Australian Government | ANSTO

EXPLAINER

Nuclear Medicine

Every Australian is likely to benefit from nuclear medicine, and on average, will require at least two nuclear medicine procedures in their lifetime*.

Through the work of ANSTO, Australia is a world leader in the advanced manufacturing and distribution of diagnostic and therapeutic nuclear medicines. These are used for the diagnosis, staging, and treatment of diseases like cancer; heart disease; and lung, liver, and muscular-skeletal conditions.

ANSTO's Lucas Heights campus in southern Sydney is home to three key facilities that enable Australia's advanced manufacturing and distribution of its life-saving nuclear medicines.

Around 75 - 80 per cent of the nuclear medicine radioisotopes used in nuclear medicine procedures across Australia come from ANSTO.

Each week, the radioisotopes produced at ANSTO enables between 10,000 to 12,000* nuclear medicine procedures in more than 250 hospitals and nuclear medicine clinics around Australia.

[*] based on published Medicare statistics combined with non-MBS data sourced from the nuclear medicine community: http://medicarestatistics.humanservices.gov.au/statistics/mbs_group.jsp

What is nuclear medicine?

Around 700,000* nuclear medicine procedures are carried out each year in Australia. These include diagnostic imaging scans such as PET and SPECT to aid in patient management, and a growing range of therapies.

Nuclear medicine imaging provides detailed physiological and molecular information to help diagnose and understand diseases of different organs and tissues such as cancers, to improve treatment and outcomes. Around 90 per cent of nuclear medicine procedures worldwide are for diagnostic purposes.

Some nuclear medicines produced by ANSTO can be used in therapeutics, for instance, to directly target and kill cancer cells.

Nuclear medicines are unique in that they can't be mass-produced to have a long shelf life as regular pharmaceutical products. Radioisotopes start to decay from the moment they are produced, and the rate of decay is referred to by its half-life, meaning the time taken for half of the radioactive atoms to decay.

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For most radioisotopes used in nuclear medicine, the half-life is measured in hours. For this reason, there is a strict manufacturing schedule to ensure radioisotopes are packaged and delivered to hospitals and medical clinics as soon as possible, so they remain effective for patient use. Having sovereign capability to produce these nuclear medicines locally in Sydney ensures ANSTO can meet the critical needs of patients in communities and the healthcare sector.

Some radioisotopes used in nuclear medicine have short half-lives and emit radiation, such as gamma rays. Their energies are suited for detecting disease while ensuring a low radiation dose to the patient.

Their rapid decay, combined with suitable emission properties, allows for high-quality diagnostic imaging while minimising radiation exposure.

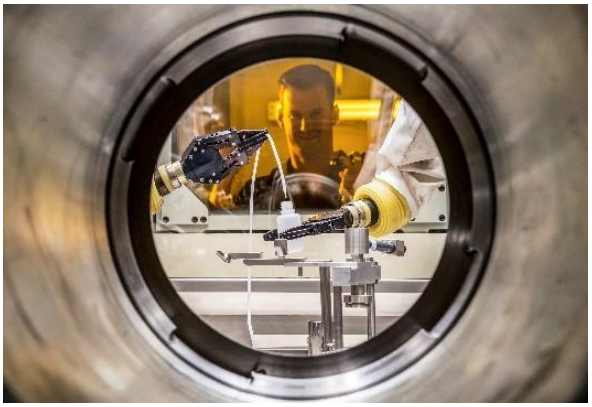
In contrast, therapeutic radioisotopes have longer half-lives and emit radiation such as beta or alpha particles, that ionise and destroy targeted tissue by damaging cellular DNA. The extended half-life enables sustained radiation delivery, enhancing their effectiveness in treatment.

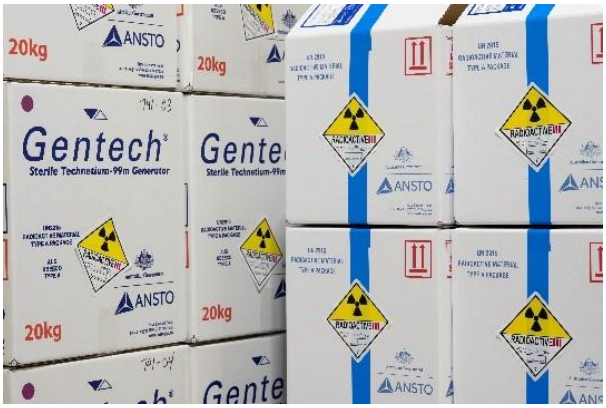
In diagnostic treatments, very small amounts of administered radioactive materials known as radiopharmaceuticals travel through a patient's body to the area being examined, allowing for detailed imaging of the targeted region. These materials act as tracers and emit gamma rays that are detected by a camera.

