ACHIEVING MORE WITH LESS

TECHNICAL GUIDANCE FOR MINIMIZING RADIOACTIVE WASTES

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At a time when environmental and financial issues greatly affect industrial operations, the efficient operation of nuclear facilities and the management of associated wastes have taken on added importance. One key issue that has emerged in the decision-making process focuses on ways to minimize radioactive wastes, in the interests of holding costs down. Yet focusing on cost considerations alone can oversimplify the issue, and could entail other drawbacks, especially in the field of radioactive waste management where many factors are involved and the timing of decisions is important.

In its technical documents, the IAEA defines waste minimization as "a concept which embodies the reduction of waste with regard to its quantity and activity to a level as low as reasonably achievable". However, this definition does not describe the complexity of waste minimization, which is an integral part of a wider and comprehensive waste management and safety culture that aims at efficiently reducing radiological and environmental impacts of generated wastes.

An improper waste minimization strategy could be "a coin with two faces" – it may offer financial savings, but it also can introduce new hazards or modify those already associated with the facility. In each approach to waste minimization, the cost gain must always be compared with other factors, especially those related to the safety of operators and the general public.

This article presents an overview of major technical aspects involved in efforts to minimize wastes, and it points out considerations that should be taken into account in the decision-making process. The main focus is on the operation and decommissioning of nuclear power plants, since these activities are major sources of radioactive waste and are expected to have the greatest potential to achieve success in waste minimization policy and techniques. The relevant waste minimization approaches could also be applied by other waste producers.

ASSESSING THE PICTURE

Waste minimization encompasses organizational, technological, and economical aspects. Each project should therefore be carefully assessed considering individual conditions and circumstances. The type of assessment that needs to be made, the level of detail to which the assessment is taken, and the thoroughness of reviews by internal bodies and/or regulatory authorities should be related to the significance of the changes involved. Of course, some types of waste are clearly more problematical than others and their generation should be avoided at any cost. One typical example is radioactive wastes which are simultaneously chemically toxic, often identified as mixed waste.

The real benefit from waste minimization projects is proportional to their complexity and scope. The highest effectiveness can be expected from national or company projects covering one or more nuclear facilities and/or from the systematic implementation of improvements in radionuclide applications.

The following components are usually considered in the planning and implementation of complex, more significant waste minimization projects: waste minimization strategy; reduction of waste sources; and minimization of waste volumes for storage or disposal.

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Waste minimization strategy. A strong requirement for waste minimization arises from the generally accepted principal objective of radioactive waste management: "...to deal with radioactive waste in a manner that protects human health and the environment now and in the future without imposing undue burdens on future generations" (*The Principles of Radioactive Waste Management*, IAEA Safety Series No.111/F, 1995). This rule is properly reflected in most of the relevant IAEA documents and also in basic regulatory and legislative documents in IAEA Member States.

A waste minimization strategy should be established to serve as a conceptual basis for co-ordinated planning and implementation of desired measures. The following topics, among others, may be covered:

Administrative considerations. These include the legislative basis for waste management and waste minimization, including proper and sound waste clearance and discharge policies; identification of responsibilities and commercial arrangements between utilities and waste managers; economic assumptions (economic support, tax rates, discount rates); the quality assurance system; and qualification and training of staff.

Technical and safety considerations. These include the power plant capacity and performance, reactor type, location; design principles of the nuclear facility and individual components; the expected operational lifetime of facilities; the waste conditioning strategy (national and also facility-specific); and the waste disposal strategy, scale, type and location of storage and disposal facilities.

Reduction of waste sources. The most straightforward method for lowering waste processing and disposal costs is to reduce the generation of wastes in terms of volume and activity at the source. The most proactive way is to consider the means of waste minimization during the definition of design and construction specifications of new facilities. Reviewing and changing existing practices at operating facilities also can significantly reduce the waste generation. A significant reduction of waste can be gained by considering potential decommissioning procedures as early as during the design stage as part of steps to properly plan the decommissioning operation.

Considering waste minimization requirements in the design and construction phase of nuclear facilities may have a direct impact on future waste production during both operational and decommissioning periods. The main design-related technical options are:

- the proper choice of materials (resistance to corrosion, high-quality surface treatments, low tendency to activate and/or produce radionuclides that may cause problems);
- application of the most effective, reliable and up-to-date technology to assure that equipment will remain operable as long as possible without replacement and/or maintenance;
- high performance of components and prevention of unintended accumulation of waste, and minimization of leakage/drainage to avoid repairing active components and producing additional waste; and
- strong separation of active and non-active media and segregation of active media according to their nature and activity.

Decommissioning of nuclear facilities is a source of extremely large volumes of radioactive waste, most of them classified as low- or intermediate-level waste. Moreover, a large part of them belong to the category called "very low-level waste". The volume contribution of intermediate- and high-level waste is comparatively small, roughly below 5%. The generation of decommissioning wastes can be significantly reduced through the application of proper decontamination techniques; the rigorous segregation and separation of the waste flow streams; the recycle and reuse of selected metals and construction materials; and the establishment and implementation of proper clearance and discharge policies.

At nuclear power plants, the coordinated efforts of operators over the last 10 years have enabled large reductions – by a factor of four to five when measured by volume and by a factor of ten when measured by total activity – in the production of operational wastes. The largest potential benefit from waste reduction efforts can be expected in the decommissioning phase. The main reason is that about 75% of waste from dismantling could be categorized as very low-level waste, which would have a high potential for clearance from regulatory control.

