

Packaging of Magnox Swarf Storage Silo Miscellaneous Beta Gamma Waste at Windscale Advanced Gas-cooled Reactor

(Conceptual stage)

Summary of Assessment Report

Issue date of Assessment Report: 5 September 2012

Introduction

Sellafield Limited (SL) has sought Conceptual stage endorsement of proposals to package wastes described as miscellaneous beta gamma waste (hereafter BGW) from the Magnox Swarf Storage Silos (MSSS) in 6m³ reinforced concrete boxes (also referred to as WAGR boxes) at the refurbished Windscale Advanced Gas-cooled Reactor (WAGR) packaging facility.

This Assessment Report provides the basis and findings of the Conceptual stage disposability assessment by NDA Radioactive Waste Management Directorate (hereafter RWMD) for packages of BGW. The assessment has been carried out through the Disposability Assessment process, whereby RWMD examines the disposability of proposed waste packages by assessment against Intermediate Level Waste (ILW) standards and specifications and the Geological Disposal Facility (GDF) concept. This concept has been developed as part of the programme to implement geological disposal for the UK's higher activity wastes. Further information on the Letter of Compliance process is available elsewhere¹.

Background

The Sellafield MSSS facility was in active use between 1964 and 1991. The waste in the silo compartments is primarily irradiated Magnox fuel cladding arising from the decanning of Magnox fuel elements contaminated by uranium metal fuel, also referred to as Magnox swarf. Some Magnox swarf was retrieved from compartments 19-22 during the 1990's and the wastes packaged at the Magnox Encapsulation Plant, covered by a separate Letter of Compliance issued in 1993. Continued concern regarding storage of the remaining waste in ageing and deteriorating MSSS compartments led NII to issue Licence Instrument 326(a) in 2000, requiring that 80% of the sludges be made passively safe by 1st August 2020.

The silo compartments contain a mixture of different types of intermediate level solid and sludge waste, from the Magnox reprocessing programme. Primarily the waste is irradiated Magnox swarf most of which has become sludge due to corrosion. Approximately 10% of the waste by volume is a variety of irradiated and contaminated BGW.

Active commissioning of MSSS bulk retrievals will begin in June 2016 at least 12 months ahead of that of the Silos Direct encapsulation Plant (SDP). This packaging proposal uses commissioning of mobile caves (silo emptying plant) in 2016 to bring forward retrieval of BGW located above the Magnox swarf layer in compartments 4, 6, 8, 10 and 12 to be packaged in the refurbished WAGR facility. The residual BGW and the swarf not processed through this proposal would be conditioned and packaged in SDP.

¹ NDA, Guide to the Letter of Compliance Process, NDA Document WPS/650, March 2008

Waste packaging proposal and scope of assessment

The 200m³ of BGW subject to this assessment is a subset of the BGW within compartments 4, 6, 8, 10 and 12. Located above the main sludge/swarf layer, it comprises a heterogeneous range of sizes and types of BGW including irradiated and non irradiated steel, activated stainless steel, reactive metals, organic/cellulosic materials, graphite, cans and drums of contaminated materials. Some cans contain post irradiation examination (PIE) fuel material some of which will be enriched uranium. Isotope cartridges tipped in the compartments might also be retrieved. Some contamination with sludge from Magnox swarf and uranium corrosion is expected and there is potential for carry-over of silo liquor with the waste (in skips under water cover).

Waste would be recovered from MSSS compartments with a grab and placed, directly and unsorted, into a skip before transfer to the WAGR facility. The waste would be robotically removed from the skip onto a table. Items such as drums, cans, tins and tubes would be mechanically opened to allow some of the sludge and liquor to drain (to be returned to MSSS) and to enhance the subsequent infiltration of grout. Large items would be size reduced as required to fit into the box. Some sorting and treatment of materials such as cellulose, wire and plastics would be undertaken, to facilitate encapsulation and production of a monolithic (but heterogeneous) wasteform.

Since the waste arrives unsorted from MSSS and there is only limited space for storage of segregated items within the WAGR facility the assumption in the proposal is that nearly all of the items transferred to WAGR would be incorporated into waste packages.

Waste would be placed into a basket and loaded into a high density version of the concrete 6m³ box. An anti-flotation grid would be added to prevent items from floating towards the surface of the wasteform. A high density grout, containing magnetite sand, would be used (to provide shielding), and the lid of the 6m³ box would be cast in place after the encapsulant grout had set. The wasteform would be a heterogeneous monolithic cementitious mass containing between 5t and 11t of waste. The gross package weight is expected to be ~45 t.

The WAGR box was designed to be an Industrial Package Type 2 (IP-2), for use with non-fissile decommissioning waste from the Windscale Advanced Gas-cooled Reactor. This extension to the application of the container is for a very different, much higher dose waste stream containing items of PIE fuel waste and contaminated with fissile material.

