

## Packaging of Sellafield Zeolite Skips

### (Conceptual stage)

#### Summary of Assessment Report

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### **Background**

British Nuclear Group Sellafield Ltd (BNGSL) has sought Conceptual stage endorsement for the packaging of “zeolite skips”, currently stored in the Magnox Fuel Storage Pond and Decanning Facility at Sellafield. Zeolite skips are 1m<sup>3</sup> enclosed steel skips containing pellets of zeolite, a natural ion exchange material. The zeolite skips were originally introduced to the facility after problems were encountered with build-up of radioactive caesium-137 (Cs-137) levels in the pond water. The zeolite selectively removed caesium from the pond water, reducing worker doses and radioactive discharges to the environment.

This document summarises the results of the assessment carried out by Radioactive Waste Management Directorate of the Nuclear Decommissioning Authority (NDA RWMD) in response to the submitted proposals to condition and package zeolite skips for long-term management. The assessment has been carried-out as part of the Letter of Compliance process, whereby NDA RWMD examines the disposability of the proposed waste packages by assessment against Intermediate Level Waste (ILW) packaging standards and the underpinning Phased Geological Repository Concept (PGRC). Further information on the Letter of Compliance process is available elsewhere<sup>1</sup>.

A Conceptual stage disposability assessment has been conducted and this Assessment Report produced.

### **Scope of the Proposals**

The Magnox Fuel Storage Pond and Decanning Facility was constructed in 1958 to replace the Pile Fuel Storage Pond as a fuel storage and de-canning pond at the Sellafield site. During its operation, the Magnox fuel was passed through to reprocessing plants after decanning at the pond. Routine operations in the Magnox Fuel Storage Pond and Decanning Facility pond ceased in 1986 when the Fuel Handling Plant took over operational de-canning and fuel storage. The last transfer of fuel was made in July 1998.

After problems were encountered with build-up of Cs-137 levels in the pond water, zeolite skips were introduced. The pond water was circulated through enclosed skips containing the zeolite. The zeolite selectively removed caesium from the pond water, although is also expected to have removed particulates of sludge by filtration. The skips contain a central separator plate, with zeolite packed on both sides. Mesh screens at the top hold the zeolite in place and a top plate containing two pumping ports encloses the compartments. These ports were used to accommodate the pumps which circulated pond water through the skips.

The zeolite originally consisted of clay bonded cylindrical pellets (1.5mm diameter x 4.5mm long) of a porous synthetic zeolite known as AW500. AW500 comprises a Chabazite structure of the approximate composition  $\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2 \cdot n\text{H}_2\text{O}$ .

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<sup>1</sup> *Guide to the Nirex Letter of Compliance Process*, Nirex Document WPS/650, June 2006.

The waste forms the whole of stream 2D13 identified in the UK Radioactive Waste Inventory. It has been assumed that the pumps form a component of another waste stream, Legacy Ponds miscellaneous beta-gamma waste.

### ***Historical Proposals***

It should be noted that proposals for packaging zeolite skips and a variety of other pond wastes, including miscellaneous beta-gamma waste, fuel residues and isotope cartridges, were made during the 1990's. Advice on the historical proposals to package these wastes at the Box Encapsulation Plant was provided by Nirex, most recently in 1998. Current proposals for packaging the zeolite skips represent new proposals, which supersede the originals.

Of particular relevance is the Best Practicable Environmental Option (BPEO) study for treatment of zeolite skips commissioned by British Nuclear Fuels (BNFL). The BNFL study concluded that an annular grouted package, i.e. one in which the zeolite skip was placed whole into a disposal box and the "annulus" (the space around the skip) filled with cement grout, could be developed to be accepted for disposal. Such a package concept could, according to the study, be designed to facilitate "rework" should this be needed in the future. The report also recommended that the packaging objective should be to achieve a very high standard of containment and integrity of the package, so as to maximise the likelihood of the package being acceptable for disposal.

### ***New Packaging Proposals***

The current proposal which NDA has been asked to advise on involves the following steps. The skip would be retrieved from its pond position, and washed externally to remove loose adhering sludge. A drainage hole would be drilled as low as possible in the side of the skip. The skip would then be transported to the encapsulation plant in a water-filled shielded flask. At the encapsulation plant the skip would be removed from the flask, and water drained from the skip back into the flask. The skip would be placed centrally within a standard 3m<sup>3</sup> Box, and the skip entombed within the box using a three stage grouting process.

The grouting process would comprise pumping grout into the top of the skip to fill the internal void space and then filling the annulus space around the sides of the skip to a depth of approximately 500mm. Once set, this would anchor the skip to the base of the box and would prevent flotation. A second pour of grout would be added after the first pour has cured. This second pour would entomb the zeolite skip up to the level of the top of the skip. This second pour would be allowed to cure and any bleed water removed. A third pour of the same grout would form a capping layer.

