SAFETY FROM RADIATION IN CANADIAN INDUSTRY

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The Atomic Energy Control Board was created to control nuclear energy so that it might be used for our benefit and not harm us. The Board is therefore interested in protecting the users of nuclear energy and all others from any harm from the ionizing radiations that are associated with its use. It has made regulations that require certain safe practices in the use of the materials that emit ionizing radiation - those materials which we call radioactive isotopes.

The Board is assisted in the administration of these regulations by the Federal Department of National Health and Welfare and by health and labour departments in the provinces. Under the Board's regulations significant quantities of substances which emit ionizing rays cannot be obtained without a licence. We therefore know who receives these radioactive isotopes, and we can investigate to see whether or not they obey the rules. Officers of the Radiation Protection Division of the Department of National Health and Welfare investigate to confirm that the licencees have the knowledge and the facilities to use the materials safely.

The Atomic Energy Control Board shares your belief that a valuable protection against danger from ionizing radiation is knowledge; knowledge of where the radioactive materials are, knowledge of the risks associated with them, and knowledge of the measures of protection that should be taken. We welcome your desire to bring a fuller understanding of these things to your members, and I am very pleased to have this opportunity to talk to you about them.
When ionizing rays were first discovered, it was not at once realized that they might be injurious to health. In 1895 the German physicist Wilhelm Roentgen was experimenting with special electrical apparatus that he had built. From these experiments he hoped to learn more about electricity. It happened that a package of photographic plates were left near his apparatus, when he used the plates later he found that they were spoilt; that is to say, when the plates were developed they were black as if they had been exposed to too much light. The effect on the plates was due to some kind of rays that came from his apparatus. He could not see the rays, but there was no other possible explanation. The rays could pass through wood and through the cover of the box that held the photographic plates, if he put his hand over the plates, the rays passed through the flesh so that when the plates were developed they showed the shadow of the bones. This was the discovery of X-rays.

Some time later, a few scientists who were experimenting with these newly discovered X-rays noticed that their hands felt warm and were inflamed, as if they had been in hot water, and they became sensitive to touch. This effect on their hands could only be due to the rays. Thus they learned that the rays could be harmful. However, the scientists soon learned to surround the apparatus that produced the rays with sheets of lead to protect themselves from them.

Meanwhile, the French scientist Henri Becquerel discovered rays coming from rock containing uranium. These rays were very much like the X-rays of Roentgen's apparatus. Then Madame Curie found that natural uranium always has mixed with it tiny amounts of two other substances that emit these rays also. She named the newly found substances radium and polonium. She was able to separate the radium and the polonium from the uranium and found that they were very much more powerful sources of rays than the uranium. Within a few years about thirty other elementary substances were discovered which emitted ionizing radiation. We call them radioactive isotopes. A number of early workers with these radioactive isotopes received injuries to their hands before the danger was realized.

It was soon discovered that ionizing radiation would cause certain kinds of skin blemishes to disappear, that cancer tumours on the skin would shrink and disappear after sufficient exposure to radiation, and that radiation was helpful in the treatment of certain other diseases. Radiation was soon used extensively for the treatment of cancer. Means were devised to measure the exposure to the radiation so that over-exposure could be avoided.
During the nineteen-twenties, bone cancer developed in a number of women that had been employed years before in putting the numbers on watch dials with luminous paint which contained radium. It was found that the diseased bone contained traces of radium. These women had been in the habit of moistening the tip of the lettering brush with their lips. Thus radium in the paint entered their mouths, and eventually found its way to the bones.

Doctors began to follow the health of persons who had been treated in the past with radiation to see if they could find evidence of other harmful effects. They have had great difficulty in proving that there are ill effects, because the ill effects happen so rarely that it is difficult to be sure that they would not have happened anyway without the radiation. However, there is no doubt that some kinds of leukemia, a disease of the blood that happens to about five people out of a thousand, happen slightly more often to people that have received large doses of radiation.