About 160 packages are anticipated to result from this work, to be stored in the existing WAGR store.

Not considered within the scope of the assessment but of note is that the WAGR decommissioning was a dry procedure with little risk of contaminating the facility. In comparison, the current proposal relies on delivery and manipulation of a wet waste stream and could potentially result in contamination and then subsequent clean-up of the WAGR facility.

Outcome of assessment

Compliance with Waste Package Specification (WPS)

The current proposal falls short of the requirements of the Generic Waste Package Specification (GWPS) and the Level 2 Generic Specification for Robust Shielded Waste Packages. It should be noted that these specifications were extant during the conduct of this assessment but that they have now been replaced with the '*Generic Specification for waste packages containing low heat generation waste*', NDA/RWMD/068. The publication of this updated specification has no consequences for the conclusions of this assessment.

Our assessment concluded that the proposed methodology, with suitable development, was capable of producing stable wasteforms and packages that could provide adequate performance regarding heat output, gas production and venting and radioactive releases during normal and transport accident conditions. However the assessment also identifies significant shortfalls in that:

- Regulatory requirements for transport of IP containers, detailed in the IAEA regulations, were not met. The waste would need to meet the requirements of Low Specific Activity (LSA) material or Surface Contaminated Objects (SCO). Our assessment concluded that the waste is not solely SCO and contained some very high activity items that would not meet the A_2 limits for LSAII or LSAIII or the distributional requirements for activity in wasteforms. Additionally the 6m³ box would be unlikely to conform to the leach test required for LSAIII materials. The assessment concluded that the PIE fuel material in the waste stream, with high content of A_2 multiples, was not LSA. The method of waste retrieval and packaging did not allow for identification and subsequent removal of these items (the PIE waste containers are identical to those used for other wastes) and so it was concluded that Sellafield Ltd could not demonstrate conformance of packages with requirements for LSA regarding specific activity multiples and the distribution in the wasteform.
- To date WAGR boxes have not been approved for fissile use. The mass and distribution of the fissile content in the packages (PIE fuel material and sludge) is greater than the current limits for IPs so does not meet current requirements for a current fissile exception. SL is liaising with the Office of Nuclear Regulation (ONR) to obtain guidance on the likelihood of meeting an alternative fissile exception proposal, and expects a response at the end of July 2012. Alternatively Sellafield Ltd could propose to classify the packages as “fissile”, supported by evidence of conformance with the transport regulations and appropriate criticality safety documentation. Indeed ONR has referred to the possibility of this option in discussions regarding this project.
- Wasteform dose and package external dose rates were assessed against IAEA and WPS requirements. Some of the packages would exceed the maximum dose limits for unshielded waste and for the 0m and 1m dose requirements at 2040. Mainly due to Co-60, decay storage beyond 2040 (for up to 30 years) would be required for all of the packages to comply with transport regulation dose requirements. Proposals for control of surface contamination at the time of package production is assessed as adequate. However, in the absence of a diffusion barrier the assessment concludes that migration of Cs-137 through pore water from the waste to the box surface (or to the box lid, if a liner were deployed) could result in surface contamination in excess of the maximum permissible level for transport.
- Corrosion of aluminium has been identified as an issue for the long term integrity of some packages due to expansive corrosion of the embedded metal (and also for wasteform production due to potential for high rates of hydrogen production). The submission recognises these issues, referring to on-going development work investigating localised encapsulation of aluminium, primarily the cladding from isotope cartridges within easily recognisable aluminium Chapelcross buckets. Without this treatment a proportion of packages are currently predicted to exhibit some level of cracking within 150 years of production.

The radionuclide inventory for the BGW was derived from MSSS tipping records. Further refinement of these records might modify the inventory derived parameters including dose rates, specific activity, fissile and aluminium content for the range of packages. Selective sorting is unlikely to be practicable for the PIE material due to the limitations of the waste recovery method, methods of identification (the PIE containers are identical to containers used for a variety of other wastes) and in the lack of significant buffer space at WAGR. The assessment concluded that although complete removal of the PIE material would probably allow the packages to meet LSA, and possibly fissile requirements, that this was not practicable.

Compliance with concepts for a Geological Disposal Facility

As described in the previous section the proposed IP packages are assessed as not legally transportable due to non compliance with LSA and fissile requirements. Assuming that these issues could be resolved, compliance with the GDF concept is considered possible.

