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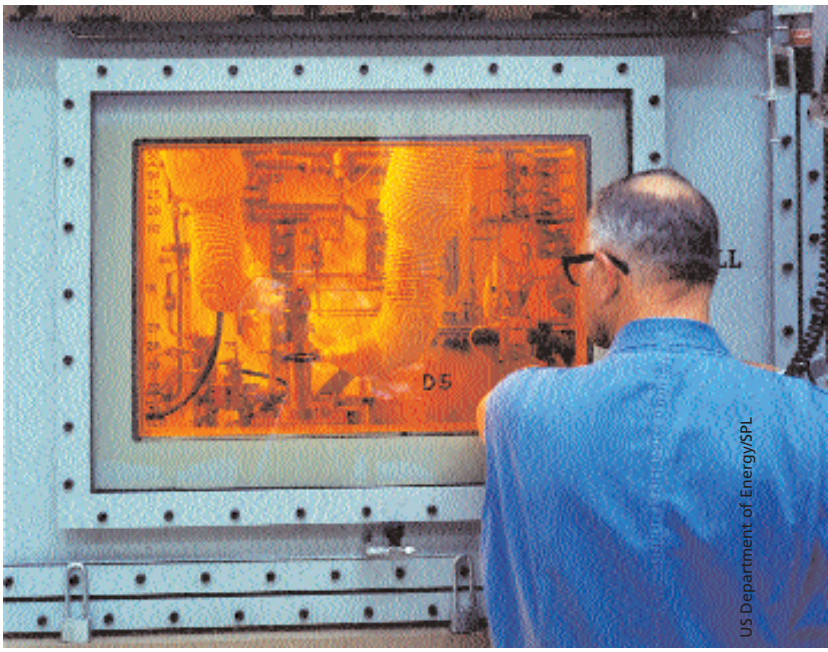
Hot, corrosive, a source of intense radiation — that's high-level nuclear waste. The nuclear industry is seeking safe ways to deal with such waste, and wants the public to help shape the decisions that are made. This article presents some information, and suggests ways to join in the decision-making process.



A technician in the USA using remote welding arms to seal radioactive waste in double-walled metal containers. He is shielded from the waste by metre-thick leaded glass. The containers will be stored under 4 metres of water

Hot problems

GCSE key words
Radioactive decay
Half-life

A small amount of radioactive waste comes from medical (2%) and military (1%) sources, but the bulk of it is produced by the nuclear power industry. In the UK, about 20% of our electricity is generated in nuclear power stations which use uranium as their fuel (see CATALYST Vol. 13, No. 4). Energy is released from the nuclei of uranium atoms by the process of fission. The waste left when the fuel is used up ('spent') contains many fission products — atoms of a variety of elements which are often highly radioactive. These hazardous substances make up a large proportion of nuclear waste. More radioactive waste is produced when power stations are decommissioned at the ends of their lives (see CATALYST Vol. 14, No. 2).

