Packaging Options for AWE Hydrodynamics Experiment Vessels (Pre-Conceptual stage)

Summary of Assessment Report

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Introduction

This is a summary of an assessment carried out by Nirex in response to a request from the Atomic Weapons Establishment (AWE) for advice on the packaging options for Hydrodynamics Experiment Vessels which are used on the Aldermaston site.

During the course of experiments these vessels become contaminated to intermediate level waste activity levels and AWE has requested Nirex input to the development of packaging options which will lead to disposable waste packages.

This Assessment Report summarises the work carried out by Nirex at the Pre-Conceptual stage to examine practical packaging options for these vessels, concentrating on a new generation of vessel currently under development.

Background

The Nirex mission is, in support of Government policy, to develop and advise on safe, environmentally sound and publicly acceptable options for the long-term management of radioactive materials in the UK. This includes all intermediate-level radioactive waste and some low-level radioactive waste (ILW and LLW). As part of this role, Nirex sets specifications and standards for the packaging of ILW and some LLW, based on its Phased Geological Repository Concept (PGRC)[1].

Nirex issues Letters of Compliance when the proposed packaging methods are judged to be capable of producing waste packages that would be consistent with Nirex requirements for long-term management and protection of the environment. This process is intended to minimise the risk of inappropriate treatment, the need for future repackaging and the creation of a new legacy of wastes to be dealt with by future generations, with all the attendant safety, environmental and cost implications. The process of obtaining a Letter of Compliance is embedded in the regulators' arrangements for the conditioning and packaging of ILW, as described in the guidance issued by the regulators[2,3].

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1 *The Nirex Phased Disposal Concept*, Nirex Report N/074, July 2003.

2 *Improved Regulatory Arrangements for the Conditioning of Intermediate Level Radioactive Waste on Nuclear Licensed Sites: Provision of Advice to the Health and Safety Executive by the Environment Agency and the Scottish Environment Protection Agency*, Regulators' Position Statement, December 2003.

3 *Conditioning of Intermediate Level Radioactive Waste on Nuclear Licensed Sites: Provision of Advice by the Health and Safety Executive, the Environment Agency and the Scottish Environment Protection Agency*, Guidance to Industry, March 2005.

Following acceptance of the recommendations of the Committee on Radioactive Waste Management (CoRWM) and the decision by Government that Nirex should be incorporated into the Nuclear Decommissioning Authority, Government has signalled that the UK should pursue the development of deep geological disposal for intermediate and other long-lived wastes. The Government response explicitly notes that wastes should be immobilised and converted to passively safe forms consistent with the needs of transport and geological disposal.

Nirex assessment of waste packaging proposals through application of the Letter of Compliance process provides the perspective on transport and disposability as required by regulators and as recently confirmed by Government. It should be recognised that the Nirex disposability assessment is one input to a wider consideration of the Best Practicable Environmental Option and ALARP (as low as reasonably practicable) justification that AWE will be required to produce as part of their interactions with regulatory bodies under nuclear site licence arrangements.

Hydrodynamics Experiment Vessels

Amongst the techniques employed by AWE Aldermaston to confirm the performance of nuclear warheads are hydrodynamics experiments that study the behaviour of materials when subjected to explosive shock.

The bulk of these trials use non-fissile materials such as tantalum, lead and depleted uranium to simulate plutonium, but necessarily some trials have to utilise plutonium itself. Although the amounts of fissile material involved are far below anything that can produce a chain-reaction, the data the trials provide are used to validate the predictions made using the simulant materials.

On occasions when fissile material is used, the experiments are conducted within robust spherical vessels of approximately one metre in diameter, made of thick high quality steel. These massively robust vessels are used to contain the materials and a variety of techniques are used to monitor and measure their performance when subject to explosive forces. After such an experiment using fissile materials, the complete vessel and its contents is stored on site as Intermediate Level Waste.

AWE is currently commissioning a new Hydrodynamics Research Facility which will use a new design of Hydrodynamics Experiment Vessel. This new vessel (the Phase II Vessel) is larger than its predecessor and AWE has requested specific input from Nirex on disposability issues and in particular on measures for packaging the Phase II vessels to meet packaging standards.

Technical Assessment

Nirex packaging standards have been designed to act as preliminary waste acceptance criteria for the generic deep geological repository, and guide waste packagers to production of waste packages that will be compliant with transport arrangements and disposal as defined by the Phased Geological Repository Concept.

All waste packages need to meet minimum standards for performance and handling as these will impact the various transport and repository safety cases. In the case of Hydrodynamics Experiment Vessels, Nirex assessment has determined that the following characteristics will be significant as conditioning proposals for the Vessels are developed:

- Activity should be immobilised and converted into a passive safe form. This can be achieved by use of cement grouts or organic polymers to form matrices in which the activity is distributed.
- The amount of fissile material within each waste package will need to be controlled within limits dictated by criticality safety cases for the various phases of waste management i.e. on-site storage, transport, repository operations and finally for the post-closure phase of disposal.
- The Hydrodynamics Vessels will need to be packaged in such a form that they can be efficiently and safely handled through the transportation system and be accepted for disposal at the planned repository. This is normally achieved through the use of standard waste containers into which the wastes are loaded and conditioned. In some special cases, it may be appropriate to utilise a non-standard waste package where it can be shown that this will convey overall waste management advantages.