After curing of the third grout pour, the box would be moved to a lidding station and the lid fitted. The box would be swabbed for contamination, and washed if necessary. The box would then be moved to an on-site store.

### ***Assessment of Disposability***

The disposability assessment conducted by NDA RWMD considers the proposed waste packages for compliance with the Phased Geological Repository Concept (PGRC). This is achieved by assessing the proposed waste packages against waste packaging standards and published generic safety assessments that address transport of waste packages to the repository and safety of operations at the facility. The wastes and packages are also assessed against the generic post-closure performance assessment.

## ***Assessment Inventory***

The Assessment of Disposability is based upon information provided by BNGSL in the submission documentation, enhanced where possible by NDA RWMD.

The submission and references report a skip sampling exercise undertaken involving three of the zeolite skips within the pond in March 1987. Samples were extracted from the skips and subjected to radionuclide, chemical and physical analysis techniques. Operational records for the uptake of caesium from the pond by the three skips have also been reported to NDA RWMD, and have proved useful to assist in development of an assessment inventory.

The information provided by BNGSL gives a general impression of the radiochemical inventory of the zeolite skips in 1987 and has enabled an assessment inventory to be developed. The analysis also showed little degradation of the pellets of AW500, with much of the smaller particulates present in the samples arising from fuel element corrosion sludge filtered out of the pond water by the zeolite bed. However, even though the three skips sampled were selected for their differing histories, they only represent just greater than 1% of the skips in the pond. More significantly, it is also unknown whether radionuclides have continued to be adsorbed by the zeolite from the pond water since 1987, or conversely whether radionuclides have been lost.

The information whilst acceptable for a Conceptual stage assessment needs to be improved for the Interim stage LoC submission, to give confidence that the indicative inventories provided are indeed realistic. New dose rate measurements may be required, to provide confidence that radionuclides have not continued to be adsorbed and that the maximum waste package assessment inventory is realistic and bounding. Use of further skip operational data, where this is available, may also improve confidence in the assessment inventory. Further sampling of the zeolite skips is unlikely to be justified given the limitations in the data that would be generated.

## ***Proposals for Waste Characterisation and Records***

BNGSL has made a commitment that all requirements in respect of data recording will be satisfied and that further details will be available at the Interim stage submission. NDA RWMD would expect that full data recording proposals be generated for the Interim stage LoC, and welcomes the commitment to discuss development of such proposals prior to future submissions. However, at this stage NDA RWMD would expect outline proposals to have been provided. Data recording methods and techniques need to be developed in parallel with waste retrieval and packaging processes and at the Conceptual stage NDA RWMD want to be assured that the proposals are practicable and can deliver a disposable package together with the necessary data records. The lack of data recording proposals will prevent the issue of a Conceptual stage Letter of Compliance at this time. In this Assessment Report, methods of generating a waste package inventory have been suggested.

## ***Waste Container***

The design of box to be utilised for the zeolite skips has not been specified in detail at this stage, but is proposed to be a version of the standard corner-lifting 3m<sup>3</sup> Box being developed for use on Sellafield site. BNGSL has agreed to seek formal endorsement of the box design once prototype testing and performance modelling is complete and prior to procurement.

## ***Transport Safety***

The assessment of Transport Safety showed that it should be possible for the proposed packages of zeolite skips to comply with all relevant transport safety criteria if transported in a Type B transport container with 285mm thick walls, such as the SWTC-285 (Standard Waste Transport Container). This assumes that the assessment inventory developed by NDA RWMD is bounding, and that waste characterisation methods are developed which can

allow compliance with transport requirements to be demonstrated. It further assumes that no free liquids remain within the skip.

### ***Operational Safety***

The assessment of Operational Safety showed that it should be possible for the proposed packages of zeolite skips to be handled and stored safely within a repository based on the PGRC. The public and worker doses are estimated to be below the Basic Safety Limit (BSL) specified in the new HSE criteria for design basis accidents<sup>2</sup>, although they are just above the Basic Safety Objective (BSO) for both public and workers. It should however be noted that the Generic Operational Safety Assessment toolkit makes conservative assumptions on accident scenarios, release fractions and exposure routes.

This positive conclusion is based on the assumption that the simple model for assessment of impact accidents which has been developed at this stage, and which suggests good protection of the skips by the entombing grout, is providing a reasonable indication of actual performance. Further modelling work and impact testing to confirm this position will be required to support an Interim stage LoC.

This conclusion also assumes that the skip will drain pond liquor successfully. There is no evidence available at this time that a single hole in the skip will result in complete drainage of pond liquor. The Generic Operational Safety Assessment (GOSA) supporting the PGRC does not include consideration of free liquids that may either be released during normal operations or during faults such as impacts. As a result, it has not been possible at this stage to judge the significance of retention of pond liquor in the skips. To provide endorsement based on the existing GOSA and PGRC design it has been concluded that evidence needs to be provided that skips will drain, and can be demonstrated not to contain potentially releasable pond liquor. An alternative, but more involved longer-term strategy, could be to estimate the potential quantities of liquors and associated radionuclide inventory that could be released under normal or accident conditions, and address the consequences for the GOSA.

