A JOINT BNFL/TOSHIBA APPROACH FOR THE OPTIMISATION OF RADIOACTIVE WASTE MANAGEMENT

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ABSTRACT

The key objective in radioactive waste management is to optimise the overall waste management system from waste generation through to disposal. To achieve this a number of criteria are utilised against which optimisation is evaluated including minimum lifetime costs and optimum volume of waste whilst maintaining maximum safety.

BNFL and Toshiba Corporation are working together to combine their expertise and experience in waste management to provide an enhanced capability. This paper describes the joint approach being undertaken by BNFL and Toshiba addressing international radioactive waste aimed at helping the global nuclear industry play its role in meeting global environmental targets.

The importance of considering the final disposal requirements such that treatment processes are optimised to produce directly disposable products is a key part of BNFL/Toshiba's strategy. To this end the team are drawing on the experience gained by UK Nirex in the development of repository scenarios for the UK. The benefits of this approach are described in the paper.

The combined experience of BNFL/Toshiba is being applied defining the overall strategy for a large number of waste streams. These include operational wastes from reactor systems and the treatment of decommissioning wastes.

INTRODUCTION

Nuclear fuel cycle operations around the world have resulted, and continue to result, in the production of a complex range of waste streams. These wastes have arisen from fuel cycle services such as fuel production, reactor operations, reprocessing operations and decommissioning activities. Environmentally friendly, cost effective solutions to deal with such wastes are essential if Nuclear Energy is to play its part in meeting global environmental targets.

THE JOINT BNFL/TOSHIBA APPROACH

BNFL and Toshiba have been working together to develop an optimised radioactive waste management strategy for the international reactor waste management and decommissioning market. The key objective in radioactive waste management is to optimise the overall waste management system from waste generation through to disposal. To achieve this a number of criteria can be utilised against which optimisation is evaluated including minimum lifetime costs and optimum volume of waste whilst maintaining maximum safety and minimum environmental impact.

By combining BNFL's experience in the field of waste treatment and disposal technologies with Toshiba's knowledge of LWR design, construction, commissioning and radioactive waste treatment systems the BNFL/Toshiba team have an in-depth understanding of the key issues and are able to offer enhanced waste treatment solutions.

The BNFL/Toshiba strategy is based on the systematic approach to waste management, which was developed, initially by BNFL as part of the overall UK Waste Management Strategy, and is now being adopted by BNFL/Toshiba for wastes generated in the Japanese Nuclear Industry.

The systematic approach forms an integral part of a process which:

- Takes account of lifetime implications (safety, dose uptake, discharges, cost and risk)
- Enables progress to be assessed
- Allows plans to be updated in response to changes in business operations
- Can be continually applied to waste management policy in order to optimise waste management plans.

The BNFL/Toshiba systematic approach comprises the following key elements:

1. Identification and characterisation of waste streams including inventory, scheduling and routing options
2. Definition and evaluation of treatment and immobilisation options based upon pre-determined criteria.
3. Storage and transport requirements
4. Identification and assessment of disposal options

The systematic approach to waste management leads to minimum cost and risk by providing a logical order of events and ensuring the necessary decision making information is available when required. The BNFL/Toshiba strategy takes account of the importance of conditioning waste to meet storage and transport requirements and to fulfil anticipated disposal requirements.

In the UK BNFL has worked with the UK regulators, and NIREX, the deep disposal agency to ensure all products arising from current waste treatment processes will be acceptable for disposal in any future repository. Thus waste is processed only once, minimising costs and secondary waste production.

The BNFL/Toshiba partnership draws on the strengths of both partners to provide evaluation from waste source through waste treatment to disposal. Toshiba are able to provide the evaluation of the operational and decommissioning wastes arising from LWRs. The team is able to, jointly evaluate the treatment options and by working closely with UK Nirex, both as a partner and through BNFL's shareholder relationship, is able to provide an evaluation of disposal needs.

WASTE CHARACTERISATION

Pivotal to developing a waste strategy for reactor and decommissioning wastes is a detailed inventory of the waste arisings and the timescales of these arisings.