Large volumes of radioactive waste have been

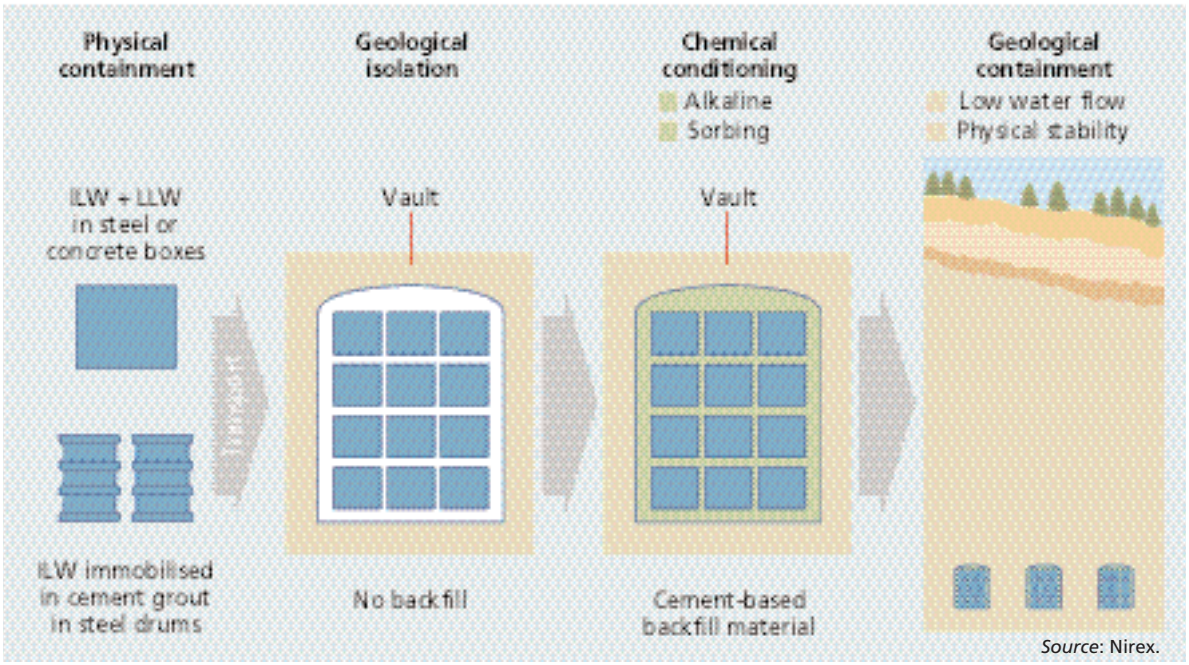


Figure 1 *The stages of containment in the long-term management of low and intermediate-level waste*

accumulating for decades. Many of the radioactive materials involved have long half-lives, so they will have to be stored safely for centuries before their activity falls to a safe level. The time has come to make decisions about how to do this.

GRADES OF WASTE

Most radioactive waste is classed as **low-level waste** (LLW). This includes things like discarded protective clothing, paper towels and wrapping materials. It is not safe to dispose of alongside household waste, so it is compacted into drums and dumped in a landfill site. The main UK dump is at Drigg, near Sellafield, in Cumbria.

Intermediate-level waste (ILW) is more radioactive. It includes materials which have been inside reactors, such as the cladding from fuel rods. This waste is cut up and packed in cement inside 500-litre stainless steel drums (Figure 1). ILW remains radioactive for centuries, so there is a problem knowing how best to deal with it.

High-level waste (HLW) is the most radioactive (and the most difficult to deal with). This material, which has been extracted from spent fuel rods, is dissolved in nitric acid and then concentrated by evaporation. It is stored in stainless steel tanks inside thick concrete walls.

HLW is so intensely radioactive that it becomes hot, and so the storage containers must be water-cooled. Attempts have been made to turn HLW into glass blocks by the process of vitrification, but this has proved tricky. The advantage of this would be that glass doesn't corrode. Ninety per cent of the UK's HLW is stored at Sellafield. Government policy is that HLW must be stored for at least 50 years to allow it to cool down; long-term management should then be easier.

Much HLW is now in a dangerous condition. It corrodes the containers which are meant to keep it safe, and these then have to be placed inside further containers. There is a constant danger of leakage into the environment. We can't go on like this!

A Greenpeace protest against a nuclear shipment from Japan, bound for Sellafield for reprocessing

CONTAINING WASTE

High-level nuclear waste is going to be with us for a long time. Even if all nuclear power stations were shut down tomorrow, we would still have to cope with existing stocks of HLW, and more would come from decommissioning work (Figure 2). In addition, there will continue to be a steady trickle from medical and industrial uses. Ideally, we would like to be able to dump all nuclear waste in some safe way and forget about it, but we can't wish this problem away.

What are the difficulties? The problem is partly one of timescale. Some fission products have long half-lives, and will have to be contained for thousands of years (Figure 3). The industrial age is just a few centuries old, and we don't have the experience of dealing with dangerous materials over longer periods of time.

So predicting the future is important. How far ahead can we look? And would it be fair to leave future generations with a problem created by our own use of energy?

The nuclear industry predicts that it will need thousands of graduates in physics, chemistry, geology, materials and environmental science over the next few years to develop safe ways of storing the radioactive waste produced by the operation and decommissioning of nuclear power stations.

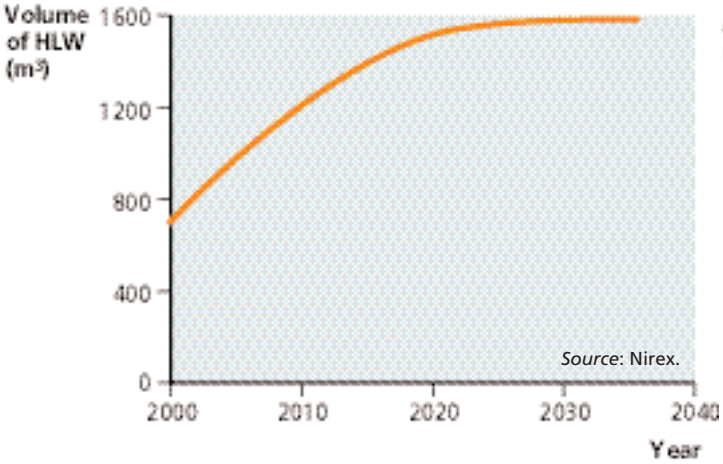


Figure 2 *Volumes of HLW will continue to rise over the next 10 years. If any new nuclear power stations are built, the graph will rise beyond 2020*

