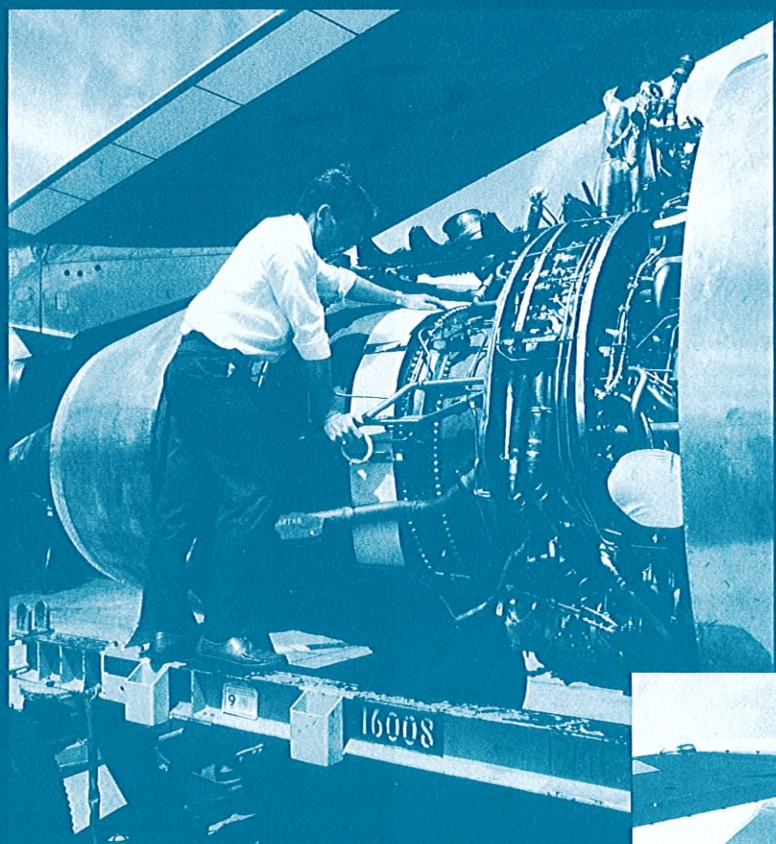
ansto RADIOISOTOPES in industry

Modern industry uses radioisotopes in a variety of ways to improve productivity and, in some cases, to gain information that cannot be obtained in any other way. Sealed radioactive sources are used in industrial radiography, gauging applications and mineral analysis, while short-lived radioactive material is used in flow tracing and mixing measurements.



A sheet of film is placed on the outside of a jet engine for routine inspection of the turbine blades using gamma radiography

A gamma source is remotely exposed inside the engine and an image is created on the film. Through the film image the engine can be examined for faults without the need for dismantling.

Gamma Radiography

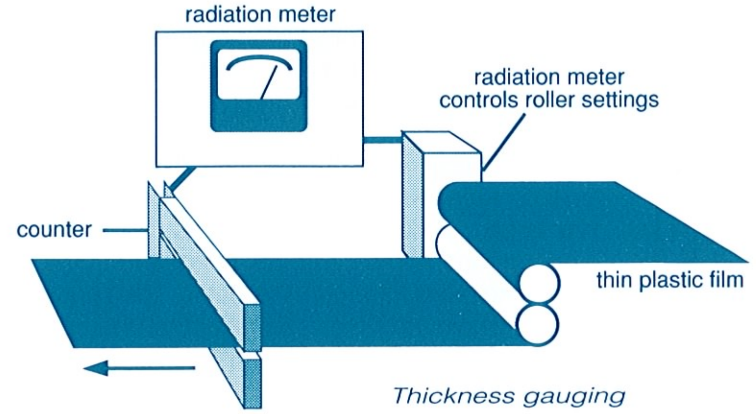
Gamma Radiography works in much the same way as x-rays screen luggage at airports. Instead of the bulky machine needed to produce x-rays, all that is needed to produce effective gamma rays is a small pellet of radioactive material in a sealed titanium capsule.

The capsule is placed on one side of the object being screened, and some photographic film is placed on the other side. The gamma rays, like x-rays, pass through the object and create an image on the film. Just as x-rays show a break in a bone, gamma rays show flaws in metal castings or welded joints. The technique allows critical components to be inspected for internal defects without damage.

