WASTE MANAGEMENT

Introduction

The sound management radioactive waste starts by reducing the waste production during the whole lifetime of any nuclear installation from the design phase, through the operation phase and ending by the decommissioning of the nuclear installation. Therefore, we are developing an interactive database covering the inventory of the nuclear installations and ensuring the traceability of the waste. We are also developing processes to reduce the amount of radioactive waste produced by the exploitation and the decommissioning of nuclear installations and to deliver a concentrated fraction of radioactive materials that can be conditioned in the most adequate manner. Because the safe management of radioactive waste in other countries is also our concern, we are still extending our participation in international organizations and programmes dealing with these problems.

Objectives

The main objectives of the sound management of radioactive waste are:

- to reduce the impact of the waste to the stakeholders, the public and the environment;
- to develop a management tool allowing to identify waste problems and to optimise decommissioning strategies;
- to perform decommissioning activities in a safe and economical way;
- to manage waste in a safe and economical way according to the legal rules;
- to develop treatment/conditioning processes (up to the demonstration phase) minimizing the risks, the volumes and costs of nuclear waste.

Tool for waste management and decommissioning

According to the new national recommendations setup by the National Agency for Radioactive Waste and fissile material (NIRAS/ONDRAF), our multi-entry model computing the decommissioning costs has to be upgraded. The upgrading concerned the part covering the physical and radiological inventory of nuclear installations. Many efforts were paid to the modelling of the activation of BR1 reactor structure material i.e. graphite (moderator and reflector of the BR1 reactor) and heavy concrete (material of the reactor bunker). This modelling allows to precise the material streams coming from the future dismantling and in particular the part of the concrete walls which could be free-released. At the same time, a new estimation of the liability fund of each SCK-CEN nuclear installation, including waste already transferred in the past to NIRAS/ONDRAF and spent fuel management, has been performed. The comparison between the results obtained in 1995 and these of 1999 allows us to conclude that globally the costs of the decommissioning works realized during the period 1995-1998 are in good agreement with the budget estimated 5 years before.

We are now updating our multi-entry model to address more adequately the aspect of the secondary waste produced by the decommissioning activities and to setup a new tariff for the decommissioning costs based on 10 years practice. Our model will be used to setup a new release of the SCK-CEN decommissioning plan and the initial decommissioning plan of the Thetis reactor (University of Ghent).

Decommissioning activities

The decommissioning activities performed this year were:

- the preparation of the hot cell 41 in view of its future decontamination;
- the dismantling of the old GSB infrastructure in the BR2 facility;
- the preparation of glove boxes in the Chemistry building in view of its future dismantling in the Central Buffer Zone;
- the dismantling of the waste piping at BIO-labo;
- the dismantling of the waste collector tank K8 at BR1.

Scrap metal has been recycled and/or decontaminated according to their radiological and geometrical characteristics.

Processes related to nuclear fuel

The recovery of fissile material from residual fresh-fuel solutions allows maximising recycling of nuclear material and minimising waste production. As in previous years SCK-CEN treated, also in 1999 about 200 l of analytical residues from Belgonucléaire. This resulted in about 15 kg recovered and documented mixed oxide that will be returned to the client.

The Japanese Institute of Research and Innovation (IRI) is developing an advanced wet-reprocessing process that includes partitioning of minor actinides...
and long-lived fission products. On their request we tested in 1999 the first step of this process. A simulated spent fuel solution with uranium, plutonium, americium, neptunium and typical fission products was separated on a column filled with AR-01, a new type of anion exchanger. The results were sufficiently promising to start the preparation of an experiment with real spent fuel that will be carried out in 2000.

Processes related to tritium

SCK•CEN invented and demonstrated the feasibility of measuring very low anaerobic corrosion rates in a relatively short time by using tritiated water. Modelling and optimisation resulted in a simple design that should allow measuring corrosion rates as low as a few nanometers per year, within a period of a few weeks or less. Several measuring cells have been constructed and the results of the tests are promising.

