Treatment and Conditioning of Nuclear Wastes

Radioactive Waste Management - Appendix 1

Treatment and conditioning processes are used to convert radioactive waste materials into a form that is suitable for its subsequent management, such as transportation, storage and final disposal. The principal aims are to:

- Minimise the volume of waste requiring management via treatment processes.
- Reduce the potential hazard of the waste by conditioning it into a stable solid form that immobilises it and provides containment to ensure that the waste can be safely handled during transportation, storage and final disposal.

It is important to note that, while treatment processes such as compaction and incineration reduce the volume of waste, the amount of radioactivity remains the same. As such, the radioactivity of the waste will become more concentrated as the volume is reduced.

Conditioning processes such as cementation and vitrification are used to convert waste into a stable solid form that is insoluble and will prevent dispersion to the surrounding environment. A systematic approach incorporates:

- Identifying a suitable matrix material - such as cement, bitumen, polymers or borosilicate glass - that will ensure stability of the radioactive materials for the period necessary. The type of waste being conditioned determines the choice of matrix material and packaging.
- Immobilising the waste through mixing with the matrix material.
- Packaging the immobilised waste in, for example, metallic drums, metallic or concrete boxes or containers, copper canisters.

The choice of process(es) used is dependent on the level of activity and the type (classification) of waste. Each country's nuclear waste management policy and its national regulations also influence the approach taken.

Incineration[a]

Incineration of combustible wastes can be applied to both radioactive and other wastes. In the case of radioactive waste, it has been used for the treatment of low-level waste from nuclear power plants, fuel production facilities, research centres (such as biomedical research), medical sector and waste treatment facilities.

Following the segregation of combustible waste from non-combustible constituents, the waste is incinerated in a specially engineered kiln up to around 1000$_{o}$C. Any gases produced during incineration are treated and filtered prior to emission into the atmosphere and must conform to international standards and national emissions regulations.

Following incineration, the resulting ash, which contains the radionuclides, may require further conditioning prior to disposal such as cementation or bituminisation. Compaction technology may also be used to further reduce the volume, if this is cost-effective. Volume reduction factors of up to around 100 are achieved, depending on the density of the waste.

Incineration technology is subject to public concern in many countries as local residents worry about what is being emitted into the atmosphere. However, modern incineration systems are well engineered, high technology processes designed to completely and efficiently burn the waste whilst producing minimum emissions.

The incineration of hazardous waste (*e.g.* waste oils, solvents) and non-hazardous waste (municipal waste, biomass, tyres, sewage sludge) is also practised in many countries.

Compaction [b]

Compaction is a mature, well-developed and reliable volume reduction technology that is used for processing mainly solid man-made low-level waste (LLW). Some countries (Germany, UK and USA) also use the technology for the volume reduction of man-made intermediate-level/transuranic waste. Compactors can range from low-force compaction systems (~5 tonnes or more) through to presses with a compaction force over 1000 tonnes, referred to as supercompactors. Volume reduction factors are typically between 3 and 10, depending on the waste material being treated.

Low-force compaction is typically applied to the compression of bags of rubbish, in order to facilitate packaging for transport either to a waste treatment facility, where further compaction might be carried out, or to a storage/disposal facility. In the case of supercompactors, in some applications, waste is sorted into combustible and non-combustible materials. Combustible waste is then incinerated whilst non-combustible waste is supercompacted. In certain cases, incinerator ashes are also supercompacted in order to achieve the maximum volume reduction.

Low-force compaction utilises a hydraulic or pneumatic press to compress waste into a suitable container, such as a 200-litre drum. In the case of a supercompactor, a large hydraulic press crushes the drum itself or other receptacle containing various forms of solid low- or intermediate-level waste (LLW or ILW). The drum or container is held in a mold during the compaction stroke of the supercompactor, which minimises the drum or container outer dimensions. The compressed drum is then stripped from the mold and the process is repeated. Two or more crushed drums, also referred to as pellets, are then sealed inside an overpack container for interim storage and/or final disposal.

