Classroom notes for: Radiation and Life

98.101.201

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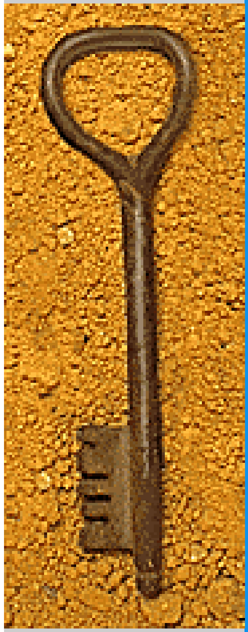
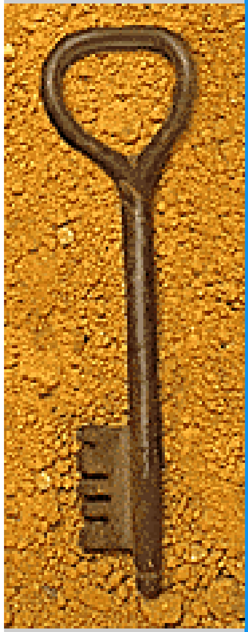


Manmade Sources of Ionizing Radiation

- 60 mrem (about 18% of total) is from irradiation by manmade sources of ionizing radiation; most of that total is from medical uses.
  - With the natural sources of ionizing radiation, for the most part, it isn't possible to exercise a large amount of control over the dose that will be received (dose from radon progeny being the exception).
  - However, for manmade sources of ionizing radiation, if not the individual, than society as a whole can effectively control the dose received. In this case, then, a new concept should be introduced: "risk vs. benefit". In other words, does the benefit received by society from a particular use of ionizing radiation outweigh the risk?
  - The objective of this course is not to instruct you that the uses of ionizing radiation are either always beneficial or always harmful; rather, ionizing radiation is something that can be either beneficial or harmful, depending upon its specific use. One must perform a "risk vs. benefit" analysis to decide for each specific instance.

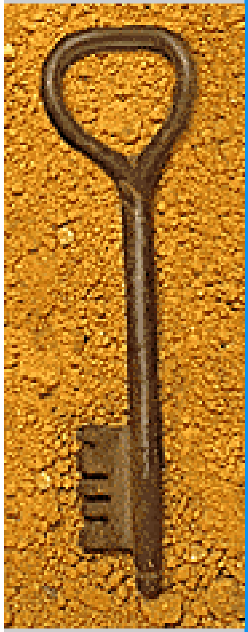


Consumer Products (10 mrem/yr- 3% of total) (NCRP 93)

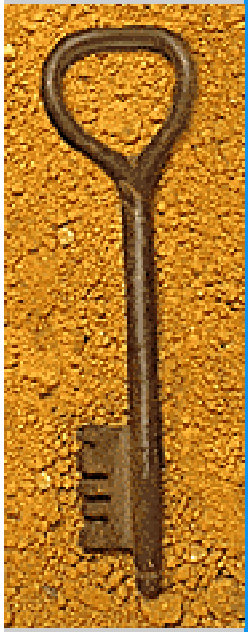
- *Airport X-Ray Machines*
- The dose equivalent is .002 mrem for each stop at airport security.
- Clearly the benefits of scanning luggage outweigh the miniscule risks posed by .002 mrem/visit.

1. Passengers walk through a metal detector at the airport — X-rays are only used on the luggage. From http://www.pcguide.com/care/care/mediaAirport-c.html:

- One of the great myths about computer media, such as floppy disks and tapes, and even hard disks and portable computers, is that they will be damaged if put through the X-ray detecting hardware at airports. This is, in fact, not true.

