Managing Radioactive Waste in Australia

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Radioactive waste needs to be safely managed and disposed of. Australia's approach to radioactive waste management and disposal must ensure that people and the environment are protected.

The topic of radioactive waste generates debate, both publicly and scientifically. Like chemical and other hazardous waste, radioactive waste needs to be dealt with to ensure its safety and its security.

Proper management and disposal of most forms of radioactive waste is technically straightforward. A robust safety regime has been developed internationally for managing and disposing of radioactive waste.

What Is Radioactive Waste?

Radioactive waste is material, whatever its physical form, remaining from a practice and for which no further use is foreseen, that contains or is contaminated with radioactive substances and has an activity or activity concentration higher than the level for clearance from regulatory requirements.

Radioactive waste is generated in Australia from the uses of radiation in medicine, industry and research. The mining industry also produces large volumes of waste containing naturally occurring radioactive material (NORM). Industrial uses include in borehole loggers, thickness and moisture gauges. An important domestic use of radioactivity is in smoke detectors, which ultimately will become waste.

Radioactive Waste Management

Radioactive waste must be managed in order to isolate it from people and the environment ("safety"). Radioactive waste must also be managed in a way that prevents it from being accessed by anybody with malicious intent ("security").

In many jurisdictions it is a regulatory requirement that, wherever possible, radioactive sources for which no further use is foreseen should be returned to the supplier, either for recycling or disposal. However, this may not be possible in all cases.

The two ways in which radioactive waste are generally managed are "concentrate and contain" or "dilute and disperse", the former for mainly solid waste and the latter for most liquid and gaseous waste.

Decision-making about radioactive waste is influenced by many factors. One of them is the view that radioactive waste should be stored in above-ground stores, either out of concern about committing the waste to the environment in a disposal site or that some better technique for dealing with the waste will be discovered in the future and that any waste that has been disposed of may need to be retrieved. These latter factors sometimes have the effect of delaying a decision about a potential disposal site.

The international community has adopted the policy, through the development of the International Atomic Energy Agency's (IAEA) waste standards, that storage of radioactive waste is an interim measure and that national policy should regard disposal as the ultimate solution to dealing with the waste. A fundamental safety principle of the IAEA is that the problem of dealing with radioactive waste should not be passed to future generations.

Australia does not have a national disposal facility specifically for radioactive waste. Australia has a large number of places in which radioactive waste is stored; some contain waste from past practices, which may not be well characterised or secured. Waste that is not well characterised or properly secured presents a safety problem when those managing the waste are not aware of its risks.

Safety assessments of examples by the international community indicate that below-ground disposal is safer and usually more cost-effective than storage.

Once material is declared to be radioactive waste it is then managed as such (known as the "operational management phase"), which includes predisposal, treatment, conditioning, short- or long-term storage and transport activities.

Radioactive waste is generated in a number of different kinds of facilities and may have a wide range of concentrations of radionuclides (species of atomic nucleus that undergo radioactive decay) in a variety of physical and chemical forms. These differences result in an equally wide variety of waste management options. A range of alternatives exists for the treatment and conditioning of the waste and for shorter or longer term storage prior to disposal.

Different types of waste may be grouped for operational waste management purposes, such as separation of waste containing radionuclides with shorter or longer half-lives (the time required for the activity of the radionuclide to decrease by half through the process of radioactive decay), or separating compressible waste from non-compressible waste.

Waste containing only short-lived radionuclides is usually stored for a short time while it decays, after which it is disposed as non-radioactive waste. Other waste containing very low concentrations of long-lived radionuclides can be released to the environment, often in gaseous or liquid form, if it complies with appropriate regulatory constraints. All other types of radioactive waste need to be eventually disposed of in a manner consistent with the safety requirements for the disposal of radioactive waste.

Operational management involves "categorisation" of the waste based on its physical and chemical characteristics. The categories are loosely related to occupational risk. "Classification" of radioactive waste for disposal is conversely related to long-term risks to members of the public and the environment.

Classification of Radioactive Waste

Two criteria are fundamental to classifying radioactive waste for long-term storage and disposal: radioactivity level and the half-lives of relevant radionuclides.

