

Sellafield Legacy MBGW at the Box Encapsulation Plant

(Conceptual stage)

Summary of Assessment Report

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Introduction

Sellafield Ltd (SL) has sought Conceptual stage endorsement of proposals for the packaging of various Sellafield site Miscellaneous Beta Gamma Wastes (MBGWs) at the Box Encapsulation Plant (BEP).

This Assessment Report provides the basis and findings of the Conceptual stage disposability assessment by NDA Radioactive Waste Management Directorate (hereafter RWMD) for packages arising from BEP. The assessment has been carried out through the Disposability Assessment process, whereby RWMD examines the compatibility of the proposed packages with the requirements for safe long-term management, including storage, transport, emplacement and extended storage underground, and disposal, as currently expressed for the reference ILW Concept for Low Heat Generating Waste. 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 Disposability Assessment process is available elsewhere¹.

Background

The Sellafield site 2011 Performance Plan shows that MSSS bulk retrievals are scheduled to begin active commissioning in June 2016 with the destination plant for the wastes, the Silo Direct encapsulation Plant (SDP), ready to start active commissioning in June 2017. Sellafield Ltd initiated a study in April 2012 to determine whether the partially constructed BEP facility, could be redesigned to process MBGW from the MSSS, to allow earlier retrieval of these wastes.

SL is investigating two scenarios for the scope of waste packaging in BEP, a 5-year model and a 30-year model. In the 5-year model the plant would only package a limited range of legacy wastes. In the 30-year model the packaging plant would support SDP for its operational lifetime and consider processing a wider range of wastes. This wider range of legacy wastes would be a larger quantity of the MSSS MBGW, waste feeds from the First Generation Magnox Storage Pond (FGMSP), Pile Fuel Storage Pond (PFSP) and historic MBGW storage cells. Additional wastes, not covered by the current study, could also be proposed in the future. As part of the SL exercise, the key differences between the 5-year model and 30-year model in terms of cost and plant functionality, etc, are to be investigated. To provide information on waste package disposability for the study, SL has made a Conceptual stage Letter of Compliance submission for packaging the range of legacy MBGW at BEP.

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

The MBGWs comprise a wide range of materials, from particulates, sludge, and organic materials through to large volumes of contaminated steel items. The fuel ponds also contain some specific items, such as skips housing zeolite ion-exchange material and ion-exchange cartridges used to cleanup pond water. Some waste streams contain residues of irradiated uranium metal and uranium oxide fuel, some of which was cemented for pond storage and has subsequently degraded. The range of radioactive contents is very broad across these wastes.

Specifically, the waste addressed by these proposals originates from:

- MBGW from the top surface of most MSSS compartments;
- Oxide fuel reprocessing wastes from MSSS;
- Stone aggregates from the base of two MSSS Compartments;
- Wastes from the fuel ponds PFSP and FGMSP, including
 - MBGW
 - Zeolite skips from FGMSP;
 - Ion-exchange cartridges from PFSP;
 - Isotope cartridges and sources from PFSP and FGMSP;
 - Cemented fuel bits and cemented Tokai Mura End Crops (TMECs) from FGMSP;
- MBGW from site historic storage cells;
- Sludge and particulates from the above wastes;
- Used equipment from donor plants and BEP (operational wastes).

Waste packaging proposal and scope of assessment

The wastes would be extracted from the current storage locations, together known as the donor plants, and sent to BEP. The submission indicates that most wastes would be emptied onto a sorting table in BEP and would be segregated into five types/categories:

- Wastes Requiring Additional Treatment (WRATs) prior to packaging in BEP;
- wastes that would be removed for temporary storage and management elsewhere;
- wastes whose quantity per box needs to be controlled and limited;
- wastes that can be encapsulated without any treatment or quantity control; and
- items of uncertain nature that require specific characterisation.

The submission identifies a number of WRATs and indicates how they would be treated. Examples of WRATs include sealed cans, bag filters and HEPA filters, loose soft wastes, bagged waste, cable and wire, gross amounts of sludge. Some waste items would require specific treatment, such as draining of pond water from Zeolite skips and ion-exchange cartridges. The option to pre-treat one waste feed at its donor plant, and then package at BEP is also included.