In 1945, the Japanese cities of Hiroshima and Nagasaki were hit by atomic bombs. Since then, American and Japanese scientists, with the support of their governments, have been following the health histories of the survivors. The exposures received by these survivors can be estimated roughly from the distance they were from the centre of the explosion at the time. Many of them received very large exposures.

These records have been a great source of information about the effects of radiation exposure. They have shown, for example, that most people who survive very large exposures of the whole body, even exposures that cause severe radiation sickness, do not have ill effects years later that can be said to be due to the radiation. Less than one per cent of the most exposed survivors have died later of leukemia.

Records have been kept also of the children of the survivors that were conceived after the bombing. These records have been studied to see if there was evidence of genetic effects - to see if the number of children with inheritable handicaps, such as certain kinds of mental deficiency or physical deformity, was greater than it would have been if the parents had not been exposed to the radiation. The experts have not been able to find a significant increase in the number of handicapped children. That does not prove that there were none due to the radiation, but it does prove that if there were any, their number was very small in comparison with the number that were not due to radiation.
Nowadays, we can produce many more kinds of radioactive isotopes and in far greater quantities by using nuclear reactors. Some of these are serving very useful purposes. Cobalt-60 for example is used for the treatment of cancer, and in industry for the inspection of welds and castings to discover hidden flaws.

There is another kind of ionizing radiation which, in many ways, is like X-rays and the rays from radioactive isotopes. This other kind is the cosmic rays which reach us from outer space. Fortunately the intensity of these rays is very weak.

We cannot escape completely from exposure to ionizing radiation. In this room at this moment we are exposed to the cosmic rays and to rays from traces of radioactive material in the ground and building materials. If we go down into a mine, the cosmic rays will become weaker the deeper we go, but there will still be a slight exposure to rays from the radioactive materials present in small amount: in the rock. Similarly, we cannot escape from ionizing rays completely in a submarine because the water of the ocean contains small quantities of radium in solution. Even in our own bodies there is a substance that is very weakly radioactive; it is potassium.

We deliberately expose ourselves to ionizing radiation when we wear a luminous dial wrist watch, for the luminous paint contains a radioactive isotope. The doctor may use X-rays to examine our bones or our lungs, and the dentist to examine our teeth.

It is important therefore to distinguish the very small exposures that we cannot easily avoid - the exposures which we are prepared to accept because the risk is relatively small such as that from the wrist watch - the exposures which we are willing to receive like the dental X-rays because we derive benefit from them, and large accidental exposures which could be more dangerous. We should distinguish big exposures from little exposures.

How do we state the size of the exposure? We speak of the number of rem in the exposure. We speak of getting three rem of exposure, just as we might speak of eating three pounds of steak, of drinking three double whiskies, and walking three miles to recover. The rem is the unit that we use to describe exposure, just as the foot is a unit that we use to describe length, and the degree is the unit that we use to describe temperature.

Let me give you some examples. The exposure which we receive from the cosmic rays and other natural causes during a year is about one-tenth of a rem. The exposure which we receive while the dentist is taking an X-ray of
our teeth is about one-tenth of a rem. In using X-rays while setting a broken arm the exposure might be several rem. The exposure to my skin just under my wrist watch during one year is probably about one-tenth of a rem.

How big an exposure is dangerous? How small an exposure is safe? Whether or not we say that something is dangerous is a question of how big a risk we are prepared to take. Is 70 miles an hour on a straight road safe? What is your opinion? There is a risk in staying in this room because we might be killed by fire or earthquake, or by an explosion like the one in Indianapolis, but the risk is so small that we say the room is safe. There is a risk from our wrist watches and from our television sets, but the convenience and pleasure of using these devices is more important to us and we accept the risk, and we say that they are safe.

The risk, of course, depends on the exposure to the rays. We cannot avoid exposure completely. Our purpose is to keep the exposures which we receive so small that we can regard it as an acceptable risk. Hence, if a powerful amount of Cobalt-60 is brought into a factory we must make sure that the exposures which people receive are below a reasonable limit.

