MAJOR CONSIDERATIONS: THE ISSUE OF WASTE STORAGE AND DISPOSAL

HABOG storage facility, Central Organization for Radioactive Waste (COVRA), Netherlands

(Photo: COVRA, Netherlands)

When people talk about the adoption of nuclear technology and use of radioactive material, one of the most contentious issues is its ultimate disposal.

The length of time needed for radioactive waste and spent nuclear fuel declared as waste to no longer present a potential hazard to human health or the environment varies significantly. This can range from a few months or years for some types of radioactive waste, to millennia for high level waste, and hundreds of thousands of years for spent fuel. As such, governments and citizens have legitimate concerns about safety in the near and long term.

Long term safety is provided by disposal, and until a suitable disposal facility has been implemented, safe management is provided by storage. While safe and sustainable solutions have been implemented or are under development around the world, it is never enough to simply reproduce the same solution in a different location. For every facility, safety has to be assessed and a license application based on a safety case has to be reviewed by a competent authority. This ensures that such legitimate concerns from governments and citizens are fully addressed and that the protection of people and the environment is provided for. Licensing a disposal facility is often a lengthy process and therefore there is a need in the near term to safely store the waste pending disposal.

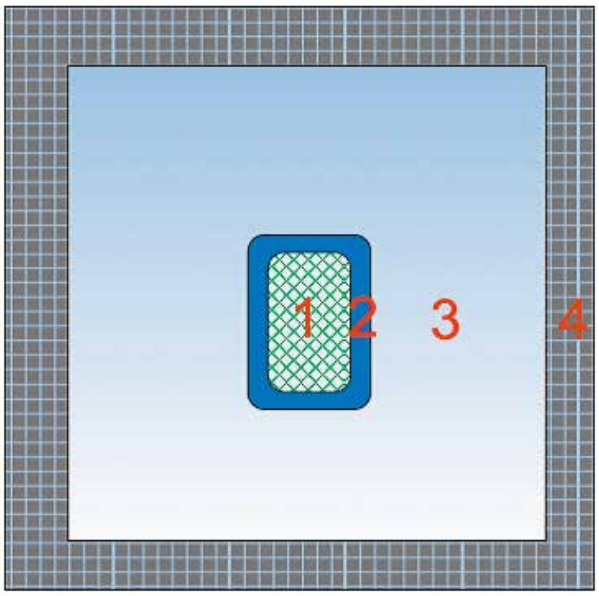
Waste Storage

Storage may be required at any stage of the waste management process and may serve several purposes, such as to allow for the decay of short-lived radionuclides, dissipation of heat, time to accumulate sufficient waste to enable efficient processing, or to provide for waste containment and isolation until a suitable path towards disposal has been implemented.

Storage is defined as the holding of radioactive sources, spent fuel or radioactive waste in a facility that provides for their/its containment, with the intention of retrieval. Storage is consequently, by definition, an interim measure.

To provide safe, retrievable, monitorable and secure storage of waste that ensures protection for workers, the public and the environment,

Schematic Representation of a Storage System



Package waste storage — physical and environmental layers of protection

1. The conditioned waste form is the primary barrier.
2. The waste container is the secondary barrier.
3. Control of the store environment is important in maintaining integrity of the waste form and waste container.
4. The store structure is the final layer of weather/atmosphere protection for the waste package and is also an important element in the physical security of the waste.

Image: *November 2012 Industry Guidance: Interim Storage of Higher Activity Waste Packages — Integrated Approach*, NDA, UK

a storage system composed of two primary components — the waste package and the storage facility itself — is required. These two components are closely linked as the properties and behaviour of one strongly influences the design of the other. Both need to be properly addressed to ensure the system meets the necessary safety and regulatory requirements. The figure above provides a schematic illustration of the storage system.

The waste package includes the waste form and the container. The preferred waste form is a stable solid product, which may be produced using a suitable conditioning technique such as cementation or vitrification. The container ensures secure containment of the radioactive material for the required storage period and for disposal, and will include features for handling and stacking in the store. Some containers in common use are illustrated on the right.

The storage facility provides an environment such that the waste packages do not degrade during the period of storage and are safe to retrieve and transfer to the disposal facility. The type of store building and its internal storage arrangement are therefore linked to the type and classification of waste being stored.

Low level waste, commonly stored in 200 litre steel drums or metal containers and likely to be routed to disposal within a short time, requires simple storage arrangements as shielding is not required. A suitable structure can be an industrial-type building able to provide protection from the local climate, with a firm concrete slab, and vehicle and personnel access doors, together with monitoring and

From top left: 200 litre steel drum, concrete boxes and stainless steel container for high level waste (HLW)

(Photos, from top left: IAEA; Magnox Limited, UK; and Sellafield Sites, UK)

Very low level waste disposal trench at the CIRES disposal facility in France.

