Decommissioning of Nuclear Facilities

Overview

All nuclear facilities need to be decommissioned when they reach the end of their operational life. This involves the decontamination and full or partial dismantling of buildings and their contents to achieve an agreed end-state consistent with the overall site end state.

Once a facility has been shut down, there is typically a transition phase during which the facility is prepared for decommissioning. This is often referred to as POCO and includes removing any readily accessible radioactive and hazardous materials and contaminated equipment. Liquids are also drained from pipes and tanks.

During this transition phase, facilities may also be decontaminated, which means removing radioactive contamination present on surfaces. Decontamination typically makes the later stages of decommissioning easier and safer by reducing hazards to operators, and reduces the total volume of radioactive waste arising. However, the design of the facility may mean that such decontamination is not possible until it is dismantled.

After a nuclear facility has been decontaminated as much as possible, it can be dismantled and, depending on the proposed end state, demolished. Sub-surface structures such as drains would normally require excavation, particularly if contaminated.

Remediation may also be required to manage any areas of contaminated soil or groundwater to ensure the protection of people and the environment during the next use of the site.

Decommissioning may be carried out immediately following permanent facility shutdown and transition or may be deferred for a predetermined period.

Decommissioning of whole facilities produces large volumes of material, including concrete, brick, steel and soils. Much of this material is non-radioactive and can be managed in the same way as conventional demolition waste, but requires careful monitoring to ensure that it is radiologically and chemically compliant with disposal criteria.

Responsibility for decommissioning

The NDA has been established to manage the decommissioning of the UK's civil nuclear legacy. This legacy comprises a wide range of facilities, including reactors, chemical plants, research and development facilities, and waste processing and fuel fabrication plants.

Owners of the current fleet of commercial reactors and other nuclear facilities are responsible for making arrangements for decommissioning when their facilities reach the end of their operational life. In the case of new build, initial plans for decommissioning must be presented to the regulator as part of the authorisation process to demonstrate practicability and that the design has been optimised to reduce volumes of radioactive waste arising in the future.

Hazard and risk reduction

Decommissioning activities are carried out to achieve a progressive and systematic reduction in risk to people and the environment resulting from radiological, chemical, biological and industrial hazards associated with a facility. Where the risks are considered 'intolerable', urgent action is taken to reduce these risks.

All sites need to plan their decommissioning activities to ensure that the greatest hazards are reduced as a priority.

Undertaking decommissioning activities typically introduces new conventional hazards, for example the use of cutting tools, which must be considered in decommissioning plans.

Decommissioning strategies

Decommissioning may be carried out immediately following permanent shutdown and transition, or may be deferred for a predetermined period. The deferral period can range from a few months to several decades depending on the size and complexity of the site programme and the decommissioning project, the purpose of deferral and the proposed end-state.

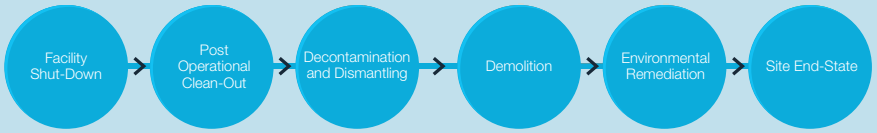
A deferred decommissioning strategy may be preferred to take credit from the radioactive decay of shorter lived isotopes (reducing the radiation hazard) or to

manage constraints such as the availability of waste management infrastructure or resources. However, delay is not always beneficial as some radionuclides decay to radioactive products that are more hazardous than the original material.

Many redundant nuclear facilities in the UK are relatively small and present only a low hazard. For such facilities the timing of decommissioning will typically depend on the overall site strategy and programme, taking account of resource availability.

Stages in decommissioning

There are several stages involved in decommissioning a nuclear facility, depending on whether a continuous or deferred decommissioning strategy is followed. Most of these stages will result in some radioactive waste being produced.



The above diagram illustrates the general stages involved in decommissioning a nuclear facility; a period of deferral, typically referred to as Care and Maintenance, may be taken between any of these stages. The level of work involved in each stage and the order of work is dependent upon the nature of the facility and the agreed Site End State. Not all steps will be involved for all facilities, some activities may occur in parallel (at the same time) and some steps may be repeated.

Environmental remediation is part of land quality management, which includes activities undertaken during operations and decommissioning, such as the prevention of leaks, characterisation and radiological and/ or chemical monitoring.

Transition from operations to decommissioning

POCO involves removing the vast majority of radioactive and hazardous materials from the building.

This typically involves draining all liquids from tanks and pipework both to remove mobile radioactivity and to reduce the risk of blockages due to solids precipitation; chemical cleaning or simple flushing may also be appropriate. All accessible and non-fixed radioactive sources, contaminated components and materials would be removed as far as practicable. By their nature, the wastes arising from the transition phase are generally similar to those that arise during normal operations.

