successful treatment of their primary tumor. Doctors and other scientists continue to research radiation therapy methods to increase accuracy, decrease exposure to healthy tissue and reduce side effects.

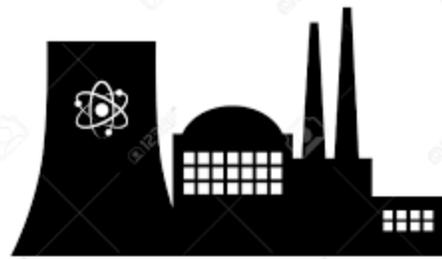
## 6) Nuclear Medicine

- Nuclear medicine procedures can help detect and treat disease by using a small amount of radioactive material, called a radiopharmaceutical.
- Some radiopharmaceuticals are used with imaging equipment to detect diseases. Others are placed in or near a cancerous tumor to shrink or kill it.
- A positron emission tomography (PET) scan is an example of diagnostic nuclear medicine.
- A PET scan uses a radioactive substance as a tracer that is injected into the blood stream. Blood carries the tracer to a specific organ in the body.
- Doctors use a special camera to watch how the tracer moves. The camera sends information to a computer, which takes pictures as the tracer moves thorough the organ. Doctors use the images to detect problems with the organ or identify how the organ is working.
- Radiopharmaceuticals are also used to treat disease by shrinking tumors and killing cancerous cells. For example, during a brachytherapy procedure, doctors surgically place small radioactive “seeds” near or inside a cancerous tumor. The radiation from the seeds helps destroy the nearby cancer cells.
- Different radioactive elements are absorbed differently by different organs. For example, iodine is absorbed by the thyroid gland, so iodine- 131 is used to diagnose and treat thyroid cancer.
- The doctors choose the best radiopharmaceutical for the part of the body they need to diagnose or treat.
- Most nuclear medicine procedures involve small amounts of radioactive materials. As a result, patients usually receive only small doses of radiation. However, some tests, such as heart scans, result in much higher doses.



## 7) Nuclear Power Plants

- Nuclear power plants produce electricity from the heat created by splitting uranium atoms. In the United States, more than 100 nuclear reactors create electricity.
- Nuclear energy comes from the splitting of uranium atoms in a process called fission. Fission releases energy in the form of heat. This heat creates the steam that is used to turn a turbine, which generates electricity.
- Among the radioactive materials found at nuclear power plants, you will find enriched uranium, low-level waste and spent nuclear fuel.
- Enriched uranium is the fuel for nuclear power plants. There may be more than 100 tons of fuel pellets (each about 1 inch long) at a single reactor. One pellet can generate about the same amount of electricity as one ton of coal.
- Low-level radioactive waste includes items used at the power plant that become contaminated with radioactive material, such as shoe covers and clothing, wiping rags, mops, filters, reactor water and tools. The radionuclides in some waste decay away quickly, allowing it to be disposed of as ordinary trash. When the radionuclides are slow to decay, waste is stored until there is enough waste for shipment to a low-level waste disposal site.
- Spent nuclear fuel is what is left when the fuel pellets can no longer go through the fission process. It is highly radioactive and stored in specially designed pools or containers.
- There are no or very low levels of radioactive materials released during normal operations of nuclear power plants. Such releases do not require any protective actions.
- The reactor buildings are built to contain the radiation from an accident.
- Nuclear power plants are required to have plans to deal with emergencies and to practice them regularly.



