

Packaging of Sellafield Magnox Storage and Decanning Facility Sludge

(Conceptual stage)

Summary of Assessment Report

Issue date of Assessment Report: 21 October 2005

Introduction

This is a summary of an assessment carried out by Nirex in response to a Conceptual stage proposal from British Nuclear Group Sellafield Ltd for retrieval and packaging of sludge from the Sellafield Magnox Storage and Decanning Facility.

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 standards and specifications for the packaging of ILW and LLW, based on its Phased Geological Repository Concept (PGRC). Nirex issues Letters of Compliance (LoC) when the proposed packaging methods are assessed 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 or 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.

In line with regulatory guidance, Nirex carries out independent assessment of the specific waste packaging proposals in particular to assess disposability of the proposed waste packages by consideration of requirements for future storage, transport and disposal as embodied in the Nirex PGRC.

British Nuclear Group's Proposals for Sellafield Magnox Storage And Decanning Facility Sludge

The Magnox Storage and Decanning Facility takes the form of a fuel storage pond, a series of adjacent bays used mainly for underwater decanning of fuel and two dry decanning caves above the level of the pond and bays. It was constructed in 1958 and routinely operated until 1986 when its replacement, the Fuel Handling Plant, was commissioned. The pond primarily processed Magnox fuels but also some less common materials. The facility entered the post-operational clean-out phase of decommissioning in 1992. However, fuel is still stored within skips in the pond, and some skips have toppled and their content partially displaced onto the pond floor. Fuel cladding and some of the fuel has corroded to form a sludge, which is present within the skips and on the pond floor. The bays now contain miscellaneous solid wastes mixed with sludge. One of the bays was used as a settling tank to collect sludge, including some receipts from the pond Rotary Skip Wash (RSW). The washing and tumbling process of the RSW produced fuel fragments, some of which would have passed the

Washers 12mm screen, and sludge in this bay has higher fuel content than sludge in other areas of the pond.

A key focus now is to complete the clean-up of the facility by retrieval and packaging of the sludge and removal of the solid items including the skips and fuel. Proposals for treatment of the solid waste items will be made separately. In the case of the sludge it is proposed to retrieve most of it from the pond and bays and store it within buffer storage tanks prior to onward processing. Production of packages is likely to start after 2010. A new packaging plant will be built, currently called Sludge Packaging Plant 1 (SPP1). Upon retrieval from the facility, the dilute sludge would be filtered through a 5mm screen to remove large pieces of metals and other debris. The filtered dilute sludge would then be partially de-watered by gravity settling. After a period of interim storage in the buffer tanks, batches of sludge would be received by the packaging plant from the buffer vessels and will undergo a more sophisticated secondary de-watering process, the details of which are to be defined. The de-watered sludge would be loaded into small sacrificial cans and the cans compacted, which would remove excess air and form a cohesive solid product. The compacted cans would be loaded into a new design 3m³ Box, which will differ from the current standard Nirex box design. A significant feature of this box would be a double skin with a cement grout infill to form an annulus. This would provide additional protection to the waste in the event of dropped load impact accidents or external fire accidents. The voidage around the compacted cans will be infilled with a cement grout to form a monolithic solid wasteform within the box.

The new box design is specific to the Sellafield Legacy Ponds and Silos projects, and some aspects of detailed design will be tailored to meet each project's requirements. Its design is already advanced, but requires finalisation and testing, and is commonly referred to as the Legacy Ponds & Silos (LP&S) Box. The LP&S Box is currently not a standard Nirex Box design. The box differs from the standard Nirex box in that it has stacking posts located at the corners rather than mid-face, a double stainless steel skin with grout infill to form the annulus rather than a single stainless steel skin, and a wider aperture lid opening, capable of allowing placement of a pond skip for other LP&S projects.

Nirex recognises that a box of square plan would be advantageous for packaging LP&S wastes and is consequently giving consideration to the issues that would arise if this square plan container were accepted into the PGRC. At this stage the evaluation of the square plan box is not complete and we propose to work closely with British Nuclear Group on the issue of the box shape and dimensions.