Once treated, all of the wastes would be packaged in stainless steel 3m³ boxes known as the Silos Direct encapsulation Plant (SDP) variant of the Sellafield 3m³ box, intended to comply with Level 3 RWMD Waste Package Specification WPS/315. This would be a single skinned box, but utilising a free-standing liner to contain the waste. Wastes would be encapsulated in the liners, and the liners subsequently loaded into the boxes. This has process advantages, is intended to minimise box external contamination, protects the outer skin of the box from some waste items as

they degrade and improves package performance. The gap between the liner and box would be filled to form an annulus prior to export from Sellafield site to a GDF.

There are variations in the wasteform design and production process for each waste type. Wastes would be encapsulated or entombed, generally with cement or a polymer. Liners would be loaded with loose waste, pond skips, Zeolite skips, Ionsiv cartridges, a liner basket and waste or be fitted with equipment to facilitate sludge encapsulation. Most wastes will be intimately encapsulated to immobilise the radioactive materials, but it is proposed to entomb the Zeolite skips and ion-exchange cartridges rather than to extract the contents from these items to intimately immobilise the wastes.

Methods of generating package records are not yet defined, but it is likely that a range of methods, would be utilised.

As the project progresses consideration may also be given to assigning wastes from multiple streams to the same 3m³ Box, but for simplicity the disposability assessment assumes that wastes would be campaigned and thus segregated by original donor plant.

Outcome of assessment

Overall outcome

The proposals to treat and encapsulate various Sellafield MBGWs at the Box Encapsulation Plant to produce disposable 3m³ box waste packages have been assessed. The assessment concluded that the packages for most of the proposed wastes are consistent with plans for a Geological Disposal Facility, and so can be endorsed, although there are some current exceptions.

A number of issues have arisen from this assessment that lead to some proposed wastes being currently excluded from endorsement. The exclusions relate to the Zeolite skips, ion-exchange cartridges, particulate wastes in one of the MBGWs if processed at the donor plant, oxide fuel reprocessing wastes from MSSS and all isotope cartridges which contain aluminium nitride.

The proposal to entomb Zeolite skips and Ionsiv cartridges rather than intimately encapsulate the wastes is novel, but does not necessarily represent best practice. It is conceivable that the benefits of a more conventional solution representing best practice will be small compared to the disadvantages to waste management at Sellafield site. SL is therefore requested to either propose a conventional wasteform production technique for a compliant solution, or show whether the proposed solution is optimum across the whole waste management lifecycle compared to conventional solutions. SL should also show that retention of free liquids in these waste items will be minimised.

In the case of the MBGW from the historic storage cells, it is currently undecided whether treatments of the waste prior to encapsulation will be undertaken at the donor plant or at BEP. It should be noted that a previous assessment for this MBGW, which proposed to treat and package waste at what is now a donor facility to BEP, identified that the treatment process for the particulate wastes at the donor plant were inadequate, and this waste fraction was excluded from the historical endorsement for packaging that MBGW. The same exclusion for processing particulate wastes from this MBGW needs to be applied from any endorsement of the current proposals whilst this remains unresolved, since these specific wastes may be treated at the donor plant under current proposals. The alternative option presented, treatment of the wastes at BEP, is endorsed since they incorporate proposals to treat all particulate wastes.

Production of disposability safety arguments addressing the proposals to package oxide fuel reprocessing wastes from MSSS, poses particular challenges. This waste contains Low Enriched Uranium wastes and various items from clean-out of a now closed reprocessing plant, some of which may not be well characterised. A Safe Fissile Mass (SFM) for waste packages containing this waste needs to be derived and may be quite restrictive compared to the proposed control of package contents during packaging. The current proposals for BEP do not incorporate radiometric assay systems that might be required to show compliance with a restrictive SFM. For this reason, the oxide fuel reprocessing wastes from MSSS are currently excluded from Conceptual stage endorsement.