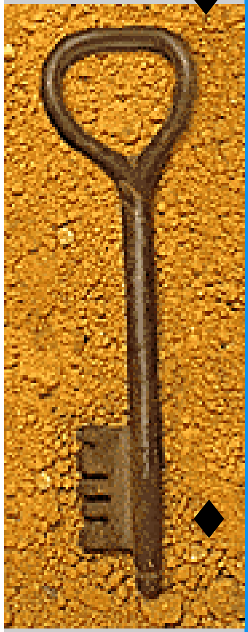


- The reason that these machines pose no threat to your disks is that X-rays are not magnetic. They are a form of *electromagnetic energy*, and perhaps it is this name that causes the confusion. Guess what electromagnetic energy is? Light. X-rays are just light waves of a specific wavelength, much like visible light, infrared (radiated heat), microwaves and radio waves. While some of these energy forms can damage media through heating (if exposed to strong enough sources, like the sun on a hot day), none affect magnetic fields. And they are present in much lower energy levels than those required to generate damaging heat.
- Some people even think that compact disks are affected by these X-ray devices. This one I really have a hard time understanding, since compact disks do not even use magnetic encoding. Their data is stored using physical structures--minute holes in the surface of a plastic disk. No form of electromagnetic radiation encountered in daily life (short of melting them with heat) will harm CDs.
- Note this does not necessarily apply to film, however, although the machines through which carry-on bags travel *typically* will not damage film. THIS IS NOT TRUE FOR FILM IN CHECKED BAGGAGE, which may be scanned by a much stronger machine. When in doubt, ask for a hand inspection of all unprocessed film.

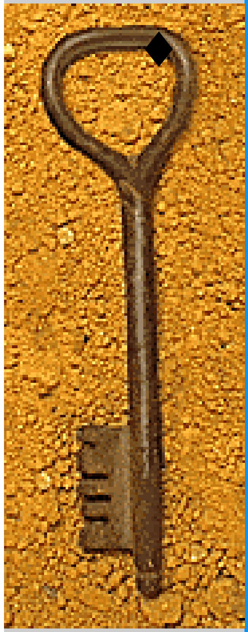


Television and Video Displays

- Televisions and video displays generate bremsstrahlung x-rays.
- The electron beam that induces the phosphors on the screen to glow also generates x-rays when it impinges on materials within the TV.
  - Watching TV over the course of one year will result in a dose of 1 mrem.
  - Using a video display (computer screen) over the course of one year will also result in a dose of 1 mrem.
- The Electronic Product Radiation Control Provisions of the Federal Food, Drug, and Cosmetic Act (originally enacted as the Radiation Control for Health and Safety Act of 1968) are located in Sections 531 through 542 of the Act. They apply to any electronic product, including: medical devices such diagnostic x-ray or ultrasound imaging devices and x-ray or electron accelerators; and non-medical devices such as microwave ovens, television receivers and monitors (video displays), industrial x-ray systems, and cordless and cellular phones. (http://www.fda.gov/CDRH/radhlth/summary.html)

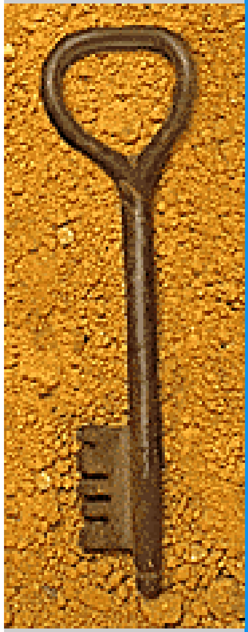


- 21 CFR 1020.10 (Television Receivers) applies to receivers and monitors that receive and convert a signal to display a "television picture". It limits radiation at 5 cm from the surface to .5 mR/hr during conditions of maximized user and service controls and a single worst-case component fault. (http://www.fda.gov/CDRH/radhlth/summary.html)
    - Benefit seems to outweigh risk for televisions.
- In reality, the CDRH states that "it should be emphasized, however, that most TV sets have been found not to give off any measurable level of radiation" and that "There should be no health hazard in watching TV at a distance at which the image quality is satisfactory to the viewer." Because there is, in reality, no measurable ionizing radiation from present-day color monitors, there is no reason to be concerned about the number of monitors in a given area. (http://hps.org/publicinformation)



Liquid Crystal Displays (LCDs) and Plasma Display Systems do not use high-voltage tubes. These display systems are also sometimes referred to as flat screens, but unlike the CRT Flat Screen, these are relatively thinner than CRT display systems and are used in laptop computers and wall-mounted screens. The voltages used in plasma displays are high enough to ionize the gas to generate and sustain the plasma. But in the plasma tube you don't have a high vacuum so the electrons cannot reach such high energies. They are pretty much limited to the ionization potential of the gas used to make the plasma which is well below the energy of even soft x rays. LCD displays have neither high voltage nor high vacuum components. Therefore, neither of these two have the potential for x rays.