The box is most likely to be manufactured with 1.4432 stainless steel, similar to grade 316S13 (Nirex standard waste containers have primarily been fabricated with 316 grades), although British Nuclear Group has also requested Nirex to assess the implications of manufacturing the box using Duplex 2205 grade stainless steel, which has not been used for this type of application before.

The transport system will need to be modified to accommodate the LP&S Box, through completion of design and development of the Standard Waste Transport Container, capable of transporting current box designs and the LP&S Box.

Disposability Assessment

The disposability assessment conducted by Nirex considers the proposed waste package for compliance with the Phased Geological Repository Concept. This is achieved by assessing the waste package against published generic safety assessments which address transport of waste packages to the facility and safety of operations at the facility. The wastes and packages are also assessed against the published Generic post-closure Performance Assessment.

Transport Safety

The assessments of transport safety show that it should be possible for boxes of Magnox Storage and Decanning Facility sludge to comply with all relevant transport safety criteria if transported in a 285 mm thick walled Type B Nirex Standard Waste Transport Container.

At this Conceptual LoC stage significant uncertainty arises over showing compliance with the specified limit on release of radioactive gases from the transport container. This may be due to exaggeration of the inventory of tritium, but may also be due to the use at this conceptual stage of conservative assumptions regarding its release. The bounding radionuclide inventory assigned to the packages for tritium is more than four orders of magnitude greater than the assigned best estimate package inventory. The bounding case is not based on a measured tritium concentration, due to a paucity of sludge inventory data for tritium. Instead, it has been derived by scaling a fingerprint for irradiated nuclear fuel to a measured radionuclide for which better sludge inventory data appears to be available. If the bounding inventory were to be realised, then a high degree of retention within the waste package would be required to prevent the transport package release limit from being exceeded. If the tritium inventory is closer to that of the best estimate, or if the tritium is significantly lost to the environment during retrieval and dewatering, or is dissolved in a fine metallic fraction of the sludge restricting its subsequent release rate from the waste, compliance might then be achievable. It is for example conceivable that this very mobile radionuclide has already substantially been discharged from the facility in pond water and by air, and the bounding tritium inventory of the sludge is thus grossly conservative. Information to confirm that compliance can be achieved will be required, and absence of firm information represents a threat to later stages of endorsement through the LoC process.

Operational Safety

The proposed packages of Magnox Storage and Decanning Facility sludge have a radionuclide inventory towards the upper end of that expected to be encountered for ILW. Four significant operational safety issues have been identified which require resolution at later stages of the LoC assessment process:

1. The assessed dose consequences of impact accidents are only just within limits set within the PGRC operational safety assessment. Though acceptable, the packaging system needs to be optimised to provide appropriate performance and better data on releases in impact accidents needs to be obtained as the project progresses. Nirex also needs to do further work on the operational safety assessment to remove inherent conservatism and provide a more realistic output.
2. The assessed dose consequences of fire accidents also approach limits, but only as a result of the assigned bounding tritium inventory and by conservatively assuming that all tritium is released in a fire accident. A reduction in the bounding tritium inventory, based on provision of improved data, or improvements in release data for tritium in fires would significantly reduce the assessed consequences of fire accidents.
3. The estimated consequences of routine radioactive gas discharges are assessed to be significant at this Conceptual LoC stage, primarily due to carbon-14 release in a gaseous form. This finding may be due to the assumptions that Nirex has had to make concerning the Magnox metal content of the sludge, and the assumption that carbon-14 is progressively converted to a gaseous form as the Magnox corrodes. These assumptions are likely to be conservative, requiring improved data to allow a more realistic estimate of discharges and attributable doses to be made.
4. The generic methodologies for demonstrating operational (and post-closure) criticality safety, including those to cover packages of waste containing irradiated natural uranium, are currently undergoing development following dialogue with regulators and waste packagers. These are likely to support higher levels of fissile materials than

previously endorsed. The levels of fissile materials in the proposed packages of sludge from the Magnox Storage and Decanning Facility are much higher than previously endorsed by Nirex, but are likely to fall within the bounds being developed for the updated methodologies. Nevertheless, until these generic methodologies have been successfully developed and justified, the Magnox Storage and Decanning Facility Sludge packaging project carries some risk for later stages of endorsement.