Because isotopes can be transported easily, gamma radiography is particularly useful in remote areas where, for example, it can be used to check welds in pipelines that carry natural gas or oil.

Where a weld has been made, special film is taped over the weld around the outside of the pipe. A machine called a "pipe crawler" carries a shielded radioactive source down the inside of the pipe to the position of the weld. There, the radioactive source is remotely exposed and a radiographic image of the weld is produced on the film. This film is later developed and examined for signs of flaws in the weld.

X-ray sets can be used when electric power is available and the object to be x-rayed can be taken to the x-ray source and radiographed. Radioisotopes have the supreme advantage in that they can be taken to the site when an examination is required - and no power is needed.

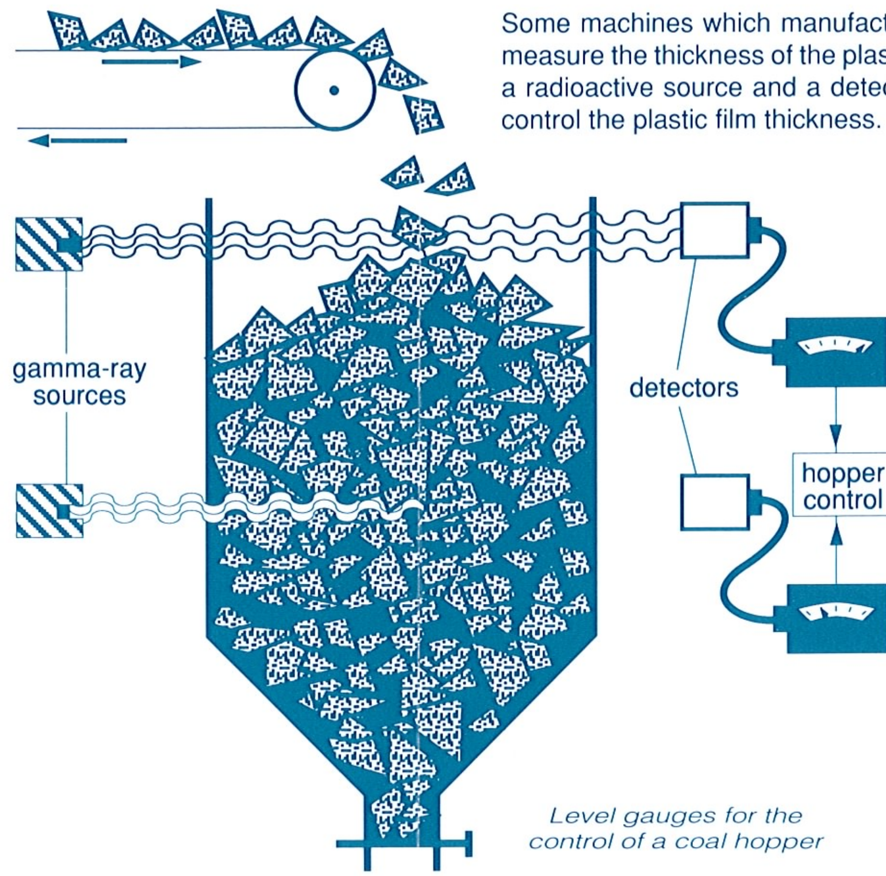


Thickness gauging

Gauging

The radiation that comes from a radioisotope has its intensity reduced by matter between the radioactive source and a detector. Detectors are used to measure this reduction. This principle can be used to gauge the presence or the absence, or even to *measure* the quantity, of material between the source and the detector. The advantage in using this form of gauging or measurement is that there is no contact with the material being gauged.

Some machines which manufacture plastic film use radioisotope gauging to measure the thickness of the plastic film. The film runs at high speed between a radioactive source and a detector. The detector signal strength is used to control the plastic film thickness.



Level gauges for the control of a coal hopper

The height of the coal in a hopper can be determined by placing high energy radioactive sources at various heights along one side with focusing collimators directing beams across the load. Detectors placed opposite the sources register the breaking of the beam and hence the level of coal in the hopper.