(Photo: National Radioactive Waste Management Agency (Andra), France)

inspection provisions; humidity control may also be necessary.

Storage of long lived vitrified high level waste or spent nuclear fuel requires a carefully designed, highly engineered facility to provide remote handling, shielding, cooling and an assured environment for the required storage period. Such a facility must also provide adequate security and, in the case of spent nuclear fuel, safeguard the fissile material.

In recent years, mainly because of the absence of permitted disposal facilities, long term storage (e.g. up to 100 years) is being considered by a number of Member States as a risk mitigation measure should there be delays in the availability of a final disposal facility. Such long term storage entails taking additional measures to ensure continuing satisfactory control and protection of the waste packages and the facility itself and to demonstrate, including by taking into account ageing of materials and structure, that the safety and security of the facility is ensured for the planned period and that a corresponding licence is given.

The HABOG facility in the Netherlands is an example of a modern long term storage facility for vitrified high level waste from reprocessing and spent fuel from research reactors. Even in this example, storage can only be considered a temporary solution, implemented with the intention and need to eventually retrieve waste for further management. Disposal is the only permanent management solution for radioactive waste capable of providing for passive, long term safety.

Waste Disposal

Different disposal solutions exist, which may broadly be classified into:

- Near surface disposal facilities, suitable for very low level waste and low level waste; and

- Geological disposal facilities, suitable for intermediate level waste, high level waste and spent nuclear fuel declared as waste.

Very low level waste (VLLW) and low level waste (LLW) present a potential hazard for durations not exceeding a few centuries. They can safely be contained in a near surface facility. Some 140 near surface disposal facilities have been successfully sited worldwide, and are in operation, or even already closed. Efficient disposal solutions for VLLW are landfill-type surface trenches utilizing a limited barrier

system. Disposal solutions for LLW rely on a combination of site properties and engineered barriers such as liners, concrete disposal vaults and covers of alternating impermeable and water diverting features, to provide the required protection.

Intermediate level waste (ILW), high level waste (HLW) and spent fuel (SF) declared as waste may present a hazard for durations exceeding hundreds of thousands of years. They therefore require disposal in a stable, geological environment, capable of ensuring long term safety without human intervention for several thousands (in the case of ILW) or several hundreds of thousands of years (in the case of HLW and SF).

Disposal of LLW and ILW is well established and several geological disposal facilities for LLW and ILW are in operation worldwide.

A few countries (Sweden, Finland and France) are well advanced in the development of geological disposal facilities for HLW including spent fuel and such facilities are expected to be operational by 2025.

Despite these success stories, the implementation of disposal strategies remains one of the greatest ongoing challenge in the management of spent fuel and radioactive waste in many Member States.

From the technical and safety perspective, geological disposal is feasible. Different types of host rock have been found to be suitable for safe geological disposal and safety cases have been developed for disposal in crystalline rock (e.g. in Finland, Sweden), in sedimentary (i.e. clay) rock (e.g. in France) and in evaporate (i.e. salt) rock (e.g. in Germany).

Initially, the suitability of a site is assessed, for example, by evaluating whether the risk of seismic activity, volcanic activity, or the presence of natural resources prevent it from hosting a geological disposal facility. With further investigation a site is characterized to a stage where the relevant natural features and processes are understood with confidence, especially regarding how they contribute to containing and isolating the radionuclides in the waste and spent fuel — and thus how they contribute to long term safety.

In addition to these natural site properties, engineered features such as the waste form, the waste package, and any buffers and seals that may be emplaced also contribute to the containment, and thus to long term safety are also analyzed and taken into consideration. Indeed, waste is processed into waste forms limiting its long term release (e.g. from a glass matrix for HLW). It is further conditioned into disposal packages preventing any contact with water for specified durations (e.g. several hundred thousand years for the copper containers in the Swedish and Finnish geological disposal design).

Top: The SFR geological disposal facility for operational nuclear power plant waste in Sweden

(Photo: Swedish Nuclear Fuel and Waste Management Company (SKB), Sweden)

Bottom: Host formation for deep geological disposal of the Finnish spent nuclear fuel inventory

(Photo: Posiva Oy, Finland)

IAEA Division of Radiation, Transport and Waste Safety and IAEA Division of Nuclear Fuel Cycle and Waste Technology