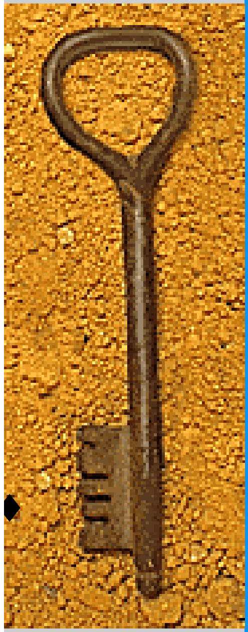
(http://hps.org/publicinformation)



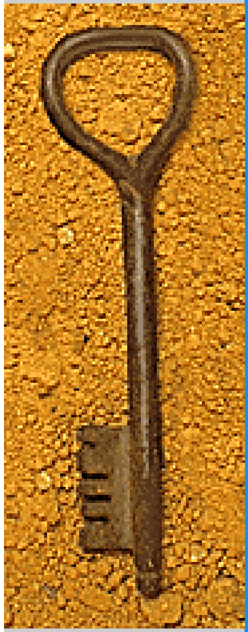
Smoke Detectors

Ionization vs. Photoelectric Smoke Alarms...What's the Difference?

- Similarities:
- Both Ion (Ionization) and Photo (Photoelectric) smoke alarms respond to combustion particles given off by developing fires. Both have to pass the SAME fire tests by Underwriters Laboratories Inc. (UL). Both are designed to give adequate warning in case of fire, whether a fire starts slowly and smolders, or bursts into flames quickly and spreads rapidly.
- Differences:
- Ion and Photo sensing chambers use different methods to detect smoke. The differences between them are pretty technical, so let's start with a simple analogy: Think of wristwatches. Some are digital, some have dials with hands. Both tell time, but they use different methods. Same idea with ion and photo smoke alarms.



- Ionization: Ion smoke alarms react to changes in ionized particles, and are somewhat better at detecting flaming fires. Flaming fires spread quickly, "consuming" or burning materials in their path rapidly. Examples include paper burning in a wastebasket or stovetop grease fires. According to a recent study released by the U.S. Consumer Product Safety Commission, 94% of reported home fires were categorized as flaming fires.
- (Note: at this point explain how the alpha particles emitted by americium-241 ionize air atoms and molecules and allow charge to flow through the air to complete the circuit; smoke or soot particles [or water vapor molecules] will attach themselves to the ions and slow the rate of charge collection)
- Photoelectric: Photo smoke alarms react to how smoke affects light, are somewhat better at detecting smoldering fires. These fires can smolder for hours before bursting into flames. Examples include cigarettes burning in couches or bedding.

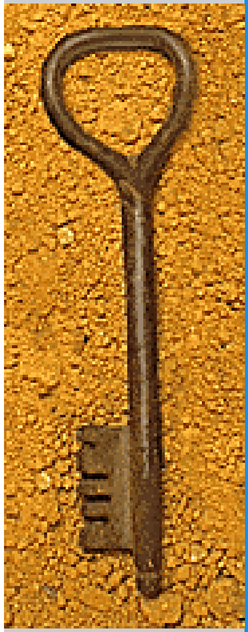


Is one better?

It's impossible to say one sensor -- photo or ion -- is universally better at detecting all types of fires. Why? Because both sensors are designed to respond to combustion particles produced by smoldering or flaming fires, and because fires themselves are different. The combustion particles produced will vary depending on what starts the fire (matches, electrical fire, etc.) and what burns (paper, fabric, wood).

If a lit cigarette drops directly onto a couch, it is more likely to start a smoldering fire. If that same cigarette drops onto a newspaper on the couch, the resulting fire may be more characterized by flames than smoldering smoke.

Major testing under the National Bureau of Standards sponsorship confirmed either type of smoke alarm will give adequate warning in either type of fire. And remember, both have to pass the SAME fire tests by Underwriters Laboratories Inc. (UL).



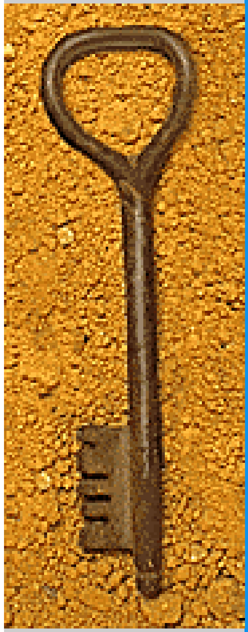
The most important factor in protecting your family is having the recommended number of working smoke alarms installed in the proper locations. It is recommended you install both photo and ion smoke alarms in your home, or choose dual sensor smoke alarms which feature both sensors in one unit.