The camera will generate an image from the areas the radiation is being emitted from, which will show any indications of abnormal conditions.

For therapeutic treatments, the administered radiopharmaceutical specially recognises and binds to tumour cells while circulating through the body. Once attached, it delivers targeted radiation that damages or destroys the cancer cell. This nuclear medicine treatment is typically administered in multiple sessions to ensure complete eradication of the cancer cells.

[*] based on published Medicare statistics combined with non-MBS data sourced from the nuclear medicine community: http://medicarestatistics.humanservices.gov.au/statistics/mbs_group.jsp





Left: Nuclear medicine production at ANSTO, and Right: Boxes containing Gentech® Generators ready for dispatch to hospitals and medical clinics

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ANSTO's nuclear medicine products

ANSTO manufactures a variety of nuclear medicines. Molybdenum-99, Iodine-131, and Lutetium-177 are the main three radioisotopes produced at ANSTO's Lucas Heights campus.

Molybdenum-99 (Mo-99) is a radioisotope which decays to become **Technetium-99m (Tc-99m)** and is the most widely-used radioisotope in nuclear medicine. Over 80 per cent of nuclear medicine procedures worldwide use Tc-99m.

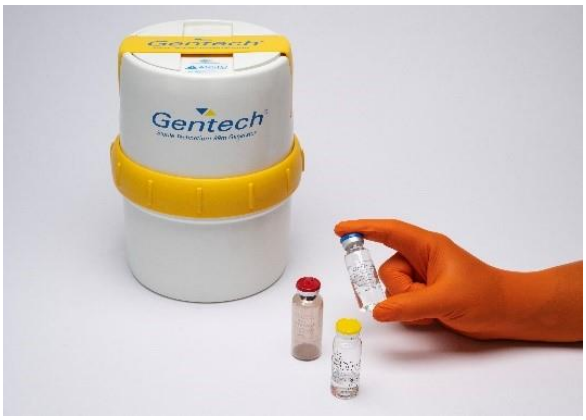
Across hospitals and medical clinics in Australia and worldwide, Tc-99m based radiopharmaceuticals are widely used for imaging various organs and soft tissues. They help assess conditions such as heart disease, bone disorders and abnormal tissue activity and potential cancers.

The produced Mo-99 is packaged into a Gentech® Generator, a shielded, portable device used to safely transport this nuclear medicine over long distances to hospitals and clinics around the country.

The **Gentech® Generator** allows the Mo-99 to safely decay to become Tc-99m during transit, where the Tc-99m is then extracted from the generator at the clinic and administered directly to patients by injection.

Sodium Iodine-131I is a radioisotope used to detect and treat disorders of the thyroid gland, including hyperthyroidism and thyroid cancer. It is administered orally and emits high energy electrons (beta particles), that are taken up by the thyroid gland tissue to destroy the gland's cells.

Lutetium-177 no-carrier-added (Lu-177 n.c.a) is a radioisotope currently being evaluated in clinical trials in Australia for its potential use in treating prostate cancer. When combined with a targeting molecule, Lu-177 delivers beta radiation directly to prostate cancer cells.



Left: Gentech® Generator and vials of Mo-99, and Right: Lutetium-177 n.c.a

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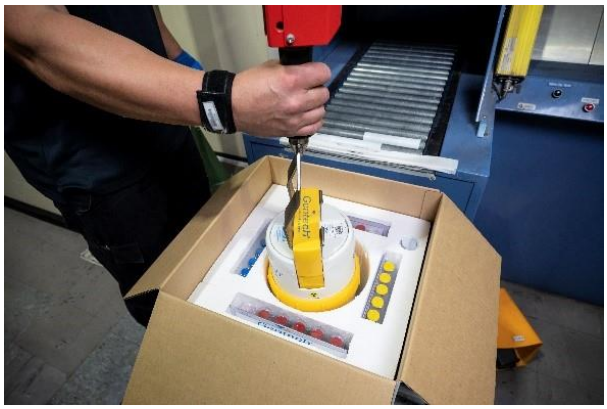
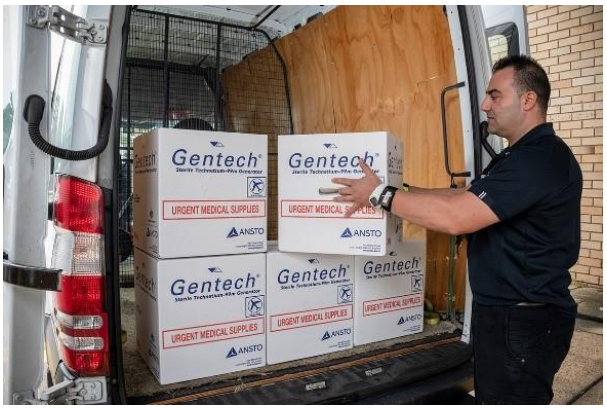
Gentech® Generator

ANSTO's own Technetium-99m (Tc-99m) Gentech® Generators are Australian-designed, portable medical devices that have been used since the late 1960s to deliver Tc-99m to hospitals and medical clinics around the country.