## 8) Uranium Mines and Mills

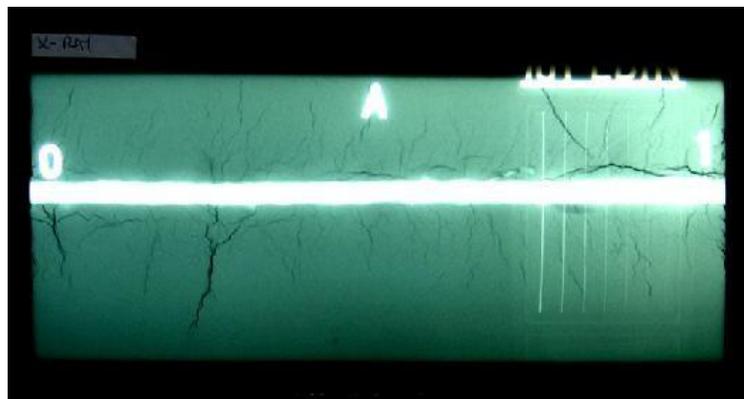
- Uranium is used as nuclear fuel for electric power generation. It is a natural mineral and has been mined and used for its chemical properties for thousands of years.
- U.S. mining industries can obtain uranium in two ways: mining or milling.
- The U.S. mining industry can retrieve uranium in two ways: by mining rock that contains uranium or by using strong chemicals to dissolve uranium from the rock that is still in the ground. When uranium is near the surface, miners dig the rock out of open pits. Open-pit mining strips away the topsoil and rock that lie above the uranium ore. When uranium is found deep underground, miners must dig underground mines to reach it. The rock is then removed through underground tunnels.
- Mining waste and mill tailings can contaminate water, soil and air if not disposed of properly.
- There are three methods for extracting the uranium from the ore: heap-leaching, in-situ leaching and milling.
- Heap-leaching is the process of dissolving a chemical by pouring a liquid on it. One example of this type of process is making coffee. Uranium heap-leaching is done by spraying chemicals over piles of crushed rock that contain uranium. Underground drains below the heap collect the uranium-bearing liquid. Once the liquid is collected, it is sent for additional processing to extract the uranium. U.S. miners currently do not use this method.
- In-situ leaching (also known as in-situ uranium recovery) is Latin for “in place.” Some uranium is found in rocks that are porous and completely soaked with water underneath the ground. In-situ leaching of uranium is done by pumping chemicals into the groundwater to dissolve uranium from the surrounding rock. The liquid containing uranium is pumped to the surface through wells. The liquid solution is then processed to recover the uranium. Currently, this is the most commonly used mining method in the United States.
- Milling is a process that removes uranium from the rock that contains it. Uranium ore is removed from open-pit and underground mines. Once at the mill, the ore is crushed and ground up. Chemicals are added to dissolve the uranium. The uranium is then recovered from the chemical solution. Tailings are the radioactive wastes that are left over from the milling processes. They can contain uranium, thorium, Uranium Ore.
- Uranium eventually decays to radium. Radium decays to release a radioactive gas called radon.



- Open pit uranium milling and in-situ mining sites do not pose a significant radon risk to the public or to miners; the radon disperses into the atmosphere. However, underground mines are a greater radiation hazard to miners.
- Without precautions, radon can collect in the mineshafts where it is inhaled by miners. The operators of uranium mines must take special precautions to protect miners, such as pumping radon gas out of the mine and replacing it with fresh air.
- Radon gas vented from uranium mines must not exceed certain limits to protect the public near the mines. It is also necessary for miners to wear respirators that protect their lungs from radioactive dust and radon gas.
- In the past, the waste rock produced by underground and open-pit mining was piled up outside the mine. This practice has caused problems on Navajo lands in particular, where more than half of the many small, abandoned uranium mines from the middle of the 20th century and their wastes remain.
- Wind can blow radioactive dust from the wastes into populated areas and the wastes can contaminate drinking water. Previously, waste rock and mill tailings were used in some Western mining areas as building materials for homes, schools, roads and other construction.
- Structures built with waste rock and mill tailings were radon and radiation hazards to anyone spending time in them. People traveling on roads made with waste rock were in danger of breathing radioactive dust.
- In response to these issues, the 1978 Uranium Mill Tailings Radiation Control Act (UMTRCA) stopped the use of mill tailings in building and construction projects.

## 9) Industrial Radiography

- Manufacturers use a method called industrial radiography to check for cracks or flaws in materials.
- Radiation is used in industrial radiography to show problems not visible from the outside without damaging the material.
- Manufacturers know that consumers expect the products they buy to be safe, to work well and to last. This reliability becomes even more important when product failure can be expensive or dangerous.
- Manufacturers also use industrial radiography to check for cracks or flaws in their products. Just like medical x-rays are used to find breaks or cracks in bones, industrial radiography uses x-rays or gamma rays to take pictures of the inside of products because they can show problems not visible from the outside.
- Radiography is useful because it does not damage or change the product being tested. For example, industrial radiography is used to test: • Gas and oil pipelines. • Metal welding. • Boilers. • Vehicle parts. • Aircraft parts. Here's how it works: A beam of x-rays or gamma rays is pointed at the item being tested.
- A detector is lined up with the beam on the other side of the item. The detector records x-rays or gamma rays that pass through the material. The thicker the material, the fewer x-rays or gamma rays can pass through. Because the material is thinner where there is a crack or flaw, more rays pass through that area. The detector captures the rays that pass through, which form a picture of the crack or flaw.
- The radiograph image is an example. It shows the condition of metal around a welding site. The welding site shows up bright white because it is thicker than the rest of the material. It has stopped the rays almost completely from passing through. The cracks are the darker areas.
- The gamma rays used in radiography come from radioactive material inside the radiography device.