Mixed waste is both radioactive and hazardous for other reasons. Conditioning and disposal is generally not possible without pre-treatment. SCK•CEN owns an amount of tritiated liquid organic waste. We intend to convert it into tritiated water, which can be further conditioned and stored, and in carbon dioxide, which can be discharged. In 1999 an appropriate infrastructure has been realised that should allow a controlled and safe handling of this volatile, highly flammable, toxic and highly radioactive material. A combination of direct combustion and catalytic afteroxidation, developed and tested by Ontario Power Technologies Canada, will assure the very high conversion rates that are required for environmental reasons. Condensation and adsorption on molecular sieves will trap the tritiated water. Processing of the waste will start in 2000.

Processes related to boron

SCK•CEN invented and developed a process for boric acid separation during evaporation, which is especially useful for nuclear power plants. Up to now, interest came mostly from East-European countries, which produced and continue to produce large amounts of boron containing waste but which lack money for a successful implementation of our process.

When existing evaporators are difficult to adapt, such as in Belgium, separation of boric acid from evaporator concentrates appears more interesting. The feasibility of this process has been demonstrated but in the absence of direct financial support, further development has been slowing down.

Oxidation and direct conditioning of contaminated metallic sodium

Among the sodium treatment processes that have been previously applied in other countries, none appears to be intrinsically safe. Therefore, SCK•CEN has conceived and patented a new process that allows carrying out the safe treatment and conditioning of alkali metals. Its design is based on the suppression of potential accidents (fire and explosion) that are inherent to the manipulation of alkali metals. The design is also integrated (i.e. it takes the conditioning of the final product into account). On the other hand, the process is developed to solve the internal problem of sodium treatment at SCK•CEN. In 1998, during the very first experiments, the oxidation and carbonation of metallic sodium was successfully achieved in a dedicated fluidised bed, using a once-through argon flow. In 1999, and for safety purposes, a gas circulation loop was designed and constructed, allowing the recycling of the fluidisation gas. The new installation was successfully tested at room temperature as well as in nominal operating conditions. The measurement of the pressure drop across the reactor allowed confirming previous calculations of the minimum fluidisation velocity. Technical achievements also include the study of the behaviour of the sodium injection line (pressure drop, determination of suitable operating conditions) and the preliminary design of the local controllers that will be used in the process control system.

The theoretical heat exchange through the fluidised bed reactor is now qualitatively described. During sodium injection, the heat exchange involves 3 modes, including a radiative component, a convective one and a conductive one. Depending on the age of the solid particles inside the reactor, one of these 3 modes of heat transfer is predominant. For newly formed particles, having the highest temperatures, the heat exchange is mainly radiative, while for elder particles with lower temperatures, the heat exchange is ensured by convection and conduction. In 2000, the modelling of the fluidised bed reactor will continue. Some experiments including the simulation of sodium injection will be carried out, to facilitate the model validation. The process control will be enhanced, through the automation of the installation. For this purpose, adequate local controllers will be either purchased or conceived and constructed. They will be installed and tested on line. The process will be demonstrated on a larger scale (injection of 1 to 10 kg of Na).
Complete oxidation of organic waste by electrochemical mediation

Organic waste represents a problem in terms of conditioning and safety under disposal conditions. The electrochemical mediation by Ag⁺ is a safe and environmentally friendly alternative to the incineration process. In 1998, we successfully demonstrated on a lab scale a new method to remove any NO₃ evolution in the cathodic compartment of the electrolysis cell. This success led us to consider seriously the development of a mobile installation for the on-site treatment of contaminated organic waste. Moreover an experimental campaign was launched in order to validate a theoretical model describing the anodic selectivity as a function of the process variables, which will allow us to optimise the working conditions and the overall yield.

