

Packaging of Sellafield Magnox Swarf Storage Silo Waste

(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 Conceptual stage proposal from British Nuclear Group Sellafield Ltd for the packaging of waste from the Magnox Swarf Storage Silo at Sellafield.

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 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 guidance issued by the regulatory bodies.

Nirex has performed an independent assessment of the specific waste packaging proposal for the Magnox Swarf Storage Silo at Sellafield, against the requirements for future storage, transport and disposal as embodied in the Nirex PGRC to confirm disposability of the proposed waste packages.

British Nuclear Group's Proposals for Packaging Waste from the Magnox Swarf Storage Silo

The waste materials currently stored in the Magnox Swarf Storage Silo are proposed to be retrieved and transferred to a new treatment plant to be constructed at Sellafield. The Conceptual stage proposal identifies two alternative options for the treatment and packaging of these wastes, based on the use of a combination of annular grouted 500 litre Drums and 3m³ Boxes. It is noted that a BPEO (Best Practicable Environmental Option) study to support this strategy is under development, but has not yet been completed.

The Magnox Swarf Storage Silo contains a mixture of different types of intermediate level solid and sludge waste, primarily Magnox fuel cladding wastes that have arisen as a result of the early Magnox reprocessing programme. The facility was in active use between 1964 and 1991 and was developed in four phases as follows:

- Original building of 6 compartments (Compartments 1-6)

- First extension of 6 compartments (Compartments 7-12)
- Second extension of 2 compartments (Compartments 13-14)
- Third extension of 8 compartments (Compartments 15-22)

Concerns regarding the ability of the deteriorating compartments to continue to store the waste in a safe manner have led to a decision to remove the waste from the silo compartments and convert the waste into a passively safe form which is suitable for interim storage, long-term management and final disposal.

The waste contained in the Magnox Swarf Storage Silo consists primarily of Magnox fuel cladding (often referred to as Magnox swarf) which has arisen from the decanning of Magnox fuel elements, as well as a variety of Miscellaneous Beta Gamma Waste (MBGW). The wastes to be considered in the assessment are identified in the 2004 UK Radioactive Waste Inventory by the following waste stream identifiers:

- 2D08 – Magnox Cladding and Miscellaneous Solid Waste
- 2D09 – Magnox Cladding and Miscellaneous Solid Waste
- 2D22 – Magnox Cladding and Miscellaneous Solid Waste
- 2D24 – Magnox Cladding and Miscellaneous Solid Waste
- 2D25 – Miscellaneous Solid Waste
- 2D35 – Magnox Cladding and Miscellaneous Solid Waste

A key focus of British Nuclear Group Sellafield Ltd. is to complete the remediation and clean-up of the Magnox Swarf Storage Silo by retrieval of the currently stored wastes. These will be treated and conditioned for passive safe storage in the Box Encapsulation Plant Product Store (BEPPS) pending availability of long-term management of facilities. On retrieval, wastes will be loaded into a transfer skip which will be used to contain the wastes for shipment to the new purpose designed treatment plant. Some large items may require some size reduction to enable loading into the skip and specialist equipment is proposed to be provided. For transfer across site the skips will require to be shielded to reduce external radiation levels and to protect workers. A site transfer flask is proposed for this purpose. The current plan envisages that 80% of the volume of waste in the Magnox Swarf Storage Silo will be retrieved and packaged by 2020. Retrieval operations are planned to commence in 2010.

The total volume of raw waste in the Magnox Swarf Storage Silo is estimated to be approximately 10,800 cubic metres (m³). Consideration is currently being given to two alternative options – denoted Options A and D – for the treatment and packaging of these wastes. Option A involves segregation of the retrieved wastes by use of a 60mm square screen to provide both “undersize” and “oversize” waste fractions. The undersize fraction which will primarily comprise the Magnox cladding and sludge, will be dried and subject to high-force compaction (supercompaction) within sacrificial cans and loaded into an annular grouted 500 litre drum waste packages for subsequent immobilisation with cement grout. The oversize fraction will be transferred directly to an annular grouted 3m³ Box and immobilised through addition of cement grout. The alternative, Option D, leads to the retrieved waste being loaded into a tumble mixer where it is blended with cement grout and the mixture tipped into an annular grouted 3m³ Box waste package. Within this option there would be coarse segregation to remove any large heavy items that may damage the mixer, these are to be direct encapsulated with cement grout into an annular grouted 3m³ Box waste package.

Disposability Assessment

The disposability assessment conducted by Nirex considers the proposed waste packages for compliance with the Phased Geological Repository Concept. This is achieved by assessing the proposed waste packages against published generic waste package specifications and safety assessments that address transport of waste packages to the facility and safety of operations at the facility. The wastes and packages are also assessed against the generic post-closure performance assessment which addresses the performance of the PGRC in the very long term after it has been closed and sealed.