What do we mean by a reasonable limit? Obviously it would be absurd to go to very great effort to keep the exposure from the Cobalt-60 much smaller than that which we are willing to receive from our own watches. The risk from radiation in Canadian industry at present is much less than the risk of injury from other causes, such as falling objects, burns, electric shock, and encounters with machine tools, etc.

It is safer to work in a nuclear energy plant or laboratory than in most other industry. This is shown by the accident statistics. In 1960 the number of lost-time accidents for Atomic Energy of Canada Limited was 1.7 per million man hours worked while the average for all industry in Canada is about 6 per million man hours. In the United States the Atomic Energy Commission recently reported 1.68 accidents per million man hours in its nuclear energy plants. In contrast, the rate for all American industry in 1959 (the last year for which the information is available) was estimated by the National Safety Council to be 6.47 accidents per million man hours.

In the Atomic Energy Commission plants in the United States only one of the 404 lost-time injuries in 1960 was caused by radiation. In the whole history of nuclear industry in the United States up to the end of 1960 only 35 out of 6,562 lost-time injuries and only three out of 219 deaths were due to radiation. Three more deaths resulted from an explosive accident to a
reactor in Idaho the following year. Therefore, to exaggerate the danger of radiation in industry is to bark up the wrong tree.

I hope that you will not misunderstand me. In saying that there is less danger from radiation than other causes of injuries, I do not wish to suggest that we should relax in our efforts to reduce the danger. I am not satisfied that we are doing all that we should.

The International Commission on Radiological Protection was set up about thirty years ago. Its members are amongst the most expert on this subject and it is regarded throughout the world as the foremost authority. This Commission has carefully considered the risks from radiation exposures and has made recommendations about reasonable exposure limits which are recognized throughout the world. As knowledge increased through the last thirty years, the Commission has revised its recommendations as it seemed desirable. The Atomic Energy Control Board, the Department of National Health and Welfare and other responsible authorities in this country, and similar bodies in other countries, are guided by the recommendations of that International Commission.

One of the recommendations of the International Commission on Radiological Protection is that those who are employed in the use of radioactive materials should not receive more than 3 rems in any quarter year period, or 5 rem in any year. This does not mean that an exposure greater than 5 rem in a year will cause certain and imminent death from radiation. The risk from an exposure of 5 rem is very small. Even ten times as big an exposure will very rarely produce observable grave effects. The Commission deliberately recommended a limit that was very small to make sure that the risks of radiation exposures are not important in comparison with the risks from many other kinds of injury that occur in industry.

The effects of radiation exposure depend, of course, on the size of the exposure. For example, if I receive an exposure of 500 rem of X-rays on a part of my arm, I can expect that in about ten days the skin will begin to show reddening like sunburn and feel warm. This will last for a few weeks and disappear and the skin will be tanned. If, instead of 500 rem, I receive several thousand rem there will be blistering and painful sores that take a long time to heal. If I receive only 200 rem I will see and feel no effect.

Note that the X-ray burn is a predictable effect. I know what to expect. The same is true of radiation sickness. With 200 rem over the whole body I can expect to be quite ill within a few hours, but with 20 rem I know
that I shall not feel sick. It can be said quite definitely that 20 rem will not produce radiation sickness, it will not produce skin burn, and it will not produce loss of hair.

However, there are other effects of radiation which are not predictable. They depend on chance. Leukemia is one of these. If I receive a whole body exposure of 50 rem it; will probably not produce leukemia some years later but I cannot be absolutely certain. It is not a matter of certainty, it is a matter of chance, like the chance of drawing a particular card from the pack. If I try to draw a particular card, let us say the seven of diamonds, from a pack of cards in one try I shall probably not succeed. The chance of drawing the seven of diamonds in one try is small; it is of course one chance in 52. The chance of getting leukemia after an exposure of the whole body to 50 rem is even smaller. With a smaller exposure the risk of leukemia will be still smaller.

It is important to notice that there are two quite different kinds of effects. Some effects, such as skin burn, are not produced at all if the dose is small. We say that these effects have a threshold, which means that they do not happen unless the exposure is greater than a certain amount that is called the threshold. Effects of the other kind, such as some kinds of leukemia, may be produced by small exposures - although the risk is very small. We say that these effects may not have a threshold.