The existing Phase I Hydrodynamic Experiment Vessels are of a size that they can be packaged into a standard $3m^3$ Box and apart from the generic waste packaging issues identified above, are not considered further within this Pre-Conceptual assessment.

The Phase II Hydrodynamics Experiment Vessels are larger and will not fit within the standard $3m^3$ Box. Nirex assessment has considered a number of options involving varying degrees of size reduction and use of different standard and non-standard boxes. Each of these options has a number of advantages and disadvantages and the Nirex assessment is offered as an input to AWE's continuing option development.

Options considered include:

- Segmenting the Vessel and packaging in a number of $3m^3$ Boxes. If the segmented Vessel was distributed amongst four Boxes then the fissile material per box would be controlled and criticality cases considerably eased. The Option would also give flexibility to future changes to Vessel design.
- Removing the stand, tertiary and outer-closure and reducing the Vessel diameter by machining flats across the widest section. Reduction of the diameter by 100mm would enable the vessel to be loaded into a standard $3m^3$ Box, although further consideration would need to be given to lidding arrangements.
- Removing the stand, tertiary and outer-closure of the Vessel and packaging in a non-standard square-plan $3m^3$ Box of increased height. This package would need to be transported in a special Type B[4] transport container denoted the SWTC-150.
- Removing the stand, tertiary and outer-closure of the Vessel and packaging in a variant of the non-standard MBGWS[5] Box. This is a square-plan container slightly larger than the standard $3m^3$ Box. The SWTC-150 is a transport container concept proposed to suit the MBGWS Box, but has not been developed to date.
- Transport and disposal of the intact Vessel without packaging into a Nirex container. The Vessel would be loaded into a handling and stacking stillage which could be

[4] Type B transport container is defined within IAEA Transport Regulations, which form the basis of UK transport legislation.

[5] Miscellaneous Beta Gamma Waste Store – a facility at Sellafield which uses a special MBGWS Box.

designed to be compatible with transport and emplacement systems. Removal of the tertiary-closure and stand would facilitate transport within the SWTC-150.

All options should be subject to internal grouting (or use of other matrix material) and apart from the stillage option, grouting of the Vessel into the disposal container. This would be required to meet package specification criteria relating to immobilisation and minimisation of loose particulate and internal voidage.

The use of organic polymer to provide the conditioning matrix could also be considered due to the presence of reactive metals within the Vessels. This would minimise the rate of corrosion of the reactive metals but may cause the generation of hydrogen from radiolysis of the organic polymer and potential degradation of the polymer matrix.

The vessel contents tend to be concentrated at the base of the vessel after an experiment. Any internal grouting or polymer encapsulation operation should include a means of distributing this material throughout the grout to achieve a more homogeneous distribution of waste within the container. Because of the particulate nature of the vessel contents and the associated loose radioactive contamination, the use of inert void fillers is unlikely to be an option for this waste.

Safety assessments for transport, repository operations and post-closure have identified that control of fissile material and demonstration of compliance with criticality safety cases will require further consideration and potentially specific safety cases to address the particular features of the Hydrodynamics Experiment Vessels.

In the case of transport, a design safety report will be required to define the transport package and to demonstrate compliance with Transport Regulations and UK transport legislation. Consideration will need to be given to the means by which information on the contents of the Hydrodynamics Experiment Vessel is generated and compliance with design safety report is demonstrated.

Conclusions

All waste packages need to meet minimum standards for performance and handling as these will impact the various transport and repository safety cases. Evaluation of Hydrodynamics Experiment Vessels has concluded that the following waste package characteristics will be important:

- Activity should be immobilised and converted into a passive safe form.
- The amount of fissile material within each waste package will need to be controlled within limits dictated by criticality safety cases for the various phases of waste management.
- The Hydrodynamics Vessels will need to be packaged in such a form that they can be efficiently and safely handled through the transportation system and be accepted for disposal at the planned repository.

Options which lead to homogeneous distribution of activity within a conditioning matrix are preferred from transport and disposability considerations. This can most readily be achieved by decontamination or segmenting options, although options involving in-vessel grouting (or polymer addition) may also prove to be acceptable, especially if they include steps to achieve mixing of the activity within the matrix.

Options which utilise standard waste packages, compliant with Nirex packaging standards, are preferred. These afford the maximum flexibility for future management phases and minimise development and acceptance risks to AWE.

Options which utilise non-standard packages can be considered, but carry additional uncertainties and will require investment by AWE to develop and qualify the disposal containers. Non-standard containers, where used, will need to meet the same performance criteria as standard packages. Some of the non-standard container options could utilise the SWTC-150 transport container concept. This container has not been developed beyond the concept stage and it is unclear whether there will be a need for the container from other users; AWE may be the only user and therefore solely responsible for development costs.

Nirex assessment of the Hydrodynamics Vessels provides a perspective on transport and disposability as required by regulatory arrangements. It is recognised that the Nirex disposability assessment is one input to a wider consideration of BPEO and ALARP that AWE will be required to address as part of nuclear site licence arrangements.