Radioactivity levels in radioactive waste range from negligible to very high concentrations of radionuclides. As the level rises, the need increases to contain the waste and to isolate it from the biosphere. At the lower range of activities, below the "clearance levels", the management of the waste can be carried out without consideration of its radiological properties. Activity limitations for a given disposal facility will in particular depend on the radiological, chemical, physical and biological properties of individual radionuclides.

Half-lives range from very short (seconds) to very long time spans (millions of years). In terms of radioactive waste safety, radionuclides with a half-life greater than about 40 years are considered to be long-lived. Such a distinction between short-lived and long-lived waste is of substantial benefit because the radiological hazards associated with short-lived radionuclides are significantly reduced over a few hundred years by radioactive decay – timeframes over which a reasonable degree of assurance can be placed on institutional control measures to contribute to disposal safety.

Six classes of waste form the basis of Australia's radioactive waste classification scheme (see box, p.11). The classification of waste obviously depends on when the waste is assigned a classification.

Through radioactive decay, waste will move

into the lower-activity classes in time. This demonstrates that the classification scheme is not static but depends on the actual conditions of the waste at the time of assessment. This reflects the flexibility that radioactive decay provides for the management of radioactive waste.

Australia's inventory of radioactive waste contains no material in the high-level waste (HLW) classification as our spent fuel is sent overseas for reprocessing, and the resultant waste forms that will eventually be returned to Australia fit the classification as intermediate-level waste (ILW).

Disposal of Radioactive Waste

There are a number of alternatives for the disposal of radioactive waste, ranging from near-surface disposal in engineered vaults or trenches to disposal in engineered facilities located in stable underground geological formations at depths of hundreds of metres.

For near-surface disposal, it is generally agreed that control of the disposal site can be relied upon for periods up to around 300 years. A definitive generic boundary between low-level waste (LLW) and ILW cannot be provided, as activity limitations will differ between individual radionuclides, and waste acceptance criteria will be dependent on the site, design and controls of a near-surface disposal facility.

For ILW, disposal in a facility at a greater depth (e.g. between a few tens and a few hundreds of metres) is indicated. This has the potential to provide a long period of isolation from the accessible environment if proper characteristics are selected for both the natural and the engineered barriers within the disposal system. In particular, the detrimental effects of erosion can generally be ruled out at such depths in the short to medium term.

Another important advantage of waste disposal at intermediate depths is that, in comparison to facilities suitable for LLW, the likelihood of inadvertent human intrusion is greatly reduced. Consequently, the facility will

Australia's Radioactive Waste Classification Scheme

The classification scheme summarised below is based on long-term safety considerations, and is applicable for extended storage and disposal of radioactive waste.

- *Exempt waste (EW)* meets the criteria for exemption from regulatory control for radiation protection purposes (i.e. waste of an activity low enough so as to not require safety measures).
- *Very short-lived waste (VSLW)* can be stored for decay over a limited period of up to a few years and subsequently cleared according to arrangements approved by the relevant regulatory authority, for uncontrolled disposal, use or discharge. This class includes waste from industrial, medical and research operations.
- *Very low level waste (VLLW)* needs a moderate level of containment and isolation, and therefore is suitable for disposal in a near-surface, industrial or commercial landfill-type facility with limited regulatory control. Such landfill type facilities may also contain other hazardous waste. Typical waste in this class includes soil and rubble with low activity concentration levels. Concentrations of longer-lived radionuclides would generally be very limited.
- *Low level waste (LLW)* has limited amounts of long-lived radioactivity. It requires robust isolation and containment for periods of up to a few hundred years and is suitable for disposal in engineered near-surface disposal facilities. This class covers a very broad range of materials that can include short-lived radionuclides at higher activity levels and long-lived radionuclides, but only at relatively low activity concentration.
- *Intermediate level waste (ILW)* is waste that, because of its content (particularly of long-lived radionuclides) requires a greater degree of containment and isolation than is provided by near-surface disposal. However, ILW needs little or no provision for heat dissipation during its storage and disposal. It may contain long-lived radionuclides that will not decay to an activity concentration that is acceptable for near surface disposal during the time for which control of the disposal site can be relied upon. Therefore ILW requires disposal at greater depths.
- *High level waste (HLW)* has radioactivity levels high enough to generate significant quantities of heat by the radioactive decay process or has large amounts of long-lived radionuclides that need to be considered in the design of a disposal facility for such waste. Disposal in deep, stable geological formations usually several hundred metres or more below the surface is the generally recognised option for the disposal of HLW.