A recent report by the Consumer Product Safety Commission (CPSC) estimates that 94% of typical household fires are flaming fires. However, since you can't be sure what type of fire might start in your home, consider installing both ionization and photoelectric smoke alarms on every level of your home, and near every sleeping area.

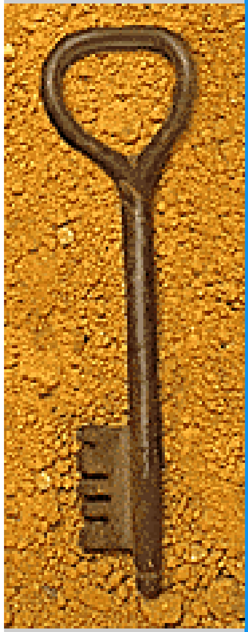
Provided as a Public Service Message from FirstAlert®

...Because your family comes first!

Smoke detectors contain .9 μCi of americium-241.



- The ingestion SALI for americium-241 is 1 μCi, therefore ingesting all of the americium in a typical smoke detector can result in a whole-body dose equivalent of 4.5 rems.
  - The inhalation SALI for americium-241 is 1×10^{-2} μCi. Theoretically, a whole-body dose as high as 450 rems could result from inhaling .9 μCi!
- The inhalation NALI for americium-241 is 6×10^{-3} μCi for the bone surfaces. Theoretically, a bone dose as high as 750 rems could result from inhaling .9 μCi!
- Realistically, there is little chance of an internal irradiation, so the he average annual dose received from living in a home with a smoke detector is from external irradiation and amounts to about.008 mrem/yr.
- Benefit clearly outweighs risk for smoke detectors !

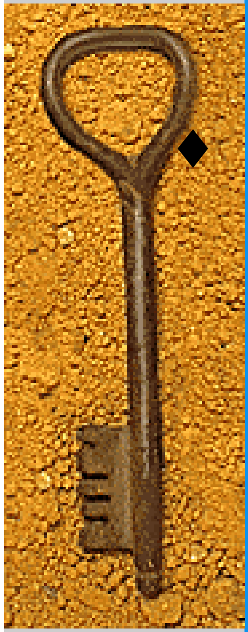


In early 2002, the FirstAlert® model SA68 smoke detector cost $7.96 at Walmart.

In the late 1930s, the Swiss physicist Walter Jaeger accidentally invented the smoke detector while trying to invent a sensor for poison gas. Small concentrations of gas had no effect on his sensor's conductivity, but it did register a drop in current when he lit a cigarette. (http://www.sciam.com/0497issue/or97working.html)

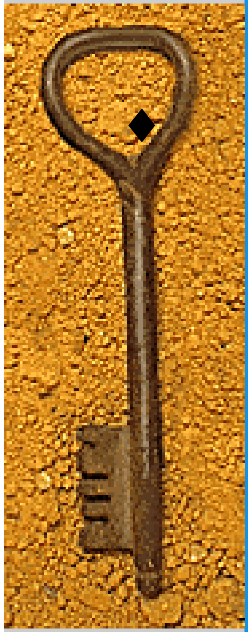
The first commercial smoke detectors came to market in 1969.(http://www.sciam.com/0497issue/or97working.html)

Smoke detectors of both types have reduced the chance of dying in a fire at home by roughly half. (http://www.sciam.com/0497issue/or97working.html)



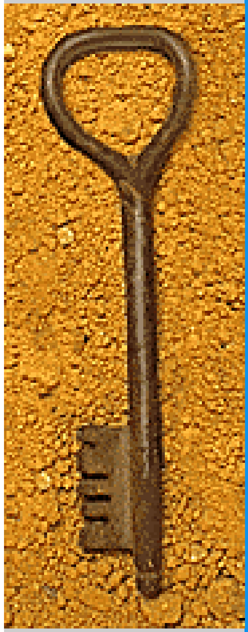
Emergency Exit Signs

- Self-luminous emergency exit signs consist of glass tubes that are internally coated with phosphor. As the tritium in the tube decays, it emits low-energy beta particles that excite the electrons in the phosphor, causing it to glow. (wysiwyg://8/http://isolite.com/abouttritium.html)
- Isolite estimates the maximum dose in a worst-case scenario would be about 30 mrem. wysiwyg://8/http://isolite.com/abouttritium.html)
- Isolite signs are available with effective lives of up to 20 years.(wysiwyg://8/http://isolite.com/abouttritium.html)
- The exit sign was manufactured by SRB, Inc. The sign is a model B100. Luminexit sign, serial number: 597374. The sign contained 9.75 curies of tritium as of 10/30/95 which was the shipment date from the manufacturer. (www.nrc.gov- event reports for 1/23/03-1/24/03)