I have spent some time talking about the small risks of leukemia resulting from small exposures to ionizing radiation because I want to call your attention to a misunderstanding. Some of your colleagues in the United States seem to be under the impression that the recommendations of the International Commission on Radiological Protection are based on the threshold idea. That is a complete misunderstanding. The International Commission has never assumed that if the dose is smaller than the recommended limit there is no risk whatever. The Recommendations of the International Commission are based on the assumption that there may be a risk, though a very small one, associated with small exposures, and a bigger risk in bigger exposures.

fact that is why the Commission has recommended such a low limit for the permissible exposure. They say so quite clearly.

It has also been said incorrectly that the views of the International Commission on Radiological Protection on this subject are in disagreement with the views expressed by the United Nations Scientific Committee on the Effects of Atomic Radiation. This has led to the suggestion that the experts cannot
agree among themselves. This is a complete misunderstanding. The two committees are in substantial agreement. It would be very surprising if they were not in agreement since some of the most active members of both committees are the same people.

Radioactive isotopes are used in industry in four ways; in radiography, for irradiation of materials and things, as parts of instruments, and in bulk for special tests. The safety aspects of these four uses are quite different.

For radiography the source of radiation is usually quite powerful. It is sealed in some kind of metal container which is usually smaller than a thimble. It is sometimes cylindrical in shape - but not always.

If the radiographic source is very powerful it is kept within a heavy shield which is sometimes called a camera. In this camera it is completely surrounded, when not in use, by lead shielding which in some cases is nine inches thick. When in use, the rays come out of a hole through the lead as a beam of radiation in the direction in which they are wanted. To stand in this beam close to the hole is very dangerous. Even at a distance of several yards from the hole it may be unsafe to remain in the beam for more than a few minutes if the source is a very powerful one. The radiographer must erect whatever barricades are necessary to prevent people from remaining in the beam of radiation for an unsafe length of time, or make sure that there is sufficient shielding to protect them from the radiation.

Less powerful radiographic sources are sometimes taken out of their lead containers. This is done when it is desirable to place the source inside a hole in a casting or a pipe or in some other place that is too small or too inaccessible for the radiographic camera. The radiographer must use barricades, or shielding, or both, to ensure that nobody is dangerously exposed.

In industrial radiography the protection of the radiographer himself is more of a problem than the protection of other workers in the plant, because the radiographer, in his impatience to get on with the job, is often tempted to go close to the radioactive source in order to adjust the position of things or for some other purpose.

When radioactive isotopes are used for the irradiation of food stuffs, chemicals or medical supplies, the radioactive isotopes are kept inside suitable shielding and the materials that are to be irradiated are moved into and out of the shielded enclosure by carrying devices in such a way that the operator and other persons are not exposed to radiation. For irradiation of small articles...
the shielded enclosure may be a cylindrical block of lead called a gamma-cell. With good design and proper precautions there is very little danger of radiation exposure from the use of such equipment. The food stuffs or other materials that have been irradiated do not, of course, themselves become radioactive; they do not emit dangerous radiation.

Radioactive isotopes are being used increasingly in various kinds of instruments and testing devices such as thickness gauges, level gauges and smoke detectors. The source of radiation in these devices is usually comparatively weak. In any case they are so constructed and mounted with built-in shielding and barriers that one cannot receive an excessive exposure to radiation unless one opens them or puts fingers or other parts of the body inside the barriers and protective shields. They may be compared to electric light sockets. The well made electric light socket is not dangerous unless we poke a finger into it. Only one safety rule is needed—a no unexperienced person should be permitted to open up these devices, remove the shielding or the barriers, or tamper with them in any way without authorization.

In the applications which I have already mentioned the radioactive isotopes are enclosed or sealed in suitable containers so that they cannot become scattered or spilt. For some other purposes radioactive isotopes are used in bulk, either as a powder or in solution. In these forms they are used for many purposes in medicine and in research, but in industry bulk radioactive radioisotopes are used so far only for special investigations such as the measurement of flow through a pipe, or for the painting of instrument or watch dials with luminous compounds.