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have to be designed so that long-term safety will not depend on the presence of institutional controls for such disposal facilities.

Another proposal for a solution to the ultimate disposal of small-volume radioactive waste is borehole disposal at depths from 30 to several hundred metres. This may be particularly beneficial in developing countries that might possess a relatively small number of disused sealed radioactive sources, which if not safely disposed can present substantial safety and security risks. The technology to prepare a small number of suitable boreholes is widely available, for instance in the mining industry. The IAEA has prepared a generic safety assessment to validate the safety of properly sited boreholes for the disposal of small volumes of ILW.

Spent Fuel

In many countries, unprocessed spent fuel is not considered a radioactive waste because it remains a substantial energy source due to the presence of plutonium and other reusable fission products. However, it needs to be stored in a safe and secure manner that isolates it from people and the environment, and keeps it secure.

Reprocessing of spent fuel recovers plutonium and uranium by extraction. In the process, radioactive waste by-products are produced that have to be safely managed and ultimately disposed of. Much of Australia's spent fuel from the research reactor at Lucas Heights is reprocessed in France and the UK. The waste by-products will eventually be returned to Australia, some in the form of vitrified waste. This waste will need to be stored as ILW while disposal options are developed.

Safety Regime

The vision of the IAEA Department of Nuclear Safety and Security is:

> A strong, sustainable and visible Global Nuclear Safety and Security Regime that provides for protection of people and the environment from effects of ionizing radiation, minimization of the likelihood of accidents or malicious acts that could endanger life and property, and effective mitigation of the effects of any such events.

In the area of radioactive waste safety, the IAEA works to assist its member states to achieve this vision by producing international safety standards and guidance for radioactive waste management, including disposal, decommissioning and rehabilitation of contaminated areas.

Australia is a signatory to the United Nations Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. The objectives of the Joint Convention include achieving and maintaining a high level of safety worldwide in spent fuel and radioactive waste management through the enhancement of national measures and international cooperation.

Through safety-related technical cooperation, the Joint Convention aims to protect individuals, society and the environment from the harmful effects of ionising radiation in such a way that the needs and aspirations of the present generation are met without compromising the ability of future generations to meet their needs and aspirations.

In Australia, radioactive waste safety is guided by a series of national codes and safety guides based on best international practice, including IAEA standards. These national codes and guidance documents are developed by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and currently cover the areas of classification of radioactive waste, predisposal management, management of NORM, near-surface disposal of radioactive waste, and radioactive waste management in mining and mineral processing, which is part of ARPANSA's role in promoting uniformity in radiation protection regulation across all jurisdictions.

Regulatory Regime in Australia

ARPANSA is a scientific and independent regulatory agency of the Australian government, which regulates Commonwealth activities in radioactive waste management. State and territory governments are independently responsible for radiation protection within their jurisdictions and regulate waste safety within their own jurisdiction.

ARPANSA, as the regulator of the

Preparing for the disposal of concreted and drummed radioactive waste in a near-surface disposal facility. Image credit: Stuart Woollett

Commonwealth's use of radiation, would only issue a licence for a radioactive waste disposal facility if and when:

- it receives an application for a licence for such a facility;
- a safety case has been produced that is considered complete and with sufficient depth;
- the licence application is stepwise (deals with siting, construction, operation and closure);
- operations are to be monitored through periodic safety reviews;
- institutional control, safeguards and information preservation are adequately addressed; and
- adequate stakeholder involvement has taken place, including opportunity for submissions to ARPANSA, and after the Agency's active involvement with all concerned parties.

ARPANSA reserves the right to decline an application if it doesn't address these issues or is otherwise deficient.

Conclusion

Radioactive waste is well-understood scientifically, and is readily classified in terms of its hazards and technical requirements. In Australia the new national classification scheme for radioactive waste is now in place. The technology for disposing of radioactive waste is available. Furthermore, a robust national and international safety regime is in place to ensure that all phases in the lifecycle of radioactive waste can be performed safely and securely. Australia is actively involved in the ongoing development of this safety and security regime.