When the intensity of radiation from a radioisotope is being reduced by matter in the beam, some radiation is scattered back towards the radiation source. The amount of 'backscattered' radiation is related to the amount of material in the beam, and this can be used to measure characteristics of the material. This principle is used to measure different types of coating thicknesses.

Ansto publications - J Evans 3/94

Ansto RADIOISOTOPES *in industry*

Scientific Uses

Radioisotopes are used as tracers in many research areas. Most physical, chemical and biological systems treat radioactive and non-radioactive forms of an element in exactly the same way, so a system can be investigated with the assurance that the method used for investigation does not itself affect the system. An extensive range of organic chemicals can be produced with a particular atom or atoms in their structure replaced with an appropriate radioactive equivalent.

Using tracing techniques, research is conducted with various radioisotopes which occur broadly in the environment, to examine the impact of human activities. The age of water obtained from underground bores can be estimated from the level of naturally occurring radioisotopes in the water. This information can indicate if groundwater is being used faster than the rate of replenishment. Tracer radioactive fallout from nuclear weapons' testing in the 1950s and 60s is now being used to measure soil movement and degradation. This is assuming greater importance in environmental studies of the impact of agriculture.

Tracing/Mixing Uses

Even very small quantities of radioactive material can be detected easily. This property can be used to trace the progress of some radioactive material through a complex path, or through events which greatly dilute the original material. In all these tracing investigations, the half-life of the tracer radioisotope is chosen to be just long enough to obtain the information required. No long term residual radioactivity remains after the process.

Sewage from ocean outfalls can be traced in order to study its dispersion. Small leaks can be detected in complex systems such as power station heat exchangers. Flow rates of liquids and gasses in pipelines can be measured accurately, as can the flow rates of large rivers.

Mixing efficiency of industrial blenders can be measured and the internal flow of materials in a blast furnace examined. The extent of termite infestation in a structure can be found by feeding the insects radioactive wood substitute, then measuring the extent of the radioactivity spread by the insects. This measurement can be made without damaging any structure as the radiation is easily detected through building materials.

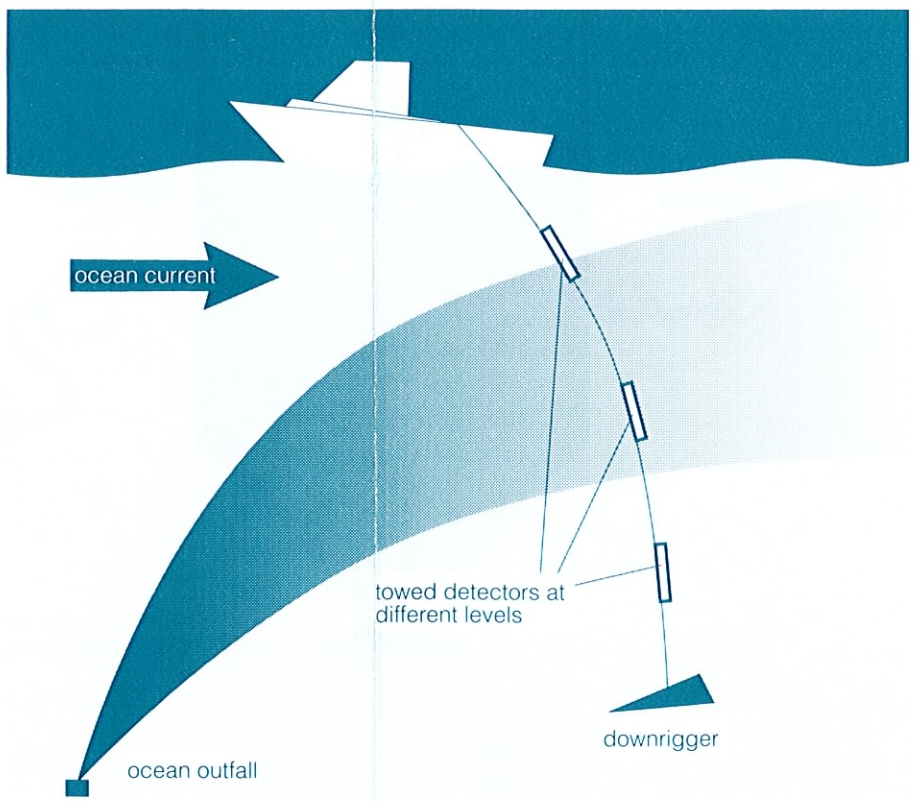
Mineral Analysis

X-rays from a radioactive element can induce fluorescent x-rays from other non-radioactive materials. The energies of the fluorescent x-rays emitted can identify the elements present in the material, and their intensity can indicate the quantity of each element present.