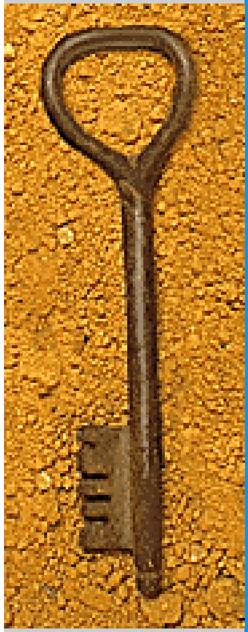
Shoe-Fitting Fluoroscopes

- These units were commonly seen in shoe stores in the 1930s through 1950s. They consisted of a vertical cabinet with an opening at the bottom into which the feet were placed. A fluorescent image of the bones of the feet and the outline of the shoe could be seen through each of the three viewing ports on the top of the cabinet (e.g., one for the child being fitted, one for the child's parent, and the third for the shoe salesman) The shoe-fitting fluoroscope is thought to have been invented around 1924 by Clarence Karrer while he worked with his father, selling surgical supplies and x-ray equipment. After building and selling several to shoe manufacturers and retailers, he was asked by the Radiological Society of North America and some radiologists to stop because it "lowered the dignity of the profession of radiology." Karrer complied, but another of his father's employees quit the company and patented the device. (http://www.orau.com)
  - Clearly the risk, small as it is, outweighs the benefit of these devices.



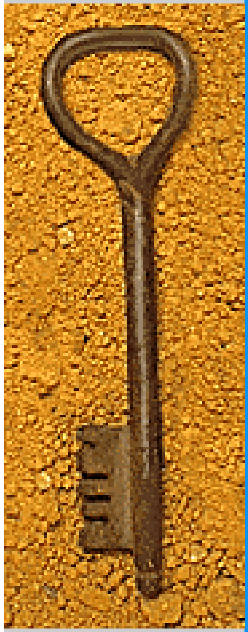
Porcelain Dentures

- Uranium was used in porcelain dentures to give them a fluorescence similar to that of natural teeth. It was added as a mix of cerium oxide and uranium oxide or as sodium uranate. The uranium composed from 0.008 to 0.1% by weight uranium with an average of about 0.02%. The practice appears to have stopped in the late 1980s. (http://hps.org/publicinformation)

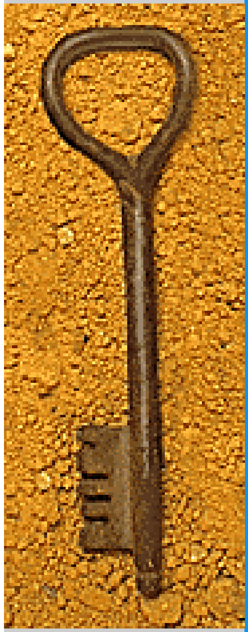


The Radium Girls

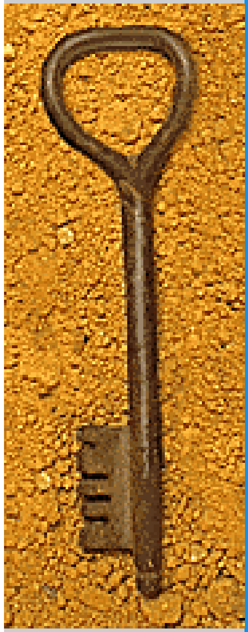
- Pierre Curie had hoped radium would have a beautiful color. Unfortunately, the element was a dull, metallic white. (*Deadly Glow The Radium dial Worker Tragedy*, Mullner, p. 9) It doesn't glow green! That is the color of the phosphorescence induced in the paint by the ionizing radiation emitted by the radium.
- Ra-226 is a radioactive element produced during the U-238 decay chain. It has a 1599-year half-life, and emits α particles (4.7844 MeV, 4.602 MeV) and corresponding de-excitation γ-rays (186.2 KeV). (*Chart of the Nuclides*, Fifteenth Edition)
- In the early 1920s a group of young women slowly and mysteriously began dying. The dying women seemed to have little in common, except that they all had previously worked as dial painters at a radium application plant in Orange, New Jersey. At the plant, the women painted the numerals on instrument and watch dials. The job seemed ideal. It paid well, depending upon the number of dials painted. And working with the new glowing radium paint was considered artistic, high-tech, and even glamorous.