- Gamma ray devices do not need electricity. They are smaller than x-ray devices. Their small size makes them useful for checking inside pipes, ships and other small spaces. However, they cannot be turned off like an x-ray device.
- The radionuclides in the device always produce gamma rays. The only way to “turn off” a gamma ray radiography device is to interrupt the beam by covering the opening with a heavy metal plate.
- Workers must be careful to close the opening when the gamma device is not in use to avoid exposure. Workers who use industrial radiography equipment must be trained to use it and wear special badges that measure their exposure to radiation.
- Exposure of the public to radiation from industrial radiography equipment is not likely, because the public is not permitted in areas where testing is conducted.

## 10) Nuclear Gauges Used in Road Construction

- Nuclear gauges use radioactive sources to measure the thickness, density or make-up of a wide variety of material or surfaces.
- Building a road isn't easy; there are many layers that help make it strong enough to support big trucks and cars. Each layer must have the right density and layers of gravel must have the right amount of moisture.
- Construction crews measure density and moisture with special nuclear gauges that are powered with sealed radioactive sources.
- There are two types of nuclear gauges, fixed and portable. Fixed gauges can be used in industry to make sure each item is the same. For example, paper mills use fixed gauges to measure the thickness of a sheet of paper and some bottlers use them to make sure that each bottle contains the right amount of liquid. Typically, a fixed gauge houses a radioactive source that is covered by a shield. When the shield is opened, an invisible beam of radiation is shone on the object. A readout on the gauge or a connected computer terminal shows the requested information, often the thickness or level of liquid in a container as it is being filled.
- Portable gauges are commonly used in industries such as agriculture, construction and civil engineering. They often measure soil moisture or other items such as the density of asphalt in a paving mix. Portable gauges work by using direct transmission or backscatter. Direct transmission is the more precise of the two, it measures how much radiation passes through an object. The denser the material, the less radiation passes through.
- Portable gauges that use backscatter are most useful for measuring uniform material such as asphalt paving. Backscatter gauges measure how much radiation bounces back to the gauge after it hits the surface of an object. The denser the material, the more radiation will bounce back.
- Nuclear gauges are designed with worker safety in mind. They are lined with a lead shielding around the sealed source, which blocks the radiation. Workers usually receive little or no radiation from nuclear gauges.
- When properly used, nuclear gauges will not expose the public to radiation.
- When no longer in use, nuclear gauges must be disposed of properly. They are hazardous waste and should not be treated as ordinary trash. Gauge manufacturers or state radiation control program staff can provide disposal instructions.



## 11) Particle Accelerators

- Particle accelerators are special machines that speed up charged particles and smash them into atoms, breaking the atoms into even smaller pieces. Scientists use particle accelerators to study the smallest building blocks of our world.
  - Accelerators can produce ionizing radiation in the form of x-rays, neutrons and charged particle beams as well as radioisotopes for use in research and technology.
  - Particle accelerators are special machines that speed up charged particles: electrons, protons and positrons.
  - Particle accelerators “smash” particles into atoms.
  - The accelerator uses electricity to “push” the charged particles along a path. It pushes them over and over to make them go faster and faster. The accelerator uses magnets to steer the particles. Sometimes particles go almost as fast as the speed of light. The magnets then steer the particles at top speed into a metal target. When these fast-moving particles hit the target, the atoms in the target split apart.
  - Then scientists can study the pieces to learn what makes up an atom and what holds atoms together. These scientists are studying the smallest building blocks of our world. According to the International Atomic Energy Agency (IAEA), more than 15,000 accelerators are in use around the world. There are many different designs, some small and some very big.
  - The largest particle accelerator in world, the Large Hadron Collider at the European Center for Nuclear Research (CERN) in Switzerland, consists of more than 16 miles of tube.
  - Some accelerators produce ionizing radiation in the form of x-rays. Other accelerators are used to create radioactive material by breaking apart atoms and making them unstable.
  - Almost all particle accelerators are either used in medicine to treat diseases or by industry to make products like ceramics and plastics.
- They can also be used for research, like the NASA Space Radiation Laboratory (NSRL) – Brookhaven, Long Island
- There are several types of and uses for particle accelerators:
    - Diagnosing and treating cancer
    - Finding oil and minerals in the earth-  
Processing computer chips with charged particle beams.
    - Sterilizing medical equipment and food.
    - Making products like ceramics and plastics.



- Particle accelerators are built and operated with safety in mind.
- Particle accelerators use a lot of energy to speed up particles and they emit ionizing radiation while they are operating.
- They are often used to produce radioactive material and, in some cases, can produce radioactive waste from running the machine.