Toshiba have over a number of years developed a detailed inventory of operating and decommissioning waste arisings from LWRs (PWR, BWR). Operational wastes can be broadly categorised as:

- Concentrated waste
- Spent resin and sludge
- Miscellaneous waste
- Ash

Whilst decommissioning wastes are broadly categorised as:

- Metallic
- Concrete

PRECONDITIONING OF WASTE

Many TRU waste streams, which are equivalent to the UK's intermediate level waste ILW, would require significant pre-conditioning prior to encapsulation to produce homogenous products. The BNFL/Toshiba strategy ensures all suitable technologies are evaluated against given criteria and the optimised solution selected.

Waste reduction in particular reduced life cycle costs is a primary objective of the strategy. In addition to activities aimed at reducing waste generation at source, a key area within waste reduction is waste volume minimisation. Specific technology development programmes contributing to waste minimisation include:

- Selective compaction of hulls waste
- Improved encapsulation matrices
- Engineered transfer systems for handling alpha active materials
- Dewatering, drying and compaction of slurries
- Improved sorting and categorisation of wastes
- Incineration
- Decontamination and metal melting

DECONTAMINATION AND METAL MELTING

BNFL's metals recycling low-level waste melter facility started operation in 1994. The plant was initially designed to volume reduce ~ 3000te of residual metals mainly aluminium with some copper, cupro nickel and steel from the BNFL's Gaseous Diffusion Plant at Capenhurst. When used alone, melting is a very efficient method for significantly reducing volumes of wastes destined low level waste disposal. When used in combination with wet or dry decontamination, it has the potential to yield materials suitable for free release and un-restricted re-use.

BNFL Metals Recycling has been set up to offer the UK nuclear industry proven techniques and facilities for commercial use at Capenhurst. In the UK, BNFL hopes to attract business from current decommissioning projects which will generate significant quantities of low level, slightly contaminated and suspect clean metallic scrap. R&D and engineering support continues to improve and refine existing decontamination and melting processes.

ENCAPSULATION OF WASTE

As a result of an extensive R&D programme started in the 1980's BNFL has adopted cementation for the encapsulation of TRU and certain LLW.

A major programme has been undertaken by BNFL over the past decade to implement the TRU strategy for waste cementation. This has involved R&D work relating to the encapsulated product and the conditioning processes. The product evaluation programme was structured in a number of phases and covered over 30 TRU types. In excess of 30 properties have been evaluated at small and full scale using non-active simulants. Where appropriate active small-scale trials have been undertaken. More details of the individual properties are described elsewhere (1).

To guarantee successful encapsulation in cement it is essential to understand product stability. A number of key parameters have been established as very important by BNFL to meet waste storage and disposal requirements:

- Behaviour and properties of the cement raw materials
- How the wastes interacts with the cements
- Effects of scale up
- Design and control of the encapsulation process

Over the past 18 years BNFL has developed two basic processes for the encapsulation of TRU, although other options have been evaluated. These are grouting for solid wastes and in-drum mixing

using a lost paddle for slurries and sludges. Solid wastes are encapsulated by infilling the voidage between the waste with a fluid grout. The solid wastes range from discrete pieces such as fuel cladding to massive items including supercompacted wastes. Liquid and slurry waste are incorporated into the cement matrix.

Five cementation plants have been planned for the encapsulation of TRU at Sellafield. The first four plants were designed and built by and are in active operation with the final plant due to be commissioned within the next few years. The current facilities encapsulate all arisings of TRU generated from reprocessing operations at Sellafield with the final plant being planned to deal with historic arisings.

BNFL's Magnox Encapsulation plant has over the past 8 years processed 10,000 drums and has achieved 97% efficiency, the Waste Encapsulation Plant (Figure 1) which processes waste arising from the THORP plant has for the 1000te fuel processed by THORP produced 900 product drums. In addition since 1993 historic wastes have also been retrieved from silos and encapsulated. Over 14,000 fully active packages have been produced and are stored in engineered facilities prior to ultimate disposal.

