Applying decommissioning experience to the design and operation of new nuclear power plants

by P. O'Sullivan, C. Pescatore and I. Tripputi*

The NEA Working Party on Decommissioning and Dismantling (WPDD) has recently undertaken a study on current approaches to applying experience from decommissioning to the design and licensing of third generation reactor systems. This study was motivated by the increased interest in several NEA countries in embarking on new nuclear power plant construction programmes relying on these reactor systems.

A report is being prepared based on information provided by regulatory authorities, electricity producers and reactor design organisations concerned with the development and implementation of new reactor systems. Initial information was provided in response to a survey whose results were subsequently discussed at a WPDD topical session in the presence of the survey respondents and of representatives of the Western European Regulators' Association (WENRA), FORATOM and the IAEA's Waste Technology Section.

The study's final report is expected to be published during 2009. Main findings are outlined hereafter.

Overview

Experience from decommissioning projects suggests that the decommissioning of nuclear power plants could be made easier if this aspect received greater consideration at the design stage and during operation of the plants. Better forward planning for decommissioning results in lower worker doses and reduced costs. When appropriate design measures are not taken at an early stage, their introduction later in the project becomes increasingly difficult. Hence, their early consideration may lead to smoother and more effective decommissioning. This has prompted national authorities and electricity producers to demand that decommissioning needs be addressed from the design stage and that preliminary decommissioning plans be provided as an input to the licensing process.

Reflections on good practice

Preliminary decommissioning plans

In recent years, it has become commonplace that decommissioning plans are developed at an early stage, subsequently revised as necessary throughout the lifetime of a nuclear installation and resubmitted periodically for approval by the competent national authorities. Together with conceptual strategies for dismantling the installation, these plans typically

* *Mr. Patrick O'Sullivan (patrick.osullivan@oecd.org) and Dr. Claudio Pescatore (pescatore@nea.fr) work in the NEA Radiological Protection and Radioactive Waste Management Division. Mr. Ivo Tripputi (tripputi@sogin.it) works at SOGIN in Italy. He is the Chairman of the NEA Working Party on Decommissioning and Dismantling.*

discuss the management of waste arising from decommissioning operations, the intended end state of the site and related environmental issues, and are used as a basis for showing that adequate financial provision for decommissioning is being made. This trend is, in turn, leading to greater emphasis being given to associated issues such as the choice of materials for construction, provisions for ease of maintenance and dismantling, providing means for limiting contamination and the definition of national clearance levels.

Decommissioning plans should address, at an appropriate level, the necessary design provisions in order to minimise the creation of radioactive waste, by limiting and controlling activation and contamination, and facilitating decontamination; to simplify dismantling and equipment handling; to enable onsite management of materials and waste; and to facilitate site release.

Elaborating the dismantling sequence at the design stage may be very beneficial in identifying design improvements beneficial to decommissioning, and hence in reducing uncertainties on dismantling costs. A clear strategy for minimisation of radioactive materials will also be very helpful in reducing waste management costs.

Overlap between operating and decommissioning requirements

An important priority for utilities is that the design provide for optimal operation and maintenance (O&M) of the facility. Design features that support O&M work will invariably also be beneficial for later decommissioning tasks. Good design practices for both O&M and decommissioning include: providing ample space for the activities being undertaken, minimisation of doses during these activities, minimisation of waste quantities, keeping plant contamination levels low, providing adequate handling capability and making provision for replacement of components. Minimisation of waste arisings is achieved, for example, through careful selection of materials and by incorporating features to limit the spread of potential contamination to clean areas and systems.

In addition to consideration being given to the nuclear island, attention should also be given to the overall balance of the plant, as areas which are difficult to access could later give rise to problems during decommissioning. In general, it is good practice to submit the entire plant to a structured review from the perspective of decommissioning.

Designing for decommissioning

Although many design requirements aimed at improved O&M will also be beneficial for decommissioning, there are nonetheless certain design considerations that need to focus directly on plant decommissioning and dismantling. Design provisions specific to decommissioning include designing structures for long-term stability and including features aimed at minimising infiltration, containing spills and releases, and retarding contaminant transport. Decommissioning experience to date suggests that greater consideration should be given to identifying the key components of particular reactor systems that are directly related to decommissioning and to defining the boundaries of these systems, regardless of the decommissioning strategy.