The potential impact of carbon-14 release from corroding uranium metal, irradiated steel and graphite is recognised as a generic issue requiring further research by RWMD. The hydrolysis of aluminium nitride from isotope cartridges, a unique waste item, would be expected to create C-14 in the form of methane, which if released could be highly significant to the GDF post-closure safety assessment. Unless on-going research can conclude that this C-14 would be contained by the geosphere above a GDF, and would not pose a threat to safety, the aluminium nitride would need treatment at the time of packaging or containment until it has decayed. Treatment or packaging for long-term containment of the cartridges may be a very significant undertaking for Sellafield Ltd, not consistent with current proposals. The proposals to package the aluminium nitride cartridges at BEP using simple encapsulants cannot therefore be endorsed at this time.

The submission does briefly mention that the proposals may be developed to consider mixing of wastes from different donor plants. This has not been considered in detail by this assessment, but in RWMD's view this may considerably complicate development work requirements, a future disposability assessment and operation of BEP, particularly for some combinations of wastes. Careful up front planning of waste combinations would be required, rather than late in the development of the project. Proposals to mix wastes are excluded from endorsement at this stage.

Box design issues

The current design of SDP box, proposed for BEP, is non-compliant with regard to the design of the twistlock lifting pocket and due to the absence of an agreed justification for the stainless steel surface finish. Work is currently on-going within SL and RWMD to address these non-compliances. These issues are feasible to resolve, either through design changes to the box or to the GDF plans, but this will take time. On these grounds the BEP proposals can be endorsed at Conceptual stage, but the LoC will be caveated to require resolution of these issues.

Cemented uranium

The cemented uranium bits and Tokai Mura End Crops are a significant waste addressed by the BEP proposals. The presence of metallic uranium raises concerns over wasteform stability and bulk gas generation. This was a key uncertainty that prevented endorsement for this a wider range of fuel materials. Based on photographic evidence and R&D on uranium corrosion, RWMD anticipates that the cemented uranium bearing materials, a fraction of the fuels and fuel bearing material, will already be heavily corroded and the issues raised previously will not be as severe for these cemented materials. SL should note that there remains a significant risk associated with the cemented uranium, which will remain until fully developed arguments and evidence to support the assumption on uranium corrosion are provided.

High dose in GDF

A very broad range of assessed worker doses has been assessed from the GDF operational safety Design Basis Accident (DBA) impact and fire fault conditions. The broad range of wastes and resultant package inventories leads mainly to low doses in faults, but also some high worker doses for the most severe accidents. Most notably the safety assessment outputs for cemented uranium bits and TMECs and the MSSS Compartment 15 MBGW generate significant DBA doses.

The maximum inventory for cemented uranium is considered to be reasonable, and may consistently apply to a number of waste packages. For this reason this stream is probably of greatest safety significance for BEP waste packages in the DBA analysis. The safety impacts are most sensitive to the assumed release fractions in this case. Adequate protection of the wasteform by the container and annulus, and evolution of the wasteform due to any residual metal corrosion are therefore likely to be important factors affecting these RFs.

A generic study of how the impact and fire fault release fractions and how they are applied to the operational safety assessment is suggesting a number of areas for improvement or optimisation by RWMD. At this stage it is difficult to estimate the potential reduction in conservatism that would arise from such studies, but it can be expected that this work will be progressed to assist a demonstration that doses would be ALARP.

Conclusions

The proposals to treat and encapsulate various Sellafield MBGWs at the Box Encapsulation Plant to produce disposable 3m³ box waste packages are consistent with disposal under the geological disposal concept for most of the proposed wastes. A Conceptual stage Letter of Compliance can therefore be provided, although some wastes are specifically excluded from this endorsement. The exclusions relate to the Zeolite skips, Ionsiv ion-exchange cartridges, particulate wastes from the MBGW in the historic storage cells if processed at the donor plant, oxide fuel reprocessing wastes from MSSS and all isotope cartridges which contain aluminium nitride. The endorsement will also contain a caveat, regarding resolution of detailed box design issues that have arisen from the SDP project, and a condition that different wastes are not inter-mixed in BEP waste until it is shown that disposable packages and suitable package records would be created.