Figure 1 BNFL's Waste Encapsulation Plant at Sellafield

ENCAPSULATION OF SLURRIES

Historically, reactor wastes, slurries i.e. concentrated liquid waste, spent resin and sludge have been treated by one of three systems developed by Toshiba for reactor systems:

- Solidification systems using conventional cements
- Plasticization systems
- Pelletisation systems

In addition asphalt solidification systems have been used for reactor wastes.

Toshiba's knowledge of reactor wastes and BNFL's encapsulation experience is now being combined to develop superior grouting systems. BNFL and Toshiba have recently undertaken a programme of work to develop a sand/cement grout system to treat low level waste arising from reactor sites in Japan.

The aim of the programme was to produce a grout that was capable of infilling miscellaneous solid waste and hence required a very high fluidity but did not exhibit bleed water following curing. The solid product then had to demonstrate suitable strength development during the assessment period.

The initial work was undertaken in the United Kingdom, with the BNFL team being complimented by a research engineer from Toshiba. The team was able to produce a grout that was capable of meeting all of the Japanese regulatory requirements by using an organic additive (Superplasticiser) to modify the grout fluidic properties.

The work was extended to produce a formulation envelope that would be suitable for plant operation and that could be suitably adopted for use in Japan. This work has now been demonstrated, in Japan, by Toshiba and BNFL.

A final report has been produced by Toshiba and BNFL and is currently held in the Japanese Diet Library (2 and 3).

DISPOSAL OF WASTES

BNFL owns and has operated its Low level Waste disposal repository, Drigg, since the late 1950's. Drigg is the UK national repository accepting waste from BNFL's operating sites, UK universities and hospitals.

BNFL has in-house skills to support the authorisation and licence to operate for the Drigg site. These skills include site characterisation, environmental software development, risk assessment and safety case preparation. In addition BNFL owns and operates experimental facilities that are equipped to provide input data for the environmental models.

UK Nirex have over the past 15 years developed expertise and technologies for assessing TRU repositories to determine the long term consequences of underground disposal.

UK Nirex are able to undertake detailed geological assessments, determine the behaviour of waste packages and environmental barriers in repository environments over a long period of time and understand the effects of climate change on the repository. This expertise is available to the team both through a collaboration agreement between BNFL Engineering Ltd and through BNFL's Nirex shareholding.

BNFL's practical experience with real sites together with Toshiba's knowledge of the Japanese regulatory conditions will be combined to give a team uniquely positioned to and capable of developing repository strategies and scenarios specific to the Japanese market.

As part of Japans R&D programme investigating repository scenarios Toshiba have been developing a series of special cements that will ensure the containment of radionuclides under repository conditions.

Toshiba's R&D programme is focussed at:-

- Ensuring a monolithic product by selecting materials to reduce hydration heat.
- Selecting materials to ensure alkaline conditions in the repository are maintained over a long period of time.
- Inhibiting radionuclide migration from the repository by selecting suitable cement admixtures and through the addition of materials such as zeolites to adsorb the radionuclides.
- Optimising the materials and blend ratios for given disposal environments.

The cements have been developed with distribution coefficients that ensure the migration of specific radionuclides is controlled and therefore the nuclides are contained by the cement environment rather than the disposal environment. Table 1 shows Toshiba's results and demonstrates their ability to produce cements with the ability to inhibit radionuclides migration.

Table 1 Distribution Coefficient

Nuclide	Cement for Process Waste	Filling Motar	Concrete of Disposal Facility	Toshiba Cement
Co-60	100	700	100	1000
Ni-63	300	400	80	900
Sr-90	30	10	10	30
Tc-99	0.5	0.3	0	4
I-129	2	0	0	50
Cs-137	3	30	30	100
Eu-152	-	-	-	100000
Pu-239	10000	10000	10000	100000

CONCLUSIONS

The BNFL/Toshiba Waste Management Strategy is based upon a systematic approach. The strategy ensures an optimum solution for waste management is adopted from waste generation through to final disposal.

The knowledge and experience in waste management of both BNFL and Toshiba are brought together to provide a team which is well positioned to develop enhanced waste management solutions which are applicable to a wide range of waste streams.

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