Avoiding Invisible Waves

By Greg Burchell

Radiation — the actual thing and even the idea of it — can be intimidating. Evoking images of mushroom clouds and barrels of wafting green poison, even the yellow and black symbol, a roundel of exclamation marks, has become synonymous with danger, sickness or death.

Citizens around the globe are exposed to miniscule amounts of radiation in the environment every day, from cosmic radiation emitted from space to the fallout from nuclear weapons testing as late as the 1980s, and even the food we eat. "If the background levels of radiation are harmful to the body, we would be extinct as a human race," says Krzyszof Starosta, an associate professor in the chemistry department at Simon Fraser University (SFU) in Burnaby, British Columbia.

Alpha particles are by far the most damaging.

MEASURED RESPONSE

There are three primary types of ionizing radiation that can pose a health hazard: alpha particles, beta particles and gamma rays — and all carry their own risks. For example, while alpha particles are by far the most damaging — the Toronto-based Radiation Safety Institute of Canada (RSIC) reports that one absorbed dose of alpha radiation produces about 20 times more damage than the same amount of absorbed dose from beta or gamma radiation — it is also the least likely to be absorbed. Unlike beta and gamma, alpha radiation must be inhaled and cannot penetrate the first dead layer of skin.

The Nuclear Waste Management Organization (NWMO) in Toronto reports that the sources of radiation exposure in Canada are as follows: radon, 37.9 per cent; medical, 22.9 per cent; internal, 13.5 per cent; terrestrial, 13.5 per cent; cosmic, 11.5 per cent; and other, 0.8 per cent.

Almost all nuclear substances and radiation devices in the country are regulated and their use licensed by the Canadian Nuclear Safety Commission (CNSC) in Ottawa. There are more than 3,000 such licences in effect, the CNSC adds.

Doses from all workers who are regularly exposed to radiation are recorded by Health Canada's National Dose Registry, with 150,000-plus workers being monitored at least quarterly for work-related exposure (see graph below). Those in the health care sector account for half of monitored workers; nuclear power or nuclear fuel industries for 19 per cent work; research for 11 per cent; and students for 10 per cent.

The dose absorbed by the body, expressed in millisieverts (mSv), can be measured externally with dosimeters, or internally, for airborne radiation, through urinalysis. Dosimeters are mandatory for all employees who could reasonably be expected to receive a dose of 5 mSv or more in a year.

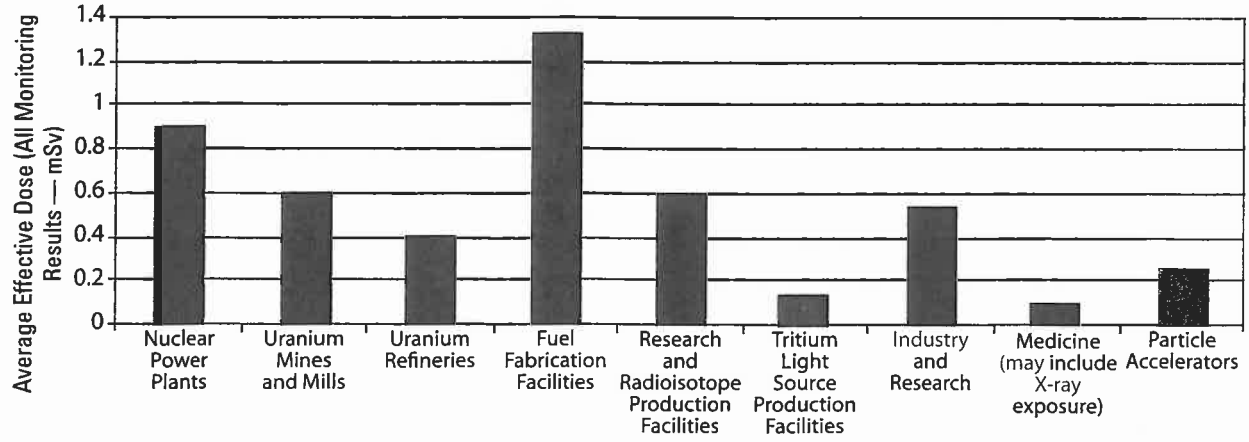
Starosta reports that SFU has about 50 labs classified for radiation use and anyone working in them must wear dosimeters, which are checked monthly.

Receiving a dose exceeding 1,000 mSv within 24 hours can lead to radiation sickness, the CNSC notes. It would take more than 5,000 mSv in a single acute dose to kill a person (see Limits on Health), the commission adds.

"It's important to note that this transfer of energy is done immediately, as the radiation reaches the tissue. Just like a physical punch, the energy is transferred only when there is contact between the more energetic object (the radiation, or the fist) and the tissue," notes information from the RSIC.