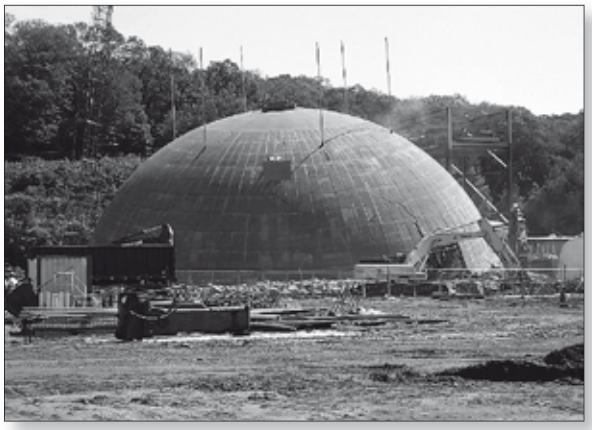
Current good practice is to implement technical provisions that circumvent the use of embedded piping, for example by routing piping in accessible areas such as dedicated pipe tunnels or trenches, or by using double barriers for all pipes traversing concrete walls or floors. Leaks in embedded piping are difficult to locate and may lead to larger amounts of waste and longer outages during plant operation. At the same time, potential radiation doses from unshielded piping need to be addressed in designing the provisions for radiation protection.

Careful optimisation of design provisions for decommissioning with those of "downstream" waste management, including making provision for facilities and space for onsite management of waste, may be expected to yield benefits in terms of reducing radiation exposure of the workforce and decommissioning costs.

Plant record systems and plant configuration management

Early consideration should be given to the needs of plant configuration management, including developing systems for maintaining records of the physical configuration of the plant on an ongoing basis. Experience from recent decommissioning projects suggests that plant records may sometimes be incomplete or inaccurate, and consequently may not reflect the final plant configuration. Plant management systems should be designed to include, in addition to those records that are directly relevant to operation, other records that might be important for decommissioning. For example, information on temporary openings made during construction may facilitate the reuse of these accesses during decommissioning.

The development of 3D models as part of the design process provides a useful management tool throughout plant operation, including for showing how configuration control can be maintained during sequential dismantlement and for visualising the locations of sources of activity to help assess where samples should be taken for radiation monitoring.



Connecticut Yankee, United States

Demolition of the containment building of Connecticut Yankee nuclear power plant.

It is good practice to retain records of the original composition of steel and concrete materials used in the plant (including technical specifications), as knowledge of any impurities may be important for future decommissioning and can reduce the extent of material characterisation that is ultimately needed. Materials used for the construction of neutron shields are of special importance. In particular, it is beneficial at the design stage to specify the allowable range of cobalt levels in steel, as well as seeking to reduce cobalt levels in absolute terms, as quantities of certain other radionuclides are often estimated from the cobalt levels. Overall, this will facilitate management of radionuclide inventories.

Plant monitoring systems

It is good practice to provide monitoring systems for early detection of leaks and contamination, including leaks from underground piping (environmental monitoring). Providing means for monitoring plant chemistry parameters, with the objective of minimising corrosion of metallic components, is also desirable. Plant operators need to give particular attention to recording this information, as such contamination may otherwise only be identified during demolition of the concrete structure.

Towards greater standardisation of design requirements

The design guidelines established by the electricity producers (as clients) provide an essential link between past experience and the design process. These guidelines need to be developed taking account of discussions with designers about what features can reasonably be delivered.

In Europe, the main electricity producers have developed standardised requirements intended to ensure that all reactor designs for the European market incorporate certain basic design features, including making provision at the design stage for waste minimisation and component removal. The European Utilities' Requirements (EUR) for light water reactors (see www.europeanutilityrequirements.org/) address in particular aspects such as material selection for reduced dose rates, good surface finishing to facilitate decontamination of materials and providing easy accessibility for removal of plant components. It is understood that the Utility Requirements Document (URD) of the Electric Power Research Institute (EPRI) will be updated to provide equivalent requirements in the coming years.

Regulators have also begun developing standardised requirements, for example through the Safety Reference Levels (SRLs) for decommissioning and waste management being developed by WENRA for use in Europe. Central to these requirements is the development of a preliminary decommissioning plan prior to the issuing of a construction licence, and the updating of this plan throughout the lifetime of the nuclear facility. The plan should take account of a safety assessment for decommissioning that is also updated periodically during the life of the facility.

Making decommissioning experience available to reactor designers

The need to incorporate dismantling lessons both at the design stage and during the whole life of a facility could be better fulfilled if dismantling experience were systematically collected, analysed and recorded. It is clear that design organisations are making positive efforts to take greater account of decommissioning needs in the design of new plants. At the same time, with some important exceptions such as the US Nuclear Regulatory Commission, it seems that there have been few systematic attempts to capture the lessons from dismantling experience, and it is not clear that there is a systematic process for integrating these lessons into the design of new plants.

An important consideration here is that, within utility and regulator organisations, the areas of design, operation, and dismantling and decommissioning are often handled by different departments. Sometimes, the responsibility is even assigned to different organisations altogether, requiring special attention to be given to co-ordination of information transfer between the different groups. The NEA study has provided an opportunity for regulators, utilities and design organisations to share their different perspectives and experience on how requirements for decommissioning should be reflected in new plant designs. ■