A supercompaction system may be mobile or stationary in concept, supplied as a basic system manually controlled, with a minimum of auxiliary equipment, to an elaborated computer controlled system which selects drums to be processed, measures weight and radiation levels, compresses the drums, places the crushed drums in overpack containers, seals the overpacks, records the drums and overpacks content via a computerised storage system.

Every year worldwide tens of thousands of drums are volume-reduced and stored, with waste generally being reduced in volume by up to a factor of 5.

Cementation [c]

Cementation through the use of specially formulated grouts provides the means to immobilise radioactive material that is on solids and in various forms of sludges and precipitates/gels (flocks) or activated materials.

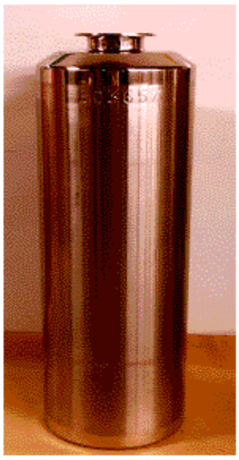
In general the solid wastes are placed into containers. The grout is then added into this container and allowed to set. The container with the now monolithic block of concrete/waste is then suitable for storage and disposal.

Similarly in the case of sludges and flocks, the waste is placed in a container and the grouting mix, in powder form, is added. The two are mixed inside the container and left to set leaving a similar type of product as in the case of solids, which can be disposed of in a similar way.

This process has been used for example in small oil drums and 500-litre containers for intermediate-level wastes and has been extended to ISO shipping containers for low-level waste materials.

The technology is being used in the immobilisation of many toxic and hazardous wastes that arise outside the nuclear industry and has the potential to be used in many more cases.

Vitrification [d]



The immobilisation of high-level waste (HLW) requires the formation of an insoluble, solid waste form that will remain stable for many thousands of years. In general borosilicate glass has been chosen as the medium for dealing with HLW. The stability of ancient glass for thousands of years highlights the suitability of borosilicate glass as a matrix material.

This type of process, referred to as vitrification, has also been extended for lower level wastes where the type of waste or the economics have been appropriate.

Most high-level wastes other than spent fuel itself, arise in a liquid form from the reprocessing of spent fuel. To allow incorporation into the glass matrix this waste is initially calcined (dried) which turns it into a solid form. This product is then incorporated into molten glass in a stainless container and allowed to cool, giving a solid matrix. The containers are then welded closed and are ready for storage and final disposal.

This process is currently being used in France, Japan, the Former Soviet Union, UK and USA and is seen as the preferred process for management of separated HLW arising from reprocessing.

Several other alternative ceramic processes have also been developed which also achieve the desired quality of product (see for example Synroc information page).

In-situ vitrification has also been investigated as a means of 'fixing' activity in contaminated ground as well as creating a barrier to prevent further spread of contamination.[1]

Further Information

Notes

a. More detailed information can be found in the brochure Incineration of Radioactive Waste, NUKEM Technologies GmbH (2007). [Back]

b. See brochure Compaction of Radioactive Waste, NUKEM Technologies GmbH (2007). [Back]

c. See brochure Cementation of Radioactive Waste, NUKEM Technologies GmbH (2007). [Back]

d. See EPA Handbook Vitrification Technologies for Treatment of Hazardous and Radioactive Waste, United States Environmental Protection Agency (EPA), EPA/625/R-92/002 (May 1992) available from the EPA's National Service Center for Environmental Publications (www.epa.gov/nscep). [Back]

References

1. An Overview of In Situ Waste Treatment Technologies, S. Walker, R. A. Hyde, R. B. Piper, M. W. Roy, Idaho National Engineering Laboratory, presented at the Spectrum '92 Conference, Boise, Idaho (August 1992). [Back]

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