In 1999, a new design for the silver(II) process has been conceived, including the improvements related to the removal of the NO₃ production. Its theoretical feasibility with respect to our mobility and safety requirements has been demonstrated by developing a simulation program, which will be further used for complementary implementations of the process and its control. In this way, the dimensioning of the installation supplied with 30 kA and handling up to 7 l/h CH₃OH has been carried out. This new approach is very attractive since the mobility of the installation is an incentive for potential clients to adopt the technique, thereby avoiding the costs associated to the dismantling of a static plant. Meanwhile, we have developed a dedicated low cost process control apparatus allowing the on-line monitoring of the required chemicals. Some other developments are in progress, concerning particularly the treatment halogenerated compounds (PCB ...) and the on-line recovery of AgX precipitates. These results should allow us to extend the application field of our process to the non-nuclear industry. We are applying for a patent concerning to financially supporting our interdisciplinary research on the edge of biotechnology and electrochemistry/electricity.

Selective separation of Co out of decontamination effluents

When stainless steel is chemically decontaminated by the MEDOC process, the effluents contain high amounts of Fe, Ni and Cr, and a relatively small amount of α-Co. However, this α-Co represents the main radioactive load (> 95 %) of the effluents. Since the removal of this Co would decrease considerably the specific activity of the main effluent stream, a process to selectively withdraw Co (i.e. without extracting Fe, Ni and Cr) is being developed, keeping the pH of the solution low enough to avoid precipitation (less than 4). The selective complexation process for Co under the rather extreme conditions that we are developing is based on the use of very specific organic molecules. An extensive literature study has shown that a first alternative to approach the problem is to produce the ligands through organic synthesis in our laboratory. On international scale, the research concerning the synthesis of these suitable ligands is in its infancy. Research at SCK•CEN on the synthesis of these ligands is presently going on. When compared to the international state of the art, our results indicate that we have already made considerable advances in the required synthesis. A second approach to separate cobalt selectively is mainly based on biotechnology in which the selective ligands are produced by biosynthesis of microorganisms. The future research will focus on the organic synthesis of the ligands (synthesis characterisation and testing of the ligand, process design). It will also focus on the biosynthesis of Co-free selective ligands for Co, and on the applicability of the biochemical process using a BICMER reactor in the acidic conditions of the decontamination effluents (in collaboration VITO and ULg). Meanwhile, an exploratory investigation of embedded dead cell membranes will also be carried out. EDF is presently considering to financially supporting our interdisciplinary research on the edge of biotechnology and electrochemistry/electricity.

Decontamination of concrete

In the framework of collaboration with WTCE/CSTC, a study concerning an electokinetic method for the non-destructive decontamination of concrete was started. Specific ligands for Co were added to a suitable electrolyte, which was forced into concrete prior to applying an electric field. The preliminary tests showed that when applying an electrical potential to a wetted concrete cylinder, no or only a very small fraction of the cobalt present in the concrete could be extracted. On the other hand, a significant fraction (20-30 %) of the caesium could be extracted. Changing the composition of the electrolyte or changing the voltage did not have a significant influence on this behaviour. Preliminary cation exchange - capacity experiments showed that large amounts of cobalt are strongly bound to the solid.
Further research should concentrate on the comparison of the used samples and real time contaminated concrete.

**Partners**

WTCB/CSTC. Wetenschappelijk en Technisch Centrum voor het Bouwbedrijf/Centre Scientifique et Technique pour la Construction

ULg. Université de Liège (contact: Prof. Remacle)

VITO. Vlaams Instituut voor Technologisch Onderzoek (contact: Roger Leysen)

NRIRR. National Research Institute for Radiobiology and Radiohygiene (contact: Prof. Lajos Gazso)

NTUA. National Technical University of Athens (contact: Prof. Marios Tsezos)

FZ Jülich Forschungszentrum Jülich

CNAM. Conservatoire National des Arts et Métiers Paris (contact: Prof. Micheline Draye)

MIT. Massachusetts Institute of Technology (contact: Ken Czerwinski)

Ontario Power Technologies, Canada (OPT)

**Sponsors**

FRIA, EDF, Institute of Research and Innovation, Japan (IRI)

**Customer**

Belgonucléaire, Belgium

ONDRAF/NIRAS (as manager of the Technical Liability Fund)