Waste package inventory

Quantitative assessments were undertaken against best estimate and bounding waste package inventories, derived from a number of sources, compiled into Data Summary Sheets. The primary sources of data for the content of Magnox Swarf Storage Silo are a combination of the UK National Radioactive Waste Inventory and information generated by British Nuclear Group based on plant operating data. Nirex has enhanced these data for the purposes of the assessment, to include estimates for any radionuclides not currently reported in the inventory but which would be expected to be present, and has generated 'best estimate' and 'bounding' waste package inventories.

The assessment inventories give cause for concern that Nirex Waste Package Specification and radiological protection criteria will be exceeded or challenged in some situations due to the expected, but currently unquantified pessimisms in their derivation, together with conservatism in the assessment approach adopted at this stage. Whilst there is reason to expect that some of these pessimisms can be removed as the proposal moves through to Interim and Final assessment stages, there is little evidence to give confidence that 'real' package inventories will be able to be derived and controlled in a way that avoids undue pessimism. This is a particular concern in the case of the Magnox Swarf Storage Silo Wastes on account of the very high inventories that maybe encountered for the bounding case.

Transport safety

Assessment of transport safety leads Nirex to conclude that it should be possible for waste packages containing Magnox Swarf Storage Silo waste 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 the case is not expected to be complete and uncertainties in the maximum radionuclide inventory need to be addressed to confirm that both the activity limit of 100,000A₂ and heat limit of 200 watts will not be exceeded for the transport package.

The uncertainty in the radionuclide inventory reflects what is believed to be the use of conservative factors in the derivation of the bounding radionuclide inventory for the waste packages, and pessimistic assumptions regarding waste composition. In the case of heat output, decay storage could be used if necessary to bring waste packages within prescribed limits. These issues can be dealt with satisfactorily as the proposal is addressed through later stages of the LoC process and such transport issues do not prevent endorsement at the Conceptual stage.

Operational safety

Assessment of operational safety leads Nirex to conclude that it should be possible for waste packages containing Magnox Swarf Storage Silo waste to comply with all relevant operational safety criteria of the PGRC, although the two proposed package options will lead to waste packages that exhibit a radionuclide inventory at the upper end of that expected to be encountered for ILW. As a consequence of the assessment, three potentially significant operational safety issues have been identified which highlight the need for further information.

The assessed worker dose consequences of severe impact accidents are close to or exceed limits set through the PGRC operational safety assessment. In order to be acceptable, the packaging system needs to be optimised to provide an appropriate level of performance in impact accidents and better data on potential releases from the waste package under impact accident scenarios will be required as the project progresses. Furthermore the acceptability of the assessed dose consequences will also be affected by a proposed update to the generic operational safety assessment required to take account of changes proposed to the HSE Safety Assessment Principles (SAPs). The update will also determine whether any conservatism in the current approach can be removed.

The estimated doses from routine radioactive gas discharges are assessed to be significant, primarily due to postulated carbon-14 release in a gaseous form. This finding will have to be followed-up as the packaging proposal is progressed, and improved data generated to confirm the fate of carbon-14 that is released from metal items as they are corroded. The Conceptual stage assessment has assumed that the carbon-14 is released in a gaseous organic form. The present assumptions are likely to be conservative and improved data will allow a more realistic estimate of discharges and attributable doses to be made.

The generic methodologies for demonstrating criticality safety, including those to cover packages of waste containing irradiated natural uranium, are currently undergoing development following dialogue with regulators. The levels of fissile materials in the proposed package options of the Magnox Swarf Storage Silo wastes are much higher than previously endorsed by Nirex, but are judged likely to fall within the bounds being developed for the updated methodologies. Nevertheless, until these generic methodologies have been successfully developed and justified, the silo waste packaging project carries some risk for later stages of endorsement.

Post-closure safety

The post-closure assessment has revealed one major area of concern that could prejudice disposal of packages of Magnox Swarf Storage Silo waste. The assessment has identified that carbon-14 if released in the gaseous form could exceed the risk target against which the PGRC is judged. This would require resolution as the packaging proposal progresses through the LoC assessment process.

The assessment estimate of gas generation and total release from waste packages are likely to be highly conservative, as it has been based on complete corrosion of the total metals present in the packages. At this Conceptual stage these are 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.

The assessment has found that there is a general lack of information on the organic content of the Magnox Swarf Storage Silo wastes, including wood, PVC, cable sheathing, oils and grease. Notwithstanding this all the indications are that these materials are unlikely to be present in sufficient quantity in the Magnox Swarf Storage Silo to threaten disposability.

Security

The Office for Civil Nuclear Security (OCNS) has contributed to the assessment of the Magnox Swarf Storage Silo wastes and has taken the view at this stage that the proposed packages may require a higher level of protection than hitherto planned for other packages of ILW in the PGRC. Nirex has commenced work to investigate the implications of this judgement on the design of the PGRC. Until this is complete Nirex would not be able to endorse the packaging proposal.