Safety assessment for the operational phase identified two main issues:

- Previous assumptions for the waste stream modelled disposal in type B packages, transported in a shielded SWTC and disposed of to unshielded ILW vaults, emplacement being through remote handling methods. This proposal, due to the combination of the high dose rate from the individual packages and contact handling of IP packages, results in a substantial increase in the predicted radiation dose to transport and GDF workers during normal transport and emplacement activities. This assessment used the generic assessments on the basis of standardised periods for exposure activities. The resultant worker dose is 4 times the annual dose design target of 1mSv for transfer at 2040. Reduction to worker dose could be accomplished through reduction in radionuclide inventory or decay storage (worker dose would be reduced by decay storage to 2070). Additionally, if in future RWMD endorse a revised proposal they may need to consider the dose to workers and whether operational changes (and change control) would be needed to maintain ALARP.
- Radiation dose to GDF operators arising from the more severe Design Basis Accident (DBA) fault scenarios (at 2040) was up to 80 times the acceptable level, due to the high inventory of the wastes and the contact handling methodology used for IPs.

Bulk gas, radioactive gas and heat generation during all phases of the GDF operation and post closure were assessed as acceptable. A criticality safety case should be able to be made for the operational and post closure phases based on the expected fissile material loadings. Previously assumed to be disposed of as unshielded ILW, transfer of the wastes for disposal to a shielded ILW disposal route does not result in significant change to the risk from the groundwater transport of radionuclides.

It is noted that in 1999 Nirex advised that there were concerns over the type of superplasticiser utilised in WAGR boxes for WAGR decommissioning, which was known to have the potential to increase actinide solubility under disposal conditions. They were endorsed as disposable due to isolation of these boxes in the GDF from the actinide bearing wastes in ILW. The addition of actinide bearing wastes from MSSS BGW, to the SILW vaults with existing WAGR boxes has not been addressed in this current assessment. RWMD will need to assess whether the addition of MSSS BGW to the SILW vaults is consistent with the implied constraint.

Statement of disposability

This assessment report has concluded that the proposed 6m³ packages containing MSSS BGW are currently not consistent with disposal under the geological disposal concept. Endorsement of the Conceptual stage LoC proposal is therefore withheld pending the satisfactory resolution of outstanding Conceptual LoC actions.

Conclusions

The proposal from Sellafield Ltd is an extension of the use of the high density version of the 6m³ WAGR box, originally used during decommissioning of the WAGR reactor, to a much higher dose, fissile containing, beta gamma waste from the Magnox Swarf Storage Silos. This assessment has identified a number of non conformances with the waste package specifications, the transport regulations and the geological disposal concept.

The key technical issues that need to be resolved prior to Conceptual stage endorsement are:

- Sellafield Ltd is advised of the need to provide quantitative evidence that they would meet the regulatory requirements for Industrial Packages (for LSA material) for all of the packages with respect to specific activity content and distribution of activity throughout the wasteform. Considering the types of waste present and the variable specific activity content, the available methods for retrieval and treatment, and the challenges associated with deriving a credible package inventory it is our opinion that this requirement is particularly challenging.
- Based on submitted inventory estimates, the current requirements for fissile exception of the proposed packages could not be met. To overcome this Sellafield Ltd would need to develop an endorsable case for meeting future fissile exceptions, or develop a credible proposal for approval of an industrial fissile (IF) 6m³ box package.
- Sellafield Ltd is advised that it will need to confirm how it would ensure that bare wasteform and external doses would meet the requirements of the transport regulations and the WPS for IPs. Sellafield Ltd will need to clarify the contribution from Cs-137 migration from this waste to package surface contamination levels and evaluate the effectiveness of proposed mitigation measures, such as internal or external liners.
- The practicability and effectiveness of Sellafield Ltd proposals for aluminium treatment and passivation, resulting in adequate package longevity, will need to be developed, documented and presented for assessment.
- Assessment of the effect of the external radiation doses concluded that radiation doses to GDF workers would be 4 times the annual dose design target of 1mSv under normal conditions at 2040. Sellafield Ltd will need to advise RWMD of the measures they propose to use to reduce worker dose to an acceptable level if different from those needed to comply with the transport regulations.
- The assessment concludes that doses to workers arising from DBA scenarios modelled at 2040 are not acceptable. Sellafield Ltd is advised of the need to confirm how package dose would be controlled to reduce this effect.

Additionally:

- RWMD will need to explore the implications for the GDF post closure phase of co-disposal of waste packages containing superplasticiser with packages containing significant quantities of actinides.
- RWMD will need to consider if change control is required for normal handling of IP packages in order to maintain doses for GDF workers as ALARP, and consider the consequences of such change on doses arising from DBA sequences.

This assessment report has been prepared by RWMD to highlight the additional information required in the next submission from Sellafield Ltd for the packaging of beta gamma waste from Magnox Swarf Storage Silos. Six Action Points have been raised, to be resolved at Conceptual stage.

RWMD supports the exploration of innovative approaches to waste packaging, including the wider use of packages such as the 6m³ concrete box. This needs to be guided by the suitability of the waste stream, and we conclude that there are significant challenges to be overcome in this particular case in using an industrial package for this waste.