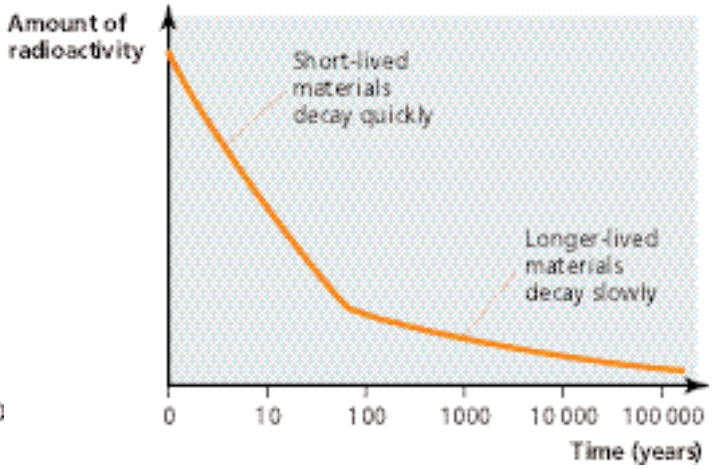


Figure 3 *While some components of HLW decay quickly, others are much longer lived and will go on being a hazard for thousands of years*

BOX 1 OPTIONS FOR STORAGE OF RADIOACTIVE WASTE

Interim surface or underground storage in appropriate conditions	Temporary storage, either at ground level, or underground; containers of waste would be monitored to check for overheating and leaks of radiation or chemicals
Long-term surface storage	Storage at ground level throughout the hazardous life of the waste. Would require constant management
Sea disposal, sub-seabed disposal	Containers of waste dumped at sea, or disposed of in a repository excavated under the seabed. Currently banned by international treaty
Disposal in subduction zones	Containers of waste buried where they will be carried further underground by the movement of tectonic plates. Currently banned by international treaty
Underground disposal	Containers of waste deposited in a space excavated below ground level, or in a borehole drilled deep into the ground. Favoured by most scientists; such repositories are now being built in Sweden, Finland and USA
Deep underground disposal	Waste deposited deep underground; containers may need further packaging to avoid chemical corrosion by surrounding clays, salts etc. The ground must be stable, without water flow, for perhaps 100 000 years
Disposal in space	Waste carried by rockets into space. Could be considered for the relatively small volumes of HLW, but rocket launches are not considered reliable enough at present

US Department of Energy/SPL

Below: *A tunnel for the storage of nuclear waste 650 metres below the ground in salt beds, New Mexico, USA*

MAKING DECISIONS

The question of what to do with radioactive waste raises many issues — social and ethical as well as scientific and technological. The UK government is encouraging a review process which will allow citizens to have a say in waste disposal. The aim is to achieve public confidence in whatever decisions are made.

Security is vital. If radioactive waste fell into the wrong hands, it could be used in a so-called 'dirty bomb' or 'radiological weapon', in which conventional explosives are used to shower radioactive materials over a large area.

Sustainability is vital, too. The burden on future generations should be minimised. Environmental damage should be no greater than is acceptable today, and we shouldn't rely on the stability of future governments. That's a lot to ask.

Nirex Ltd, the body that researches ways of dealing with waste, is coordinating the national debate on these issues. Box 1 details some of the options it is considering. You can find out more from Nirex (**http://www.nirex.co.uk**), and you can contribute to the debate by attending public meetings and exhibitions, and through the internet (Box 2).

LONG-TERM MANAGEMENT

It is proposed that radioactive waste and materials would be packaged securely, and then stored in one or more of the ways shown in Box 1.

Several disposal methods have already been ruled out. These include:

- Allowing hot containers of highly-active waste to melt their way down into rocks, or into polar ice-sheets — it's too uncertain where the material would end up.
- Transmutation, a process in which waste is irradiated with beams of fast neutrons, converting unstable isotopes into stable ones — the technology has not yet been developed.

BOX 2 JOIN THE DEBATE

Find out more and join in the debate about handling nuclear waste at
http://www.schoolscience.co.uk/content/4/physics/nirex/index.html

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