This technique is used to determine element concentrations in process streams of mineral concentrators. Probes containing radioisotopes and a detector are immersed directly into slurry streams. Signals from the probe are processed to give the concentration of the elements being monitored, and can give a measure of the slurry density. Elements detected this way include iron, nickel, copper, zinc, tin and lead.

Gamma ray transmission or scattering can be used to determine the ash content of coal on line on a conveyor belt. The gamma ray interactions are atomic number dependant, and the ash is higher in atomic number than the coal combustible matter. Australia leads the world in the supply of on line ash gauges with 180 installed world wide.

Neutrons can react with elements in a sample causing the emission of gamma rays which, when analysed for characteristic energies and intensity, will identify the types and quantities of elements present. Additionally, neutrons can be deflected back to their source by surrounding material. For instance, a probe containing a neutron source can be lowered into a bore hole where the radiation is scattered by collisions with surrounding soil. Since hydrogen (the major component of water) is by far the best scattering atom, the number of neutrons returning to a detector in the probe is a function of the density of the water in the soil.



Tracing of sewage dispersion from ocean outfalls

Industrial Radioisotopes used by Ansto

Naturally occurring radioisotopes:

Chlorine-36	Used to measure sources of chloride and the age of water (up to 2 million years)
Carbon-14	Used to measure the age of water (up to 50,000 years)
Tritium	Used to measure 'young' groundwater (up to 30 years)
Lead-210	Used to date layers of sand and soil up to 80 years

Artificially produced radioisotopes

Caesium-137	Used for radiotracer technique for identification of sources of soil erosion and deposition
Silver-110m Cobalt-60 Lanthanum-140 Scandium-46 Gold-198	Used together in blast furnaces to determine resident times and to quantify yields to measure the furnace performance
Gold-198	Used to trace factory waste causing ocean pollution, and to trace sand movement in river beds and ocean floors
Gold-198 & Technetium-99m	Used to study sewage and liquid waste movements
Zinc-65 & Manganese-54	Used to predict the behaviour of heavy metal components in effluents from mining waste water
Iridium-192 Gold-198 Chromium-57	Used to label sand to study coastal erosion
Tritiated Water	Used as a tracer to study sewage and liquid wastes

What are radioisotopes?

Many of the chemical elements have a number of isotopes. The isotopes of an element have the same number of protons in their atoms (atomic number) but different masses. In an atom in the neutral state, the number of external electrons also equals the atomic number. These electrons determine the chemistry of the atom. The atomic mass is the sum of the protons and neutrons. There are 82 stable elements and about 275 isotopes of these elements.

When a combination of neutrons and protons, which does not already exist in nature, is produced artificially, the atom will be unstable and is called a radioactive isotope or radioisotope.

Radioisotopes can be manufactured in several ways. The most common is by neutron activation in a nuclear reactor. This involves the capture of a neutron by the nucleus of an atom resulting in an excess of neutrons (neutron rich).

Radioisotopes can also be manufactured in a cyclotron in which protons are introduced to the nucleus resulting in a deficiency of neutrons (proton rich).

The nucleus of a radioisotope usually becomes stable by emitting an alpha and/or beta particle. These particles may be accompanied by the emission of energy in the form of electromagnetic radiation known as gamma rays. This process is known as radioactive decay.

Radioisotopes have very useful properties: radioactive emissions are easily detected and can be tracked until they disappear leaving no trace. Alpha, beta and gamma radiation, like x-rays, can penetrate seemingly solid objects, but are gradually absorbed by them. The extent of penetration depends upon several factors including the energy of the radiation, the mass of the particle and the density of the solid. These properties lead to many applications for radioisotopes in the scientific, medical, forensic and industrial fields.

Australia's Only Radioisotope Producer is

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