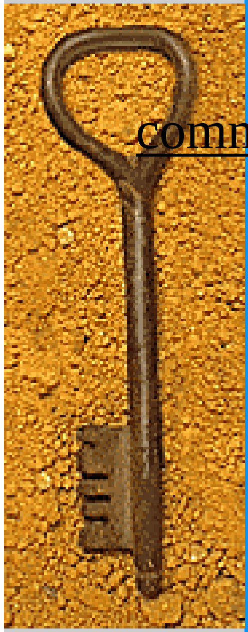
- Most of the women worked at the radium plant during World War I. The war created an enormous military demand for many types of radium-luminous devices. The nation's armed forces desperately needed radium dials for instruments aboard airplanes, submarines, and warships, and soldiers needed watches with glowing dials for night fighting.
- Several years after leaving the plant, the former dial painters began developing a variety of mysterious medical problems. The women experienced abnormal blood changes, and they became severely anemic. They suffered from intense arthritic-like pains, particularly in the joints, which spread throughout their bodies. Some of the women suffered from spontaneous bone fractures of the arms and legs. A few of the former workers even became lame when their legs strangely began to shorten.



- The most common symptoms they experienced, however, were horrible teeth and jaw problems. Typically, their teeth would ache constantly. And when a tooth was extracted, the socket would continue to bleed and not heal. Instead, it would slowly and painfully ulcerate. Eventually, the ulcer would spread and progressively worsen, leading to jaw necrosis, with parts of the women's jaws rotting away and disintegrating. Many times the necrosis would be so widespread that large sections of their jaws would have to be removed, in some cases leaving them horribly disfigured. (*Deadly Glow The Radium dial Worker Tragedy*, Mullner, p. 1)
- Additional cases of the new disease were found at other dial-painting facilities in Waterbury, Connecticut, and Ottawa, Illinois, thus proving the sickness was not caused by some unique factor which only occurred at the radium plant in Orange, New Jersey. Eventually, the new occupational disease of radium poisoning, a form of chronic radiation sickness, would be recognized.



- The first victims of radium poisoning would die from aplastic anemia and related complications, while later victims would succumb to rare radium-induced head and bone cancers and sarcomas. Although many of the deaths would occur in the 1920s and 1930s, others would die decades later. The last death occurred in 1988. In total, 112 radium dial workers are known to have died from the occupational disease. (*Deadly Glow The Radium dial Worker Tragedy*, Mullner, p. 5)
- The occupational exposure standard developed for the radium dial painters would become the primary safety standard for the U.S. atomic-bomb-producing Manhattan Project. (*Deadly Glow The Radium dial Worker Tragedy*, Mullner, p. 6)
- During the Cold War, the nation and the world would again turn to the radium dial workers. This time the women would provide unique and invaluable information on the possible long-term health effects of radioactive fallout from aboveground nuclear testing. (*Deadly Glow The Radium dial Worker Tragedy*, Mullner, p. 6)



Average Annual Doses

commercial/consumer use	average annual dose (mrem)
traveling by jet aircraft (per hour in air)	.5
Boston to LA (per roundtrip)	5
wearing porcelain crowns or false teeth	.07
wearing radioluminous luminous wristwatch	.06
stopping at airport security (each time)	.002
watching TV over the course of one year	1
using a video display (computer screen) (one yr)	1
living in a home with a smoke detector	.008
using an old lantern mantle (per use?)	.2
using a plutonium-powered pacemaker	100

(*Chemistry in the Community* 4th Ed., American Chemical Society, p. 431)

smoking cigarettes (1.5 packs per day) (polonium-210 is present)	~1,000

(*The Health Physics Society's Newsletter*, August 1994, p. 1 and *NCRP Report No. 95*, 1987, pp. 23-24)