Instances of workers receiving massive doses of radiation in a short period of time and developing radiation sickness is virtually unheard of in Canada, says Mike Haynes, RSIC's vice-president of scientific affairs, who adds he cannot recall

2007 CANADIAN OCCUPATIONAL DOSE BY FACILITY TYPE



LIMITS ON HEALTH

Dose (mSv)	Effect or Source
5,000	dose that may lead to death when received all at once
1,000	dose that may cause symptoms of radiation sickness if received within 24 hours
100	lowest acute dose known to cause cancer
30 -100	radiation dose from a full-body CT scan
50	annual radiation dose limit for nuclear energy workers
1.8	average annual Canadian background dose
1.0	annual public radiation dose limit
0.1 - 0.12	dose from a lung X-ray
0.01	dose from a dental X-ray
0.01	average annual dose due to air travel

Source: Canadian Nuclear Safety Commission, reflecting recommendations of the International Commission on Radiological Protection

it happening in his 35 years in the nuclear power industry. "This is almost in the realm of science fiction," Haynes says.

The last time workers anywhere received such traumatic doses of radiation was the Chornobyl disaster a quarter-century ago, when 28 nuclear power plant employees died from acute radiation sickness after an explosion and fire at a nuclear reactor in the Ukraine. "That type of thing has never happened since," Haynes reports.

Even Japan's Fukushima Daiichi meltdown a year ago did not, as of September of 2011, have any recorded deaths or serious injuries from direct radiation exposure.

Individuals react to radiation differently. As an example, a dose of 25 mSv would cause a reduction of red blood cells, but levels would be back to normal within a couple of days to a couple of months, Haynes says. The general consensus is that any single dose below about 250 mSv will not produce acute effects like nausea or illness, he adds.

Long-term effects are less definite, although no less dangerous. As exposure increases, so do the odds of developing cancers. But like smoking cigarettes, there is no certainty that someone will get cancer because of the doses received.

The International Commission on Radiological Protection, an independent body that publishes standards and guidelines, estimates the risk of developing a fatal cancer rises by four per cent for every 1,000 mSv of radiation exposure.

"We know from the atomic bomb survivors and the other populations that certain types of cancer are related to radiation exposure. And that's from doses that are probably hundreds, if not thousands, of times higher than people typically receive in workplaces," Haynes explains.

Because radiation changes materials at the atomic level, there is also the fear of genetic effects developing or being passed to one's offspring. "There is some evidence that radiation produces genetic effects from animal experiments where they've been exposed to high levels of radiation, much, much higher than would ever occur occupationally," Haynes says, but adds that 70 years spent studying survivors of the atomic blasts in Hiroshima and Nagasaki has never shown statistical evidence of an increase in humans exposed.

"We don't assume that there is an absolutely safe level, that if you're below X, there's no chance of developing a cancer. What we know is that if it's higher, then the risk increases."

WITHIN LIMITS

The CNSC sets the annual dose limit for the public at 1 mSv and, for nuclear energy workers, at 50 mSv with no more than 100 mSv in a five-year period. If a worker exceeds the dose limits, the licensee is required to do the following:

- immediately notify the person and the CNSC;
- require the person to leave any work likely to add to dose;
- conduct an investigation to determine the magnitude of the dose and to establish the causes of the exposure;
- identify and take any action required to prevent similar incidents from occurring; and,
- report to the CNSC the results of the investigation or the progress that has been made within 21 days after becoming aware that the dose limit was exceeded.

As a member of the International Atomic Energy Agency in Vienna, Canada ascribes to the ALARA principle, meaning radiation doses should be kept "as low as reasonably achievable."

There are three key strategies to reduce radiation dosage.

ALARA is "based on the assumption that any radiation exposure increases the risk of long-term effects. That's a bit controversial because some people believe that's not true. They believe that below certain levels, there's no risk at all," Haynes says. "However, for radiation protection purposes, it is generally the policy, virtually worldwide, that we will assume, to be safe, that any exposure could increase the risk."

Starosta says there are three key strategies to reduce radiation dosage: minimize exposure duration; maximize distance from the source; and erect barriers between the radiation source and individual.

Determining the safe distance depends on radiation type and source size. "Skin can stop alpha particles and low-energy beta particles, while a thin aluminum sheet will stop all beta particles. Higher energy radiation — including neutrons, gamma rays and X-rays — can penetrate the human body if it is not properly shielded," notes the NWMO.

The general rule for shielding against gamma rays is the denser the material, the better protection that it will offer, Haynes says: the more material the rays have to pass through, the less intense they will be.

In 2007, Health Canada reported only three monitored workers had received radiation doses of 50-plus mSv, with an average dose of 0.33 mSv.

"The dose limits are set assuming that a person works for 50 years and receives the annual limit every year. In reality that doesn't happen to anyone," Haynes assures. OHS

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