Post-Closure Safety

The post-closure safety assessment has revealed no major areas of concern that should prejudice disposal of packages of Magnox Storage and Decanning Facility sludges.

Even though Magnox Storage and Decanning Facility sludge would not be expected to represent the highest radioactive gas releases from ILW products, the estimated risk from the gas pathway attributable to the Magnox Storage and Decanning Facility sludge package is only just below the risk target. The risk is attributed to release and migration of carbon-14 labelled methane. The estimates of gas release are likely to be highly conservative, based on a range of assumptions, and further generic and waste specific work by Nirex and British Nuclear Group is required to improve the estimates.

There is a lack of information on the organic content of the sludge, including oils and grease, but it is judged at this Conceptual LoC stage that these materials are unlikely to be present in sufficient quantity in Magnox Storage and Decanning Facility sludge to threaten disposability.

The relatively high radiogenic heat output from the packages may also necessitate special measures to be taken in order to limit temperature rises in the repository vaults after backfilling. The packages possess no other features that might adversely affect repository post-closure performance.

Security

The security regulator, the Office for Civilian Nuclear Security, has contributed to the assessment of Magnox Storage and Decanning Facility sludge and has taken the view at this stage that the proposed packages of Magnox Storage and Decanning Facility sludge will require a higher level of protection than planned for other packages of ILW incorporated into the PGRC. Nirex has therefore instigated the process for changing the necessary aspects of the design of the PGRC to provide the higher level of physical protection. Early discussion with OCNS to confirm physical protection standards applicable to all stages of waste package production, storage, transport and emplacement in the PGRC is recommended.

Potential Package Design Improvements

In order to fully assess the proposed waste packages against Nirex packaging standards and underlying concept safety assessments, it is necessary to have an understanding of the characteristics and performance of the proposed waste package. At this Conceptual LoC stage, as would be expected, little of the development work is complete, although the design of the box is at a more advanced stage of development. This Assessment Report includes a number of Action Points directing British Nuclear Group to future development work needed to complete the disposability assessment.

In summary, the key areas requiring further development are:

- improvements in the understanding of the sludge radionuclide inventory, especially for tritium, and for some chemical species such as the Magnox metal, uranium metal, graphite and organic content;
- development of the secondary de-watering process for the sludge, the sacrificial can design and the compaction process;

- research into the longevity of the wasteform, and how this is affected by the sludge composition, the de-watering process, and the design of the sacrificial can and infill grout;
- finalisation of the design and the testing of the new annular 3m³ Box, and consideration of whether to pursue use of Duplex 2205 stainless steel. Early decisions on the use of Duplex 2205 also need to be made to facilitate appropriate R&D within British Nuclear Group and Nirex;
- the impact accident performance of the waste package and the resultant releases, including information on the break-up behaviour of the compacted sludge and any benefits for retention by the sacrificial cans;
- generation of more realistic estimates for radioactive gas releases from the packages;
- data required to support the revised approach to criticality safety;
- discussion with the Office for Civilian Nuclear Security to confirm physical protection standards applicable to this waste package.

Other Requirements

At future LoC stages of submission, British Nuclear Group will also need to comply with a number of mandatory requirements. These will include:

- conducting all phases of the Magnox Storage and Decanning Facility sludge packaging project under an appropriate quality management system (QMS);
- further development and finalisation of a data recording methodology for the waste packages;
- conforming with international Safeguards issues and associated data recording requirements;
- provision of a Waste Product Specification and Criticality Compliance Assurance Documentation.

Summary and Conclusions

A Conceptual stage assessment of British Nuclear Group Sellafield Ltd's proposals for packaging of Sellafield Magnox Storage and Decanning Facility pond sludge has determined that the proposed waste packages are likely to be compliant with Nirex standards and specifications and the underpinning Phased Geological Repository Concept. There are a number of areas where improved data would be required associated with the sludge inventory, relating to routine gas releases and how the waste packages will perform in impact accidents. The generic approach to criticality safety is being revised, but is only partially developed at this stage and needs to be finalised. Early decisions on the use of Duplex 2205 need to be made to facilitate appropriate R&D. A conceptual stage disposability assessment has been conducted and an Assessment Report produced.