As an alternative to decontamination, residual contamination may be fixed by use of special coatings to reduce the risk of it becoming airborne.

If a decision is taken to defer decommissioning, further preparation may be required according to the period of deferral. This may include the removal of equipment and large components, such as gloveboxes. Such components may be sent off site to specialist facilities for decontamination, allowing the steel to be recycled.

Ancillary buildings outside of the main facility, such as offices, stores and laboratories, may be decontaminated and, if required, demolished during this stage.

Care and Maintenance

The deferral period may last many decades and is often known as a period of Care and Maintenance or Care and Surveillance.

The key activities that will take place during this period are environmental and condition monitoring and any essential maintenance work to provide assurance that the building and other structures remain safe. Another essential element is the maintenance of records that describe the status of the enclosed facility. The proposed decommissioning plan will be subjected to ongoing review and update, such that decommissioning can recommence efficiently and effectively. It will also be necessary to control access to the site/ facility.

Few radioactive wastes will be produced during the store period except for items that have been used for monitoring and maintenance in active areas.

Decontamination and dismantling

Decontaminating a facility involves the complete or partial removal of radioactive substances or material from surfaces, or from within a system or item. This reduces the magnitude of radioactivity within a facility, which may facilitate decommissioning (e.g. allowing man access for further dismantling), reduce the period required before dismantling, minimise the volume of radioactive waste arising, and increase the potential for recycling and reusing components.

Simple chemical and mechanical cleaning techniques are often sufficient to decontaminate surfaces. They are likely to generate secondary wastes (e.g. swabs and wipes) that will need to be managed.

Coatings designed to fix loose particulate contamination in place are typically rubber-like materials designed to be stripped from the base material, removing the contamination.

Dismantling is carried out to reduce the size of components so that they can be removed more easily and placed in waste containers. A range of different techniques can be used for dismantling and include mechanical cutting techniques, such as shears and saws, to thermal cutting techniques using torches and lasers. These tools can be operated manually or remotely using robotic systems to minimise the exposure of workers to radiation and particulate contamination.

It is not always practical to fully decontaminate a building/plant items before it is dismantled, so further decontamination of resulting waste items may be appropriate to minimise the volumes of radioactive waste.

Demolition and final site remediation to achieve agreed end state

After dismantling the internal structures, systems and components within a facility, the building structures will require radiological and often chemical monitoring. The building structures may also require further decontamination before reuse or being demolished according to the proposed end state. Demolition is usually carried out using conventional techniques but with additional monitoring for radioactivity.

Depending on the planned use of the site, further work may be required to remediate any ground and groundwater contamination. This would typically involve removing contaminated soil and buried structures, such as foundations and pipe-lines. Other controls may be required where the end-state does not require removal of all residual contamination:

- breaking the pathway between contamination and sensitive receptors for example using physical barriers, or
- using the process of 'monitored natural attenuation' to monitor the natural degradation of contaminants over time

As with the decommissioning of conventional industrial sites, it may also be appropriate to use institutional controls, such as land use restrictions, to manage risks to people and the environment from residual contamination.

Site End States

Most NDA site has an agreed Site End State. The Site End State sets out the high-level remediation objectives for the site, considering the land's next planned use or probable future uses.

For many NDA sites, the Site End State is not scheduled to be achieved for many decades, so it is important to ensure that there is flexibility in the long term site decommissioning and remediation plans.

A wide range of issues could affect the proposed Site End State, such as changes in policy and regulations, advances in technology and changes in the desires of a community through generations.

It may not be realistic or even necessary to remediate a site to its natural pre-industrial condition. Therefore, for some sites, remediation work will focus on preparing the site for future industrial uses.

Radioactive wastes produced during decommissioning

In terms of volume, the majority of radioactive waste produced in the UK arises from later stage decommissioning activities, where large building structures are dismantled and demolished, and land is remediated. However, the greatest amount of radioactivity is typically associated with the materials removed during the POCO stage, and the secondary wastes generated from decontamination activities.

These wastes will often be categorised as ILW and may include liquids and sludges. Other wet materials such as ion-exchange resins (used to remove contamination from liquids) may also require treatment and disposal. These mobile wastes will typically be mixed with cement to make a solid material, and either disposed promptly as LLW; or ILW will be stored on the site until a disposal route is available.

Large volumes of material will be produced when the buildings are finally demolished and the site remediated. This will be in the form of building rubble, concrete, soil and steel items. Most, if not all, of this demolition material is not radioactive and so can be managed in the same way as conventional demolition rubble, and would preferentially be reused or recycled.

Some of the demolition material may be contaminated with low levels of radioactivity, and require treatment and disposal as LLW or VLLW.