Use of radioactive isotopes in bulk has the added safety problem of preventing or controlling the spread of radioactive contamination. If the material is a powder it can be blown as dust and breathed into our lungs. The dust can settle on the floors, on furniture, and on tools from which we may get it on our hands. Unless we wash our hands very carefully before eating or smoking it will get on food and cigarettes and be eaten.

If the radioactive material is dissolved in a liquid the liquid may leak from equipment, or be spilt. By this means also it can contaminate things which we touch with our hands and hence our food and cigarettes. It can be carried on our clothes to our automobiles and our homes.

Bulk radioactive materials are not often used in the factory or the shop. They should only be used by persons who are properly trained to handle radioactive materials in such form. Care is needed not only to prevent escape...
and spilling but also to recover or dispose of the radioactive material in a safe way. If there is any possibility of leakage a survey with a suitable instrument should be made after the tests are completed to find the contamination. The contamination should be cleaned up by persons who are properly instructed for such a task.

How much should the workers in a factory where radioactive materials are used be expected to know about them and the dangers associated with them? It seems to me that an understanding of a few simple facts is sufficient for those who are not required to deal with these materials directly.

These workers should recognize the trifoil symbol which calls attention to radiation hazards and know what it means.

They should know that the radiation cannot be seen or felt. If they pick up in their hands a capsule containing a strong radioactive source they will not know that they are being injured at the time. Any painful effects will not occur until hours or days later.

They should realize the importance of distance; that the danger decreases very rapidly as you move away from the source and, for that reason, they should not come close to an unshielded radioactive source or any unknown object that might be a radioactive source.

They should realize the importance of time; that the danger increases with the length of time that one remains close to the source.

They should understand the meaning of shielding; that heavy material placed between the source and themselves gives some protection. The denser the material the more effective it is. The thicker the material the more effective it is.

They should know that some rays are more penetrating than others and that shielding that might be sufficient in one case might not be sufficient in another. A thin brass cover may be sufficient shielding on some instruments but a light partition constructed of studding and wallboard is very little protection from a strong radiography source.

They should know that they should not open up or otherwise tamper with any instrument that contains radioactive materials.

They should know that they should not smoke or eat in a place where unsealed radioactive materials are being used and that they should wash their hands very carefully before handling food and cigarettes afterwards.

For his peace of mind a worker should know that if he receives an exposure that produces a skin burn or radiation sickness the risk that this
may lead in later life to cancer or leukemia is less than the risk that he will be killed in a motor accident.

Besides this general knowledge there is certain information which employees should be able to get from the employer through their trade union representative,

They should know where radioactive sources in the plant are located. They should know whether or not such sources are so shielded and guarded at all times that it is safe to work close to them for any length of time.

They are entitled to know what special conditions, if any, are imposed in the licence. Such special conditions may, for example, require the wearing of film badges by some employees, the use of dosage meters, the use of barricades and signs, or the use of special shielding or limitations on the use of materials to certain times of day or to certain areas in the shop.

In making regulations to protect workers from radiation, we assume that they do not know the facts that I have just mentioned. However, even with the best of regulations and the best intentions, hazards can result from mistakes and oversights. The employee's own understanding of the points which I have mentioned is an added protection for him.

Those who are directly engaged in the use of ionizing radiations should, of course, have a much fuller knowledge and understanding of ionizing rays and of safety in their use than those who are merely working in the same place. Officers of the Department of National Health and Welfare enquire about the training of radiographic technicians who use radioactive materials before licences are granted.

I feel that we should endeavour to raise the standards of training of radiographers. The difficulty here is the lack of opportunities for these specialists to improve their training. It would cause hardship to them to require suddenly without warning certificates to show that they have received an approved course of training or passed suitable examinations. It is our hope, however, that in less than two years we will be able to insist that every industrial radiographer and assistant show evidence that he is well trained in the technology and safety of his occupation.