Typical practical steps that can contribute to the reduction

of operational radioactive waste generation are to:

- limit the number and size of the controlled areas and identify all points in the working areas and all stages in the process where it is possible to prevent material from becoming radioactive waste;
- establish waste accounting and tracking systems to quantify sources, types, amounts, activities and characteristics of waste;
- apply recent technological processes (good operational practice) and modify maintenance and refurbishment procedures leading to waste reduction;
- reuse recovered materials (e.g. boric acid, special metals, fission material) to reduce waste generation and decrease operational costs;
- recycle and reuse liquids within the process (such as decontamination solutions and laundry water) to reduce the volume and potential environmental impact of discharged liquids;
- establish a system of sorting waste and separating waste streams to prevent improper mixing and to assure more efficient characterization and subsequent processing;
- establish a rigorous system for segregation of non-active and active contaminated waste in the controlled area; and
- increase the flow of information among staff regarding waste reduction philosophies, techniques and improved methods, and emphasize the training of staff in waste reduction practices.

These procedures are oriented mostly to the reduction of waste generation by operators of large nuclear facilities. Nevertheless they are fully applicable as well to small users of radionuclides.

Minimization of waste volumes for storage or disposal. Storage and disposal costs are often the main, though not the single reason, for operators to reduce the volume of generated wastes. In the face of public and political opposition to construction of facilities, for environmental or other reasons, the effort to maximize the use of space in existing storage and disposal facilities has taken on added importance for waste management organizations.

Various treatment and conditioning techniques enable substantial reduction in the final volume of conditioned waste.

One technique is to store waste materials for sufficient time periods over which their radioactivity levels decay. It is commonly used for reduction

Photo: The reactor vessel head of a prototype reactor in Germany was cut during dismantling operations. Proper planning of reactor decommissioning can lead to a large reduction in wastes.

of waste from short-lived radioisotope applications, and to a certain extent for waste from nuclear facilities in operation or being decommissioned. This approach could simplify and increase the effectiveness of subsequent waste treatment and/or conditioning processes, or lead to the waste's clearance from regulatory control. Reduction of radioactive waste volumes by natural decay is one important factor leading to the selection of a deferred dismantling strategy for decommissioned nuclear facilities.

Another technique is to recycle and reuse metals, as well as some types of civil construction materials (concrete), arising from the refurbishment and decommissioning of nuclear facilities. The main economic benefit arises from savings achieved in avoided disposal costs, rather than through the material's reuse or recycling directly. The same reasoning applies to the melting of metal scrap, through which significant reductions in waste volumes are achieved.

For certain types of wastes, advanced methods of processing can be applied to reduce waste volume and to meet regulatory requirements for its storage and/or disposal.

For large volumes of highly diluted aqueous waste containing radiochemical and chemical contaminants, advanced membrane and micro-filtering processes are being developed. At the Los Alamos National Laboratory in the United States, for example, a new integrated membrane filtration system was developed to treat about six to ten million litres of liquid radioactive waste. The titanium-dioxide microfiltration system yields a higher concentration factor over the previous treatment method, reduces chemical usage, and provides high-quality effluent water for discharge.

Membrane methods also can be applied for the treatment of complex waste containing various proportions of organic components. They can serve as an efficient alternative method to more complicated high-temperature, catalytic and biodegradation methods used for the decomposition of organic compounds.

Other methods build upon the use of incineration and supercompaction, which are most widely applied to reduce the volume of solid radioactive wastes, offering reduction factors of more than ten. Through the combined incineration of solid waste and many types of low-level organic wastes, some specific problems can be resolved. For example, used oil and ion exchange resins can be transformed into stable, homogenous mineral forms suitable for final conditioning and disposal.

TIMELY GUIDANCE

Throughout nuclear energy's development, technologies and methods have been developed for the effective management of radioactive wastes, including their minimization. Recent years have seen further advances in processing techniques and practices designed to save costs and meet regulatory requirements that are becoming stricter for environmental and other reasons.

As part of its work in the field, the IAEA has issued a number of technical reports on various aspects of radioactive waste management, including minimization strategies and practices.* To achieve real benefits from strategies to minimize radioactive wastes, a full evaluation of all available options is needed from environmental, economic, and technical perspectives.

Over the coming years, the cooperative exchange of technical experience will have to remain an important element of radioactive waste management programmes, as more nuclear facilities become candidates for decommissioning and new technologies are developed for processing different types of waste streams. ❐

*These reports include *Factors Relevant to the Recycling or Reuse of Components Arising from the Decommissioning and Refurbishment of Nuclear Facilities* (TRS-293); *Planning and Management for the Decommissioning of Research Reactors and other Small Nuclear Facilities* (TRS-351); *Status and Technology for Volume Reduction and Treatment of Low- and Intermediate-Level Solid Radioactive Waste* (TRS-360); *Assessment and Comparison of Waste Management System Costs for Nuclear and Other Energy Sources* (TRS-366); *Minimization of Radioactive Waste from Nuclear Power Plants and the Back End of the Nuclear Fuel Cycle* (TRS-377); and *Characterization of Radioactive Waste Forms and Packages* (TRS-383).