## 12) Radiation and Airport Security Scanning

- Transportation Security Administration (TSA) screeners at airports check passengers and suitcases for dangerous items such as weapons. To do their job, they use different kinds of screening equipment such as backscatter x-ray and cabinet x-ray machines. They also use millimeter wave machines and metal detectors.
- Generally, the amount of radiation received from a backscatter machine equals the amount of cosmic radiation received during two minutes of flight. The risk of health effects is very, very low.
- Millimeter wave scanners use radiofrequency (non-ionizing) radiation. The machine bounces the waves off the body. Millimeter wave scanners emit thousands of times less energy than a cell phone.
- Metal detectors use no radiation.
- Luggage is screened with cabinet x-ray machines. The thick walls and lead curtains of the cabinets keep radiation from escaping. The machines must meet strict standards about how much radiation can escape. The machines must also have locks, warning lights and warning labels.
- Passenger scanners can detect threats such as weapons or explosives that a person could be carrying under their clothing.



### 13) Radioactive Material From Fertilizer Production

- An ingredient in some fertilizers is the mineral phosphorous to help plants grow strong roots.
- When processing phosphate rock to make fertilizer, the phosphorous is removed by dissolving the rock in an acidic solution. The waste that is left behind is called phosphogypsum.
- Phosphogypsum emits radon, a radioactive gas. It also contains uranium and radium, which are radioactive elements.
- Phosphogypsum is stored in big piles called stacks. Some stacks cover hundreds of acres and are hundreds of feet high.
- As the phosphogypsum dries out, it forms a thick crust that keeps the radon from escaping into the air.
- Most of the naturally occurring uranium and radium found in phosphate rock end up in this waste. As a result, phosphogypsum has a higher concentration of these naturally occurring radioactive elements.
- Uranium decays to radium and radium decays to radon, a radioactive gas. The waste that is produced in fertilizer production is stored in large piles (stacks). In the aerial photo at right, you can see that the top of a phosphogypsum stack is covered in water.
- Phosphogypsum is very watery when it is first put on the stack. As the phosphogypsum dries out, a crust forms on the stack. The crust thickens over time, reducing the amount of radon that can escape and helping keep the waste from blowing in the wind.



Phosphogypsum is watery at first. As it dries, it forms a crust, which blocks most of the radon.

#### 14) Depleted Uranium (DU)

- If someone asked you what uranium is used for, you would probably think of reactor fuel and nuclear weapons. However, uranium has other uses. Some of these other uses happen after the most radioactive parts of uranium ore have been extracted for nuclear reactor fuel and nuclear weapons.
- The left over part of the ore is called depleted uranium, or simply DU.
- Depleted uranium is the material left after most of the highly radioactive uranium-235 is removed from uranium ore for nuclear power and weapons.
- DU is used for tank armor, armor-piercing bullets and as weights to help balance aircraft.
- DU is both a toxic chemical and radiation health hazard when inside the body.
- It is dense (1.7 times denser than lead) and actually contains several forms of uranium. Uranium-235 (U-235) is the most radioactive form and makes up only a small part of the ore. U-235 is removed from the ore for use in nuclear reactor fuel and nuclear weapons. The DU that is left is 40 percent less radioactive than the original uranium ore.
- In the 1970s, the U.S. Department of Defense (DoD) began to search for a very dense metal that could penetrate the strong armor of tanks. The metals tungsten and DU were the top two choices. At the time, the U.S. Department of Energy was operating facilities that produced DU as a waste product. This meant DU was plentiful and cheap and therefore, it was chosen. DoD used DU to make bullets and mortar shells, very strong armor for tanks and weights to balance aircraft.
- DU mainly emits alpha particle radiation. As a result, exposure to the outside of the body is not considered a serious hazard. However, inside the body, DU is a health hazard. Inside the body, the radiation it emits (alpha particles) directly affects living cells, and its chemical toxicity can cause kidney damage.
- The first major use of DU in the battlefield was during the Persian Gulf War in 1991. During the war, approximately 20 U.S. soldiers were hit with DU fragments that became permanently embedded in their bodies.
- To date, studies have shown that these soldiers have not experienced health problems related to DU. In addition, their children, who were born after the war, have not shown any DU-related health problems, such as birth or developmental defects.



- There continues to be veterans with imbedded DU fragments under their skin, but health surveillance by the Department of Veterans Affairs Medical Center shows no medically significant health effects so far.
- DU contamination of spent shells and shell fragments is a problem at some military firing ranges. However, due to its density, DU is only found as fine particles near facilities that manufacture or process uranium. DU's high melting point and high density help to ensure that it is not very mobile in air. However, fine DU particles can contaminate soil and water.

What types of radiation (alpha particles, beta particles, x-rays or gamma rays) are used or given off by the device, process or treatment?

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List the benefits and impacts of the source. Consider the social, economic and environmental impacts.

Benefits	Impacts

Do the benefits outweigh the impacts?

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Is there any alternative to the device, process or treatment?

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