Waste Characterisation and Records

An important aspect of any disposability assessment is the methodology proposed to identify the waste and to generate information on the content and characteristics of the as-manufactured waste package. Such information will form an important component of the waste package record that will be generated throughout package life, including retrieval, conditioning and subsequent waste management phases, and would be a requirement to facilitate transport through the public domain and acceptance into future facilities such as the Phased Geological Repository.

It is necessary that the content of waste packages, both radioactive and relevant inactive components, is known to a sufficient degree of accuracy. This is primarily in order to support the safety case for the waste packages to enable transport, and to demonstrate compliance with package-specific limits for disposal. It is noted that the accuracy required is strongly related to the significance of the waste in question when compared with other types and the total disposal inventory. The Magnox Swarf Storage Silo wastes constitute a significant waste type in terms of volume and activity, which is likely to challenge some package limits and contribute significantly to overall radiological impact of a future disposal facility. Significant development of techniques and technologies for the characterisation and control of wastes will be required as the project is taken forward. These will enable a strategy to be generated that supports the case that appropriate packaging controls are in place and real package data can be assigned to waste packages to demonstrate that the packaging concepts are viable.

Potential Package Design Improvements

At this Conceptual LoC stage, development work by British Nuclear Group is by necessity at an early stage and a number of action points identifying additional information and/or research needs have been identified. It is envisaged that the action points when completed will provide the necessary information to enable completion of the disposability assessment. In summary, the key areas requiring further development are:

- Improvements in the understanding of the silo radionuclide inventory, especially for carbon-14, and for some chemical species such as Magnox metal, uranium metal, graphite and organic materials.
- Understanding of wasteform corrosion and estimated peak gas generation rates.
- Effectiveness of the de-watering and supercompaction processes for the Option A undersize fraction.
- Research into the longevity of the wasteform types, and how this is affected by waste composition, the de-watering and supercompaction processes for Option A undersize waste fraction, and the effectiveness of the direct grouting process for the Option A oversize waste fraction.
- Research into the longevity of the wasteform types, and how this is affected by waste composition, and effectiveness of the tumble mixing process for the Option D mixed waste option.
- Finalisation of the design and the performance testing of the annular grouted 500 litre Drum design for the Option A undersize waste option.
- Finalisation of the design and the performance testing of the annular grouted 3m³ Box and confirmation from British Nuclear Group of their intent to adopt the requirements proposed by Nirex for a square-cornered 3m³ Box.
- Understanding the impact accident performance of the waste package types and the resultant releases, including generation of information on the break-up behaviour of the wasteforms under consideration.

- Generation of realistic and justifiable records for the content of individual waste packages based on interrogation of existing records and development of a representative suite of package fingerprints.
- Further work on waste package data assignment and control, to underpin the viability of data recording for each Option, to support the view that the assignment of real package data to individual waste packages is credible and can provide process control to meet package limits on an individual waste package basis.
- Data required to support the revised approach to criticality safety.

Summary and Conclusions

A Conceptual stage disposability assessment has been conducted and an Assessment Report produced. It is judged that both Option A and Option D can be developed to the stage where they would meet disposability criteria as defined by the PGRC, although there are three issues that are preventing the issue of a Conceptual Stage LoC at this time.

- Uncertainties associated with the package radionuclide inventory caused by lack of clarity regarding proposals for characterisation of wastes and/or assignment of real package inventories, give cause for concern that pessimistic waste package inventories will continue to indicate that Nirex Waste Package Specification and radiological safety criteria will be exceeded or challenged.
- The proposed waste packages will require a higher level of physical protection than currently embodied within the PGRC. Nirex has initiated further work to assess the implications of increased levels of protection for the PGRC.
- The LP&S Box as presently envisaged would not be compatible with Nirex standards and therefore would be considered non-standard. This issue is being taken forward through a separate interactive joint working initiative between Nirex, BNGSL and NDA.

The latter two issues are being pursued by Nirex and are considered to be soluble. The first issue requires action by BNGSL to provide further definition of proposals for characterisation of wastes, assignment of inventory and control of process in order to give confidence that the present uncertainties in the derivation and assignment of waste package inventories can be reduced. At the current time these uncertainties are indicating that waste packages will challenge Nirex Waste Package Specification and radiological safety criteria as presently specified. It is important at this Conceptual stage for BNGSL and Nirex to have confidence that there are credible plans to support the case that real package data can be assigned to waste packages to demonstrate that the packaging concepts are viable.

It is concluded that the proposals presented by BNGSL for the packaging of Magnox Swarf Storage Silo wastes are potentially endorsable. Further definition of proposals for characterisation of wastes and assignment and control of package inventories, based on the extensive work undertaken to date, would provide confidence that Nirex Waste Package Specification and radiological safety criteria will not be exceeded.