### ***Post-Closure Safety***

Overall, the post-closure assessment has not identified any issues that would prejudice disposal of zeolite skip packages.

### ***Generic Waste Package Specification***

In addition to meeting safety criteria for disposal within the PGRC, the proposed packages are expected to meet the quantitative requirements of the NDA Generic Waste Package Specification (GWPS). This assessment has concluded that they may not comply with the qualitative objectives regarding:

- minimisation of voidage;
- immobilisation of radionuclides, as particulates and free liquids;
- ensuring packages exhibit progressive behaviour with increasing impact severity;
- whether best practicable means have been employed for containment of water-soluble radionuclides within the waste package have been employed.

With regard to the latter point, there is insufficient data available from BNGSL to assist NDA RWMD in determining whether best practicable means for containment of water-soluble radionuclides within the waste package have been employed in the package design. Before endorsement of the proposals can be considered, BNGSL will need to work with the NDA RWMD on this latter requirement, to show how the package is expected to perform and to

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<sup>2</sup> *Safety Assessment Principles for Nuclear Facilities*, HSE, 2006 Edition.

demonstrate that best practicable means have been employed to contain soluble radionuclides.

### ***Requirements for Further Work***

To progress the proposals at the Conceptual stage, it is necessary for BNGSL to:

- develop outline data recording proposals applicable to the zeolite skip;
- provide evidence and arguments that skips can be successfully drained and demonstrated not to contain releasable pond liquor at the time of transport to the repository;
- work with the NDA RWMD to demonstrate that best practicable means for containment of water-soluble radionuclides within the waste package have been employed in the package design.

Further activities required for later stages of endorsement are also identified within the Assessment Report, through a series of Action Points. These points include activities to improve the confidence in the skip radionuclide inventory, requirements for completion of product development work and testing including simulant impact modelling and tests.

### ***Policy***

The 2003 regulatory position statement on conditioning of ILW<sup>3</sup> recognises that it may not be practicable to demonstrate compliance with all aspects of the waste package specification, but three successful outcomes from a disposability perspective may nevertheless enable the issue of a Letter of Compliance. These are:

- (a) all criteria are met;
- (b) it is demonstrated that it is not necessary to meet all criteria;
- (c) it is not possible to meet all criteria now, but credible plans are in place for future re-work schemes to produce a disposable product.

In the case of the zeolite skip proposal it would appear that endorsement via route (b) may be possible. On this basis, even though the packaging proposals may not represent good packaging practice, it is concluded that a case for disposability could potentially be made, assuming the requirements for further work identified above are completed successfully. The NDA RWMD would need to present the arguments for endorsement to the NDA RWMD Waste Management Advisory Committee (WMAC) to seek independent advice prior to concluding whether a Conceptual stage Letter of Compliance can be provided.

### ***Conclusions***

The Conceptual stage submission from BNGSL for the retrieval and packaging of Sellafield zeolite skips has been assessed. It has been concluded that a Conceptual stage Letter of Compliance cannot be provided at this time. To progress the proposals it is necessary for BNGSL to:

- develop outline data recording proposals applicable to the zeolite skip;
- provide evidence that skips can be successfully drained and demonstrated not to contain pond liquor at the time of transport to the repository;
- work with the NDA RWMD to demonstrate that best practicable means for containment of water-soluble radionuclides within the waste package have been employed in the package design.

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<sup>3</sup> *Improved Regulatory Arrangements for the Conditioning of Intermediate Level Radioactive Waste On Nuclear Licensed Sites*, Regulators' Position Statement – December 2003, SEPA/HSE/EA.

It is concluded that the proposed waste package will not comply with some qualitative requirements of the Generic Waste Package Specification. Notwithstanding this it is judged that a case for disposability can nevertheless potentially be made. Regulatory guidance accepts that endorsement via issue of a Letter of Compliance can be provided in cases where it is not necessary to meet all of the specification criteria. On this basis, even though the packaging proposals may not represent good packaging practice, a case for disposability can potentially be made. Once the developments above are successfully completed, the NDA RWMD will present the case for package disposability to the NDA RWMD Waste Management Advisory Committee to seek independent advice, prior to concluding whether a Conceptual stage Letter of Compliance can be provided.

The consistency of the proposed waste packages with the PGRC is typically demonstrated through the provision of an Assessment of Disposability. Such an assessment has been provided, highlighting where disposal requirements have been met. This could be developed further when the above issues are resolved or at future LoC stages. It should be noted that significant additional development work has been identified for the proposed product.

Due to the high inventory and novel processing proposals, it is judged that this proposal would be assigned priority<sup>4</sup> Category W, as defined in the regulators guidance for the management of radioactive waste on nuclear licensed sites, February 2007.

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<sup>4</sup> Category W is defined as projects or modifications regulators will wish to consider and assess in most cases .