This ANSTO invention revolutionised nuclear medicine imaging in Australia by enabling imaging procedures to be performed not only in major capital cities, but throughout regional and rural Australia.

As Mo-99 decays quickly to become Tc-99m, it presents a logistical challenge to transport long distances. The Gentech® Generator provides a solution to this problem by providing a more reliable supply method. A single Gentech® Generator can supply a week's worth of Tc-99m.





Left and Right: Gentech® Generators being packaged into boxes ready for dispatch to hospitals and medical clinics

How is Mo-99 produced?

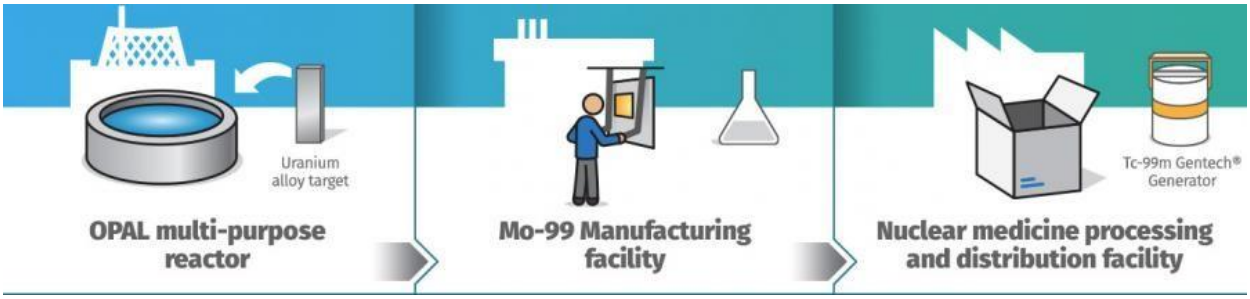
The production of nuclear medicine starts at the OPAL (Open Pool Australian Lightwater) multi-purpose reactor. Uranium alloy targets are lowered into the OPAL reactor, where they are irradiated. This irradiation causes fission of uranium-235, producing a range of fission products, including molybdenum-99 (Mo-99).

In the next step known as the separation process, the irradiated uranium targets are taken to large hot cells at the ANSTO Mo-99 Manufacturing Facility where an industrial chemical separation process extracts the Mo-99 in liquid form from the other fission waste products.

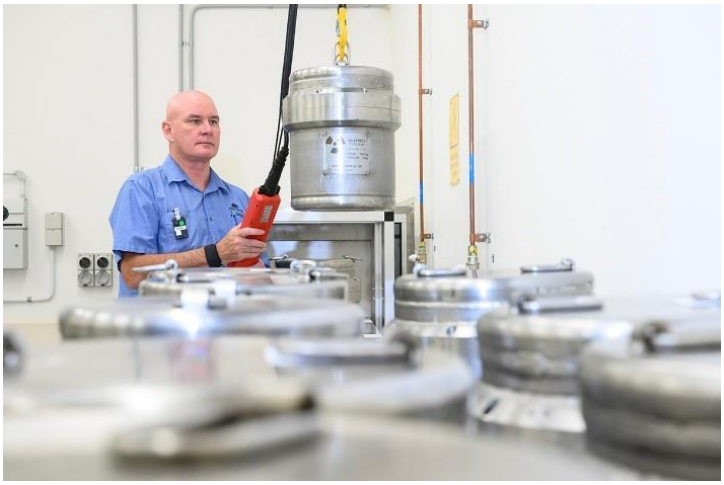
Hot cell manipulators are operated by staff to perform chemical separation of Mo-99, protected by a one-metre-thick wall of radiation-shielded special glass.

An additional purification process then follows in smaller hot cells, whereby any trace impurities are removed from the active Mo-99. A full production run is completed within approximately 26 hours, and ANSTO completes several production runs each week.

The Mo-99 is then packaged into radiation shielded containers and exported overseas or packaged into Gentech® Generators (to decay into Tc-99m) for distribution to Australian hospitals and clinics.



Above: Producing Mo-99 at the Mo-99 Manufacturing Facility using hot cells and